ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING

by

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To my father Ahmad Tony & father in law Said Mustafa,
my mother Kustinah & mother in law Syarifah Nadirah,
my wife Syarifah Mastura,
my son Di Raja Qusayyi Rabbani,
and
my daughter Wan Lubnayya Nabigha.

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ABSTRACT

Liquefaction has caused significant failures and represents a significant problem for the community and geotechnical engineering designers (Pyrah et al., 1998). However, in practice, a single reliable method for assessing the liquefaction potential of soils is not well defined, particularly for aged soils. This is due mainly to the fact that most research has been based on ‘clean sand’ as the calibration to define the boundary between liquefaction and non liquefaction behaviour. Therefore, a well defined procedure for liquefaction assessment which is applicable to soils of any age is a crucial first step in reducing the risk of substructure failures and mitigating casualties resulting from earthquakes.

The research presented herein is focused on investigating the capability of the cone penetration test (*CPT*) and flat dilatometer test (*DMT*) for liquefaction assessment on natural soils considering soils deposited more than 1100 years ago at Gillman, South Australia. The recommended *CPT* procedure from the 1996 *NCEER* and 1998 *NCEER/NSF* Workshops is employed. In addition, the age correction factor proposed by Hayati et al. (2008) is used to revise the cone resistance ratio (*CRR*) values obtained from the *NCEER/NSF* procedure. The *DMT* procedure is selected as another contender in this liquefaction assessment because some researchers, such as Yu et al. (1997), Sladen (1989) and Marchetti (1999), claimed that the *DMT* is able to capture the ageing effect of the soils.

Extensive study to define the peak ground acceleration for this liquefaction assessment is conducted by using one-dimensional, site-specific ground response analysis (*SHAKE91* and *EERA*). The most recent and significant natural earthquake motions recorded by two separate accelerogram stations are obtained and manipulated to suit the data entry format of the response analysis methods. The soil unit weight and its shear wave velocity are derived from *CPT* and *DMT* data by using several empirical correlations. The results are then applied individually to each procedure.

The critical state approach for liquefaction assessment introduced by Jefferies & Been (2006) is used to verify the assessment of both the *CPT* and *DMT* procedures. The simple critical state parameter test proposed by Santamarina & Cho (2003) is undertaken on 6 soil samples taken from the study site to estimate the in-situ state parameter.

Liquefaction assessment using the *CPT* data incorporating ageing and *DMT* procedures (i.e. Marchetti, 1982 and Monaco et al., 2005) are presented and a comparison between all procedures is carried out. Re-examination using critical state approach is made. In addition, the consequences of the liquefaction in terms of ground settlement are also investigated.

Finally, this study shows that soil ageing increases the ability of soil to resist during the seismic loading. Furthermore, by assuming that the critical state approach represents the true conditions of the study site, the liquefaction assessment method proposed by Marchetti (1982) from *DMT* data provides better prediction than the others.

STATEMENT OF ORIGINALITY

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university, or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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In the name of Allah, the Most Gracious, the Most Merciful. All praise is due to Allah, Lord of all that exists and may His peace and blessing be upon His Prophet and Final Messenger Muhammad (pbuh). I am indebted to Allah Subhanahu Wata'ala for the strength, nourishment and opportunities which I have been blessed with during this period of study.

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ABBREVIATIONS AND NOTATIONS

$\sigma_m^{'}$	additional radial stress for the simple critical state parameter test
$\sigma_{ci}^{'}$	applied pressure for the simple critical state parameter test
A_t	area inside the transparent tube for the simple critical state parameter test
$\sigma_{3i}^{'}$	correction applied pressure for the simple critical state parameter test
ϕ_{cs}	critical state friction angle for the simple critical state parameter test
d_i	distance for the simple critical state parameter test
$p_i^{'}$	mean principal stress in each measurement for the simple critical state parameter test
h_i	measured water level for the simple critical state parameter test
V_{w0}	reference water volume for the simple critical state parameter test
G_s	specific gravity of the soil
γ_w	unit weight of water
e_i	void ratio
ΔV_i	volume change for the simple critical state parameter test
V_t	volume of the device with soil for the simple critical state parameter test
V_d	volume of the device without soil for the simple critical state parameter test
V_s	volume of the soil for the simple critical state parameter test
V_{sp}	volume of the specimen for the simple critical state parameter test
V_{wi}	water volume for the simple critical state parameter test
h_0	reference water level for the simple critical state parameter test

W_s	soil unit weight for the simple critical state parameter test
κ	impedance ratio
$\mathit{\Gamma}$	intersect of the CSL at 1 kPa mean stress pressure
ψ	normalising state parameter
λ	slope of the CSL
ε	axial strain in the specimen
Φ	dilatometer friction angle
ϕ‘	internal friction angle
σ'_m	additional radial stress
σ'_{vo}	effective vertical overburden stresses
ψ_0	in situ state parameter
ρ_r,	density of the bedrock
β_s	soil critical damping ratio
ρ_s	soil density or soil unit weight
ε_{vi}	post-liquefaction volumetric strain for the soil sub-layer *i*
σ_{vo}	total vertical overburden stresses
Δz_i	thickness of the sub-layer *i*; and *j* is the number of soil sub-layers
A	amplification ratio
A/D	Analogue to Digital
a_{max}	peak horizontal acceleration at ground surface
a_o	bedrock peak ground acceleration
a_r	incoming bedrock peak ground acceleration to the upper layer.
AS	Australian Standard
ASTM	American Soil Testing and Material
a_t	surface acceleration
BH	Borehole

BP	Before Present
C_A	strength gain factor and
c_h	dilatometer coefficient of consolidation
c_M	membrane correction
CPT	Cone Penetration Test
C_Q	normalising factor of cone penetration resistance
CRR	cyclic resistance ratio
CRR_K	cyclic resistance ratio corrected for age
CS	critical state parameter
CSL	Critical State Line
CSR	Cyclic Stress Ratio
Cu	coefficient of uniformity
c_u	undrained shear strength
D	initial diameter of the specimen
D_{10}	the grain diameter (in mm) corresponding to 10% passing by weight
D_{50}	the grain diameter (in mm) corresponding to 60% passing by weight
DMT	Dilatometer Test
D_R or Dr	relative density
e	void ratio
E_D	dilatometer dilatometer modulus
EERA	Equivalent-linear Earthquake Response Analysis
EPROM	Erasable Programmable Read Only Memory
FS	Factor of Safety,
f_s	sleeve resistance.
g	acceleration of gravity;
G_0	small strain modulus

GHS the accelerogram at Government House, Adelaide

H thickness of soil layer

I/O Input/Output

I_c soil behaviour index

I_D dilatometer material index

IBM International Business Machine

ISOPT International Symposium on Penetration Testing

ISSMFE International Society of Soil Mechanics and Foundation Engineering

k soil specific coefficient proposed by Jefferies & Been (2006)

K_0 coefficient earth at rest

K_c correction factor of fines content

K_D dilatometer horizontal stress index

K_{DR} factor to correct the effect of aging

$\mathrm{k_h}$ dilatometer coefficient of permeability

LCD Liquid Crystal Displays

LL Liquid Limit

m rigidity specific coefficient proposed by Jefferies & Been (2006)

M earthquake magnitude.

M compression modulus of the membrane material

MCC Modified Chinese Criteria

$\mathrm{M_{DMT}}$ dilatometer vertical drained constrained modulus

MPU *M*icroprocessor Unit

MSF Magnitude Scaling Factor

n exponent that varies with soil type

NCEER National Center for Earthquake Engineering Research

NSF National Research Foundation

OCR Overconsolidation Ratio

p_0	dilatometer corrected first reading
p_1	dilatometer corrected second reading
P_a	1 atm of pressure
PGA	Peak horizontal Ground Acceleration
PGV	Peak Ground Velocity
PL	Plastic Limit
Q	normalised parameter of tip resistance
q_c	field cone penetration resistance measured at the tip.
q_{c1N}	normalised penetration resistance
$q_{\mathrm{c1N,cs}}$,	equivalent clean sand normalized tip resistance,
q_D.	penetration resistance of dilatometer blade
Q_p	dimensionless cone resistance based on mean stress
RAM	Random Access Memory
r_d	stress reduction coefficient/factor
S	ground settlement
SASW	Spectral Analysis of Surface Waves
SPT	Standard Penetration Test
t	age or time since initial soil deposition or last critical disturbance
T	wave transmission
TL	termoluminescence
TUK	the accelerogram at Mt. Osmond, Adelaide
U_0	pre-insertion pore water pressure
USCS	Unified Soil Classification System
V_s	shear wave velocity
V_sr	shear wave velocity of the bedrock
z	depth below the surface

γ_{soil}	total unit weight of soil
ρ	soil mass density
ψ	in-situ state parameter

p.i: Line 19 should read:
... (1989) and Marchetti (1997), claimed that the *DMT* is able to capture the ageing effect of ...

p.3: Line 15 should read:
... originally by Schnabel et al. (1972) and *EERA* by Bardet et al. (2000). For the ...

p.4: Line 22 should read:
... (Schnabel et al., 1972) and *EERA* (Bardet et al., 2000). The results of the site-specific ground ...

p.10: Last line should read:
... dilative behaviour or a strain hardening response. Although cyclic mobility can occur slightly below the normalising state parameter, ψ is an important parameter to detect liquefaction flow, which often causes disastrous failures on structures (Martin & Lew, 1999).

p.12: Line 12 should read:
... less than approximately 10% clay-size fines (< 0.002 mm), and a liquid limit (*LL*) in the ...

p.12: Line 14 should read:
... with more than approximately 10% clay-size fines and a *LL* more than or equal to 32% are ...

p.13, Table 2.1: The correct table is:

Liquid Limit[1] / Clay-size Content [2]	Liquid Limit[1] <32%	Liquid Limit[1] ≥32%
Clay-size Content [2] <10%	Susceptible	Further Studies Required (Considering plastic non-clay sized grains - such as Mica)
Clay-size Content[2] ≥ 10%	Further Studies Required (Considering non-plastic clay sized grains – such as mine and quarry tailings)	Not Susceptible

Notes:
[1]Liquid limit determined by Casagrande-type percussion apparatus.
[2]Clay-size content defined as grains finer than 0.002 mm.

p.15: Line 16 should read:
... cyclic loading (Glaser & Chung, 1995). Moreover, obtaining high quality undisturbed sandy samples is difficult and costly. Thus, in-situ testing is very useful and usually ...

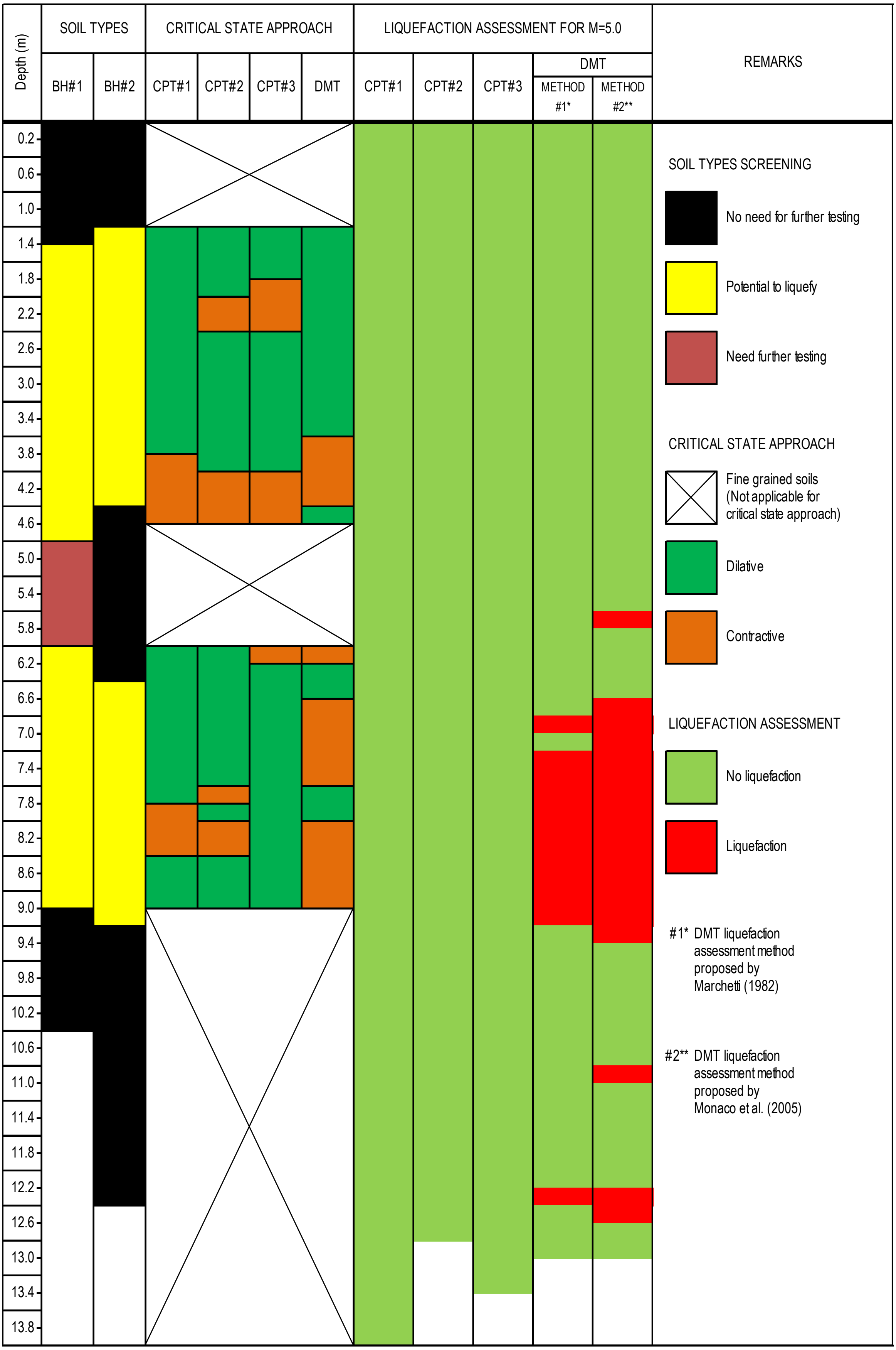
p.175: Line 6 should read:
... 6.4, 6.5 and 6.6 to depict the impact of different magnitude of earthquake at study site. As seen in the plots, the *CSR* values increase when the earthquake...

p.180: Line 2 to 3 should read:
... (identified by green shading) occurs at a depth of approximately 2.2 m; (2) the layer which exhibits the highest impact during an earthquake is the layer at a ...

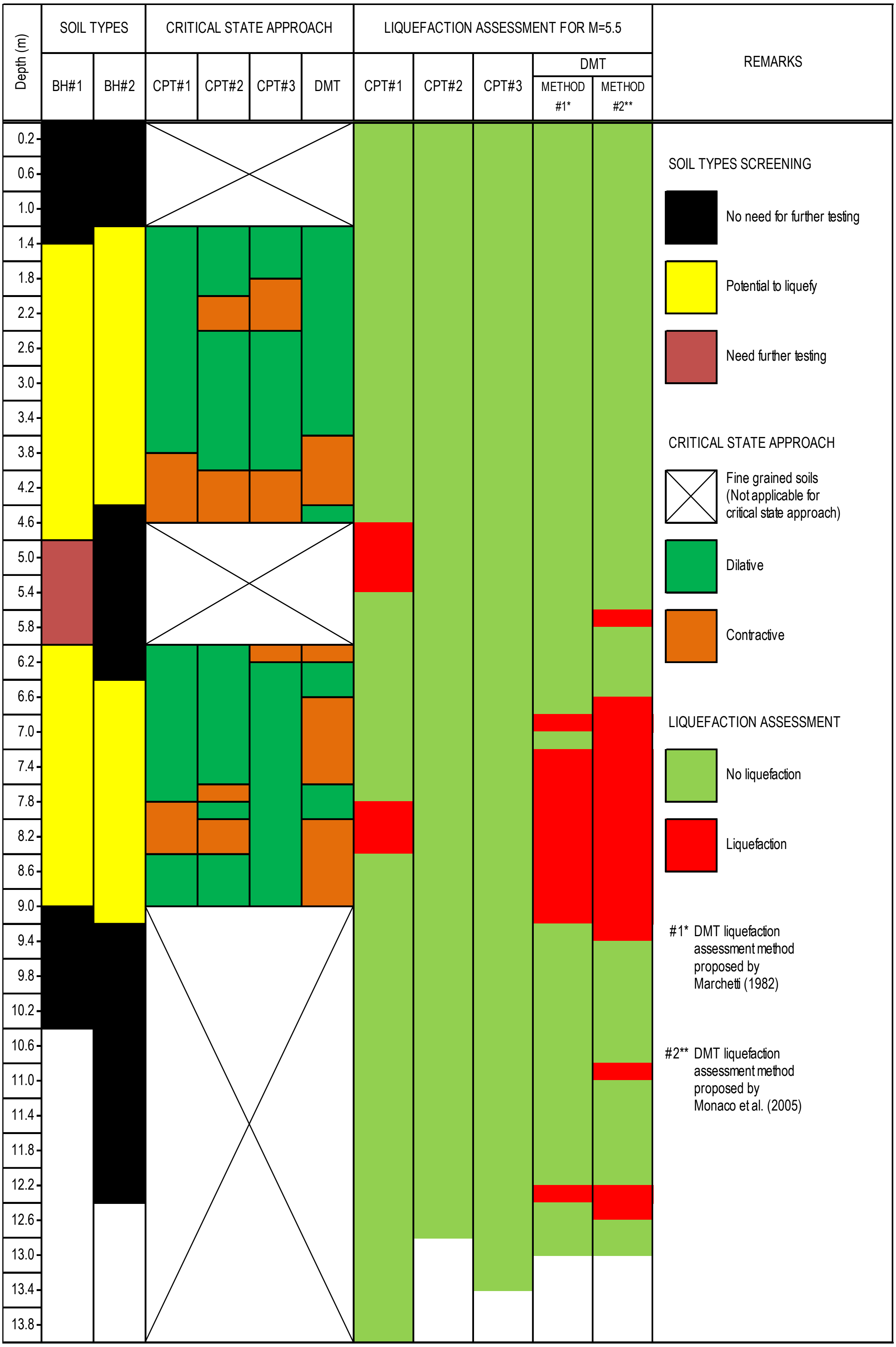
p.180: Line 5 to 6 should read:
... shading); and (3) an increase of 0.5 in earthquake magnitudes causes a rise of the thickness by a factor of 1.5.

p.181: Line 1 should read:
... highest impact during an earthquake is a layer at a depth of between 7.8 to 9.8 m ...

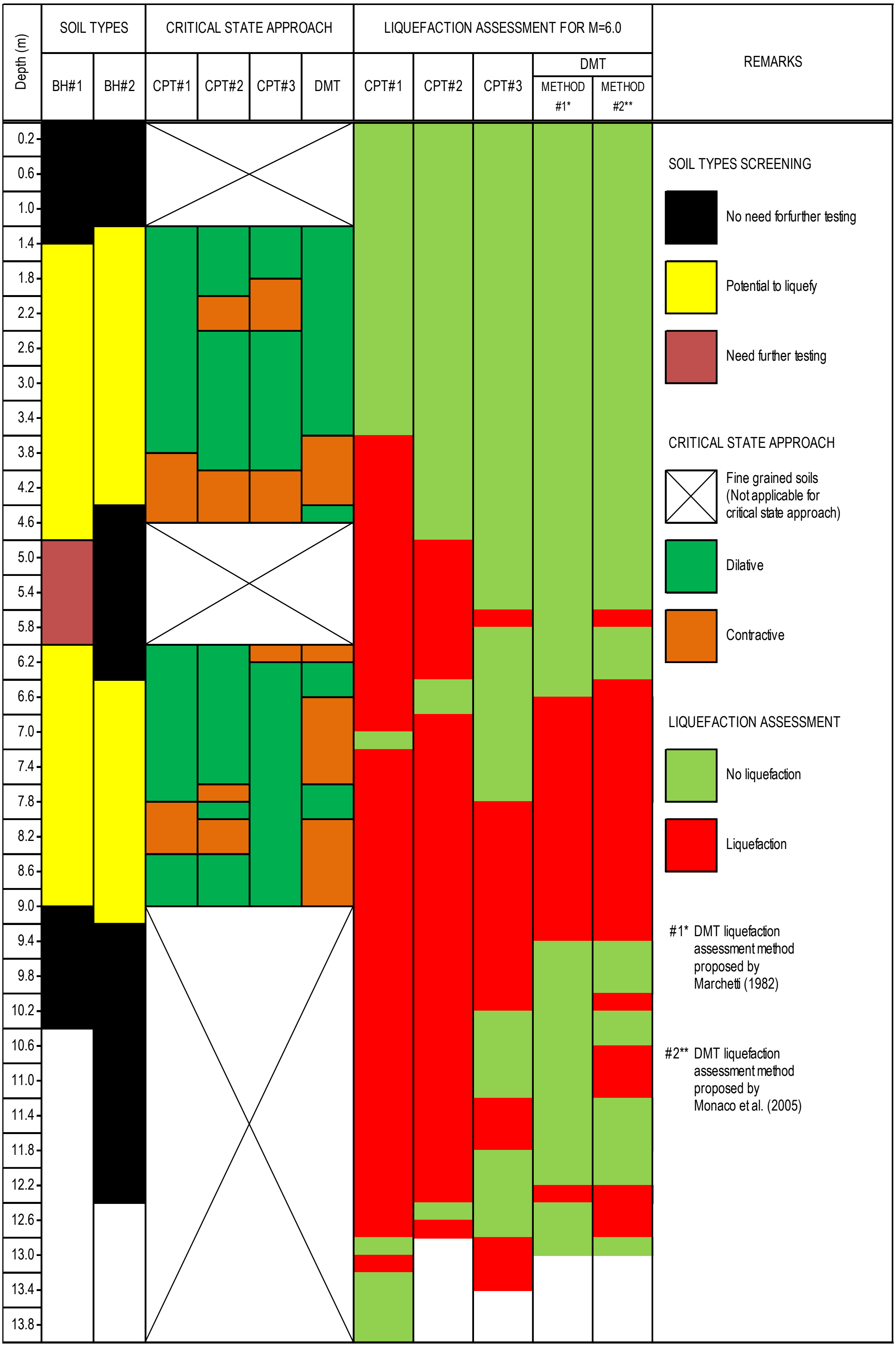
p.202, Table 6.9: The correct table is:



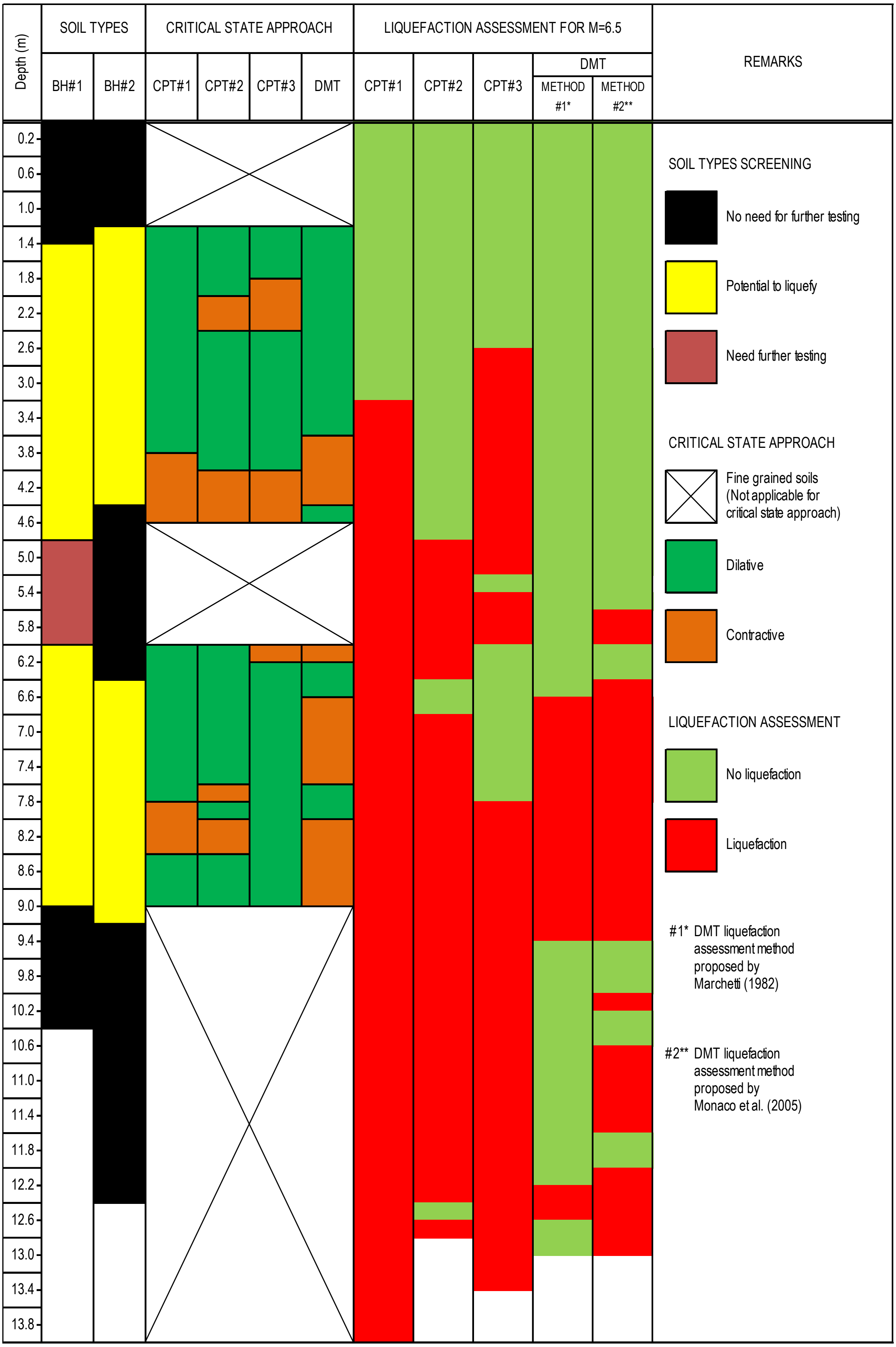
p.203, Table 6.10: The correct table is:



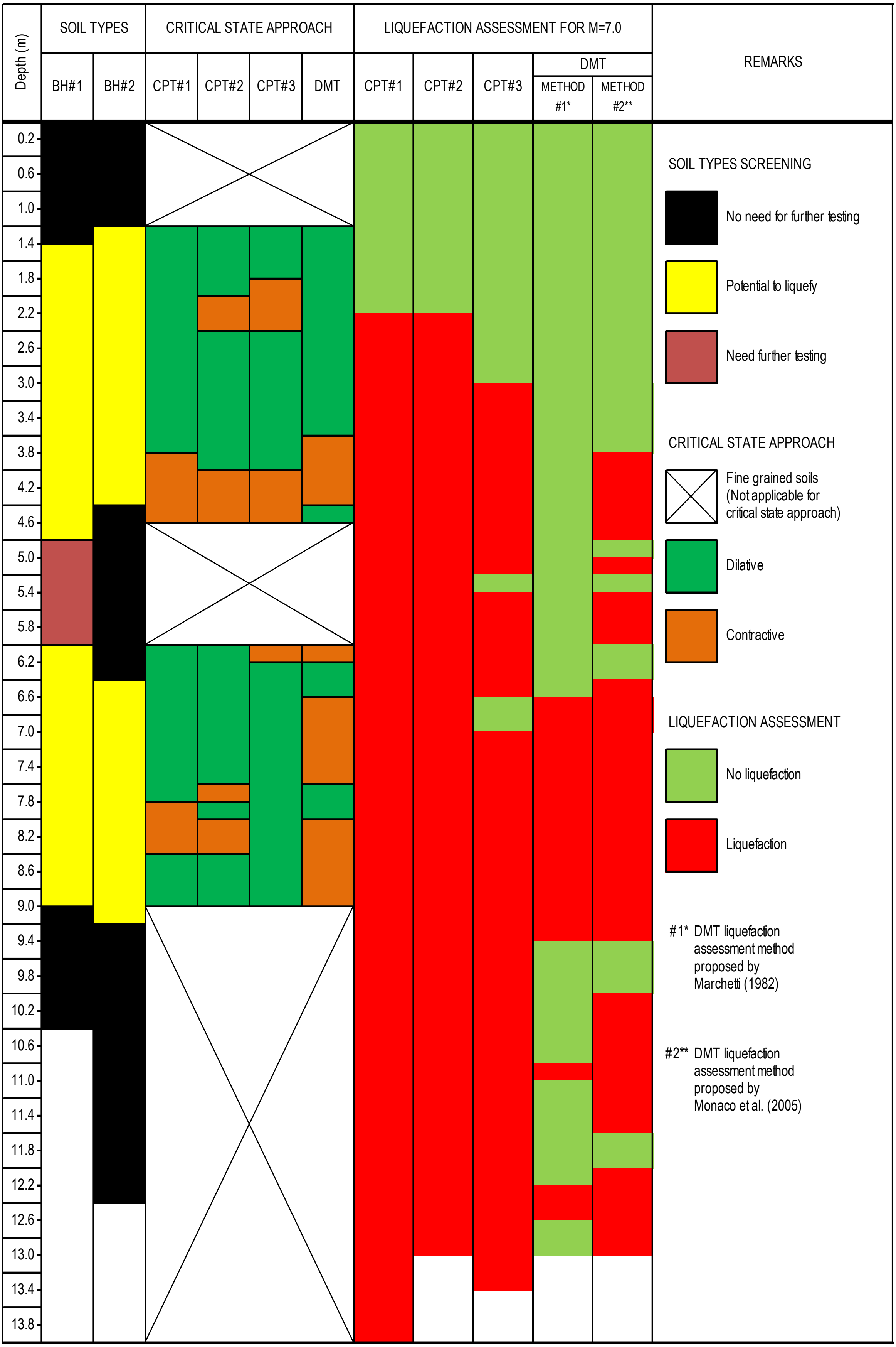
p.204, Table 6.11: The correct table is:



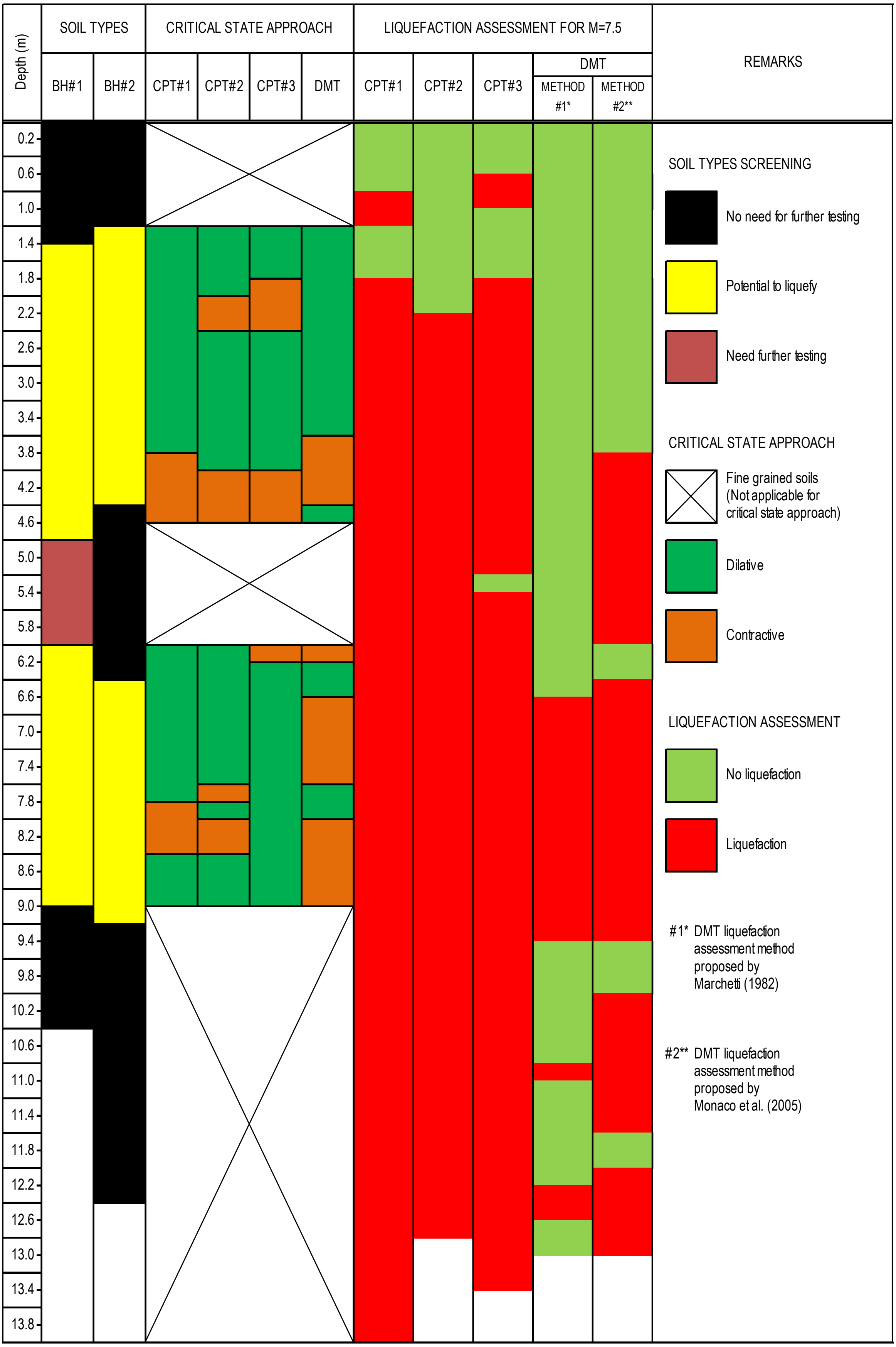
p.205, Table 6.12: The correct table is:



p.206, Table 6.13: The correct table is:



p.207, Table 6.14: The correct table is:



p.216: Line 5 should read:
... specific ground response analysis using the *SHAKE91* (Schnabel et al., 1972) and *EERA*...

p.216: Line 6 should read:
... (Bardet et al., 2000) techniques. The results of the site-specific ground response analysis ...

p.223: Line 28 should read:
... properties of a stiff, overconsolidated clay. Ph.D. Thesis, Faculty of Engineering, The University of Adelaide, Adelaide, 469pp.

p.224: Lines 19 to 20 should read:
... penetrometer tests to estimate settlements of shallow footing on calcareous sand. *Proceedings 7th Australia-New Zealand Conference on Geomechanics,* Adelaide, pp. 909 - 914.

p.227: Lines 15 to 16 should read:
... conventional field testing. *Proceedings 2007 Conference on Earthquake Engineering in Australia*. Australian Earthquake Engineering Society, Paper No. 40, Wollongong, November.

Chapter One

INTRODUCTION

1.1 INTRODUCTION

Liquefaction is the transformation of coarse-grained soil from a solid state into a liquid state as a consequence of hydrostatic pressure build-up owing to the application of either a sudden shock or cyclic loading (Chaney & Pamukcu, 1990; Youd et al., 2001), such as that caused by earth tremors, water flow or sudden loading (Barker, 1981). The soil layer softens as liquefaction occurs, allowing large cyclic deformations to arise. Generally, the softening of the soil stratum is also accompanied by loss of shear strength that possibly will lead to large shear deformations, ground oscillation or even flow failure (Youd et al., 2001). This phenomenon has devastating effects on structures in many parts of the world (Greene et al., 1994; Power & Holzer, 1996), causing the tilting of high rise buildings, subsidence, surface rupture and subway collapse (Piya, 2004; Sonmez et. al., 2008).

Liquefiable soils are loose particulate materials, such as silt, sand and gravel which are very difficult to sample in order to provide representative undisturbed specimens for laboratory testing (Glaser & Chung, 1995). Since loose soils are often densified on sampling and handling, laboratory measurement of cyclic strengths are higher than in-situ testing values (Ishihara, 1985 and Peck, 1979, cited by Glaser & Chung, 1995). Therefore, in-situ testing is preferred for liquefaction susceptibility prediction (Kulasingam et al., 1999; Martin & Lew, 1999) rather than laboratory testing. Moreover, in-situ testing offers a better opportunity to investigate soil structure, dealing with the arrangement of particle groups, including particle sizes, inclusions and discontinuities (Johnston, 1983). In addition, there are several soil characteristics which are impossible to model in the laboratory, such as the age of the soil profile, the degree of consolidation and cementation, and the strain history, which affects the potential of a soil to liquefy under cyclic loading (Glaser & Chung, 1995).

Several procedures utilising in-situ testing have been developed to assess the liquefaction potential of soils (Andrus et al.,1999; Youd et al., 1998). Each method has its own advantages and limitations in terms of the number of test measurements at the liquefaction site, the capability of the in-situ testing and the measured test parameters (Youd et al., 1998). The US National Center for Earthquake Engineering Research (*NCEER*) has identified the electrical cone penetration test (*CPT*) as an excellent in-situ testing method for geotechnical site characterisation for the evaluation of soil liquefaction. Conversely, Sladen (1989), Yu et al. (1997), Robertson and Wride (1998) and Marchetti (1999, cited by Totani et al., 2001) warned that *CPT*-based cyclic resistance ratio (*CRR*) estimation, used in liquefaction assessment, might include errors because the cone is not sensitive to the age of sand deposits. Instead, these authors proposed the use of the flat dilatometer test (*DMT*). Totani et al. (2001) indicated that the *DMT* horizontal stress index parameter, K_D, is influenced by soil age. Marchetti (1982) (cited by Robertson & Campanella, 1986) found that K_D appears to rise with increased age, cementation and stress history. However, Robertson & Campanella (1986) suggested that the correlation between *CRR* and the horizontal stress index, K_D, for liquefaction assessment requires considerable field verification and is not recommended for silts.

In 2008, Hayati et al. analysed data from over 30 sites in five countries and proposed an ageing correction factor, K_{DR}, to incorporate the ageing effect into the *CPT-CRR* value. They recommended this factor for correcting the liquefaction resistance for aged sand deposits. Since Hayati et al.'s research there has been no justification or comparison of a *CPT* method that incorporates ageing with other in-situ testing, such as *DMT*. This lack of follow up research led to the research undertaken and reported here.

In summary, currently *CPT* and *DMT* in-situ testing have limitations in terms of liquefaction assessment, particularly if soil ageing is included in the liquefaction evaluation. The research presented here was undertaken to compare the reliability of liquefaction assessments derived from a state-of-the-art *CPT* method incorporating ageing and *DMT* procedures.

1.2 AIMS AND SCOPE OF RESEARCH

This research has focused on the evaluation of soil liquefaction utilising the *CPT* incorporating ageing and *DMT* in-situ testing methods. The results of this research will provide a better understanding of the *CPT* incorporating ageing and *DMT*-based methods on liquefaction assessment. In addition, the techniques proposed in this research will enable engineers to justify necessary actions for liquefaction assessment.

In order to achieve the overall aim of this research, several specific aims or steps were undertaken, as summarised below:

1. Site investigation using *CPT* and *DMT* in-situ testing was undertaken at very close proximity points, to enable appropriate cross comparison to be made. The distance and position of each test was arranged in such a way as to ensure that the disturbance due to the penetration of one test did not adversely affect the other, as well as to minimise any appreciable change in the nature of the soil. In addition, soil samples were taken continuously to allow visual inspection and perform laboratory testing.

2. Site-specific ground response analysis was conducted to establish the most influential parameter affecting cyclic stress ratio (*CSR*), i.e. peak ground acceleration. This ground response analysis was carried out using the computer program *SHAKE91*, developed originally by Schnabel (1972) and *EERA* by Bardet and Ichi (2000). For the liquefaction assessment, the results of the site-specific ground response studies were used to develop the *CSR* values that could be used for predicting the liquefaction potential of soils.

3. A laboratory-based technique, using critical state parameters, was used as an independent means of examing the reliability of the liquefaction assessments. The technique was suggested by Jefferies & Been (2006). The critical state parameters were measured using a simple critical state parameter (*CS*) test proposed by Santamarina & Cho (2001).

4. Liquefaction assessment using *CPT* incorporating aging effects and *DMT* procedures were undertaken. A comparison between both procedures was also carried out. Re-examination using the critical state approach was conducted. In addition, the results of the liquefaction assessment were used to predict the manifestation of liquefaction and its effect with respect to the ground surface settlement of the study location.

1.3 ORGANISATION OF THE THESIS

The state-of-the-art *CPT* and *DMT* in-situ testing has its own usefulness and limitations for liquefaction assessment, particularly if soil ageing is taken into account in the liquefaction evaluation. This research was undertaken to compare the reliability of liquefaction assessments derived from both procedures.

In **Chapter 2**, the existing literature is reviewed regarding the liquefaction phenomenon, the critical state parameter, the types of liquefiable soils and state-of-the-art liquefaction assessment utilising the cone penetration test (*CPT*) and the flat dilatometer test (*DMT*). This includes the basic, necessary equipment, the standard operational procedure, application and data interpretation, and determination of the cyclic resistance ratio (*CRR*). The influence of ageing on liquefaction, such as particle cementation and re-arrangement, is also presented. In addition to this literature review, determination of the age of a soil deposit and its influence on *CRR* are reviewed.

In **Chapter 3**, the existing data, including the conditions of the study location, such as soil profile/soil stratigraphy, geological history, geotechnical characteristics, and an overview of the experimental program are discussed. This chapter also provides details of the field and laboratory testing, including layout, equipment and methods. The general results obtained from the field and laboratory tests are presented.

In **Chapter 4**, the method of obtaining the most influential parameter of cyclic stress ratio (*CSR*) (i.e. peak ground acceleration) by performing site-specific ground response analysis is discussed. This ground response analysis was carried out using *SHAKE91* (Schnabel 1972) and *EERA* (Bardet & Ichi, 2000). The results of the site-specific ground response studies were used to establish the *CSR* values for predicting the liquefaction potential of the soils, as described in Chapter 6.

In **Chapter 5**, the simple critical state parameter test (*CS*) for six selected and applicable samples is described. The results are used to estimate the in-situ state parameter as proposed by Jefferies & Been (2006) for the *CPT* and Yu (2004) for the *DMT* data.

In **Chapter 6**, the *CSR* and *CRR* at the study site are examined using the results presented in Chapters 3 and 4. The effect of the age of the soil on *CRR*-*CPT* is described. A comparison between both procedures is offered. The soil types and critical state parameter approach for verifying the results of liquefaction assessment using the *CPT* method incorporating ageing effects are described, as are the *DMT* procedures. In addition, the manifestation of liquefaction and its effect with respect to settlement at the ground surface of the study site are investigated. Finally, a summary and the conclusions of the research, as well as areas for future research, are presented in **Chapter 7**.

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Chapter Two

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter explores the liquefaction mechanism, the theory of the liquefaction process, the critical state line and state parameter, the types of liquefiable soils, and reviews the *CPT* and *DMT* methods of liquefaction assessment using the simplified procedures proposed by Seed and Idriss in 1971. The discussion includes all the associated variables, such as peak ground acceleration (*PGA*), stress reduction factor and the magnitude scaling factor (*MSF*). In addition, the influence of ageing on liquefaction and the effect of liquefaction are presented.

2.2 LIQUEFACTION

Liquefaction is the process of transforming a solid state material into a liquid state (Brown, 1993) as a result of an abrupt excessive hydrostatic build-up (Chaney & Pamukcu, 1991; Youd et al., 2001) and effective stress reduction (Committee on Soil Dynamics, 1978, cited by Youd, 2003). The build-up of pore pressure can momentarily reach the in-situ confining stress and, as the pore water pressure approaches a value equal to the applied confining pressure, the soil begins to undergo deformation (Pyrah et al., 1998). The resulting deformation can be large enough to constitute failure (Robertson et al., 1992, cited by Pyrah et. al., 1998). This is the case with loose soils, when pore water pressure increases suddenly to a value equal to the applied confining pressure, and an unlimited deformation occurs (Chaney & Pamukcu, 1991).

2.2.1 Liquefaction mechanism

In general, soil liquefaction is frequently associated with large earthquakes (Rauch, 1997). As the seismic waves propagate through saturated granular sediment deposits, they induce cyclic shear deformation, which causes the collapse of loose particulate structures. A mesoscale, liquefaction mechanism is illustrated in Figure 2.1. As the collapse occurs, the particle arrangement is disturbed and, for granular loose sediments, loads previously carried through particle-to-particle or intergranular contacts are transferred to the interstitial pore water.

This load shift generates an increase in pressure exerted on the soil particles by the water in the voids and the consequence is a reduction in the intergranular or effective stress. Since pore water pressures rise as the sediment layer softens, greater deformation results and the rate of collapse of particulate structures is accelerated. If the pore pressure reaches its confining stress, the effective stress drops to zero and the deposit begins to behave as a viscous liquid rather than as a solid. Thus, liquefaction has occurred (Youd, 2003).

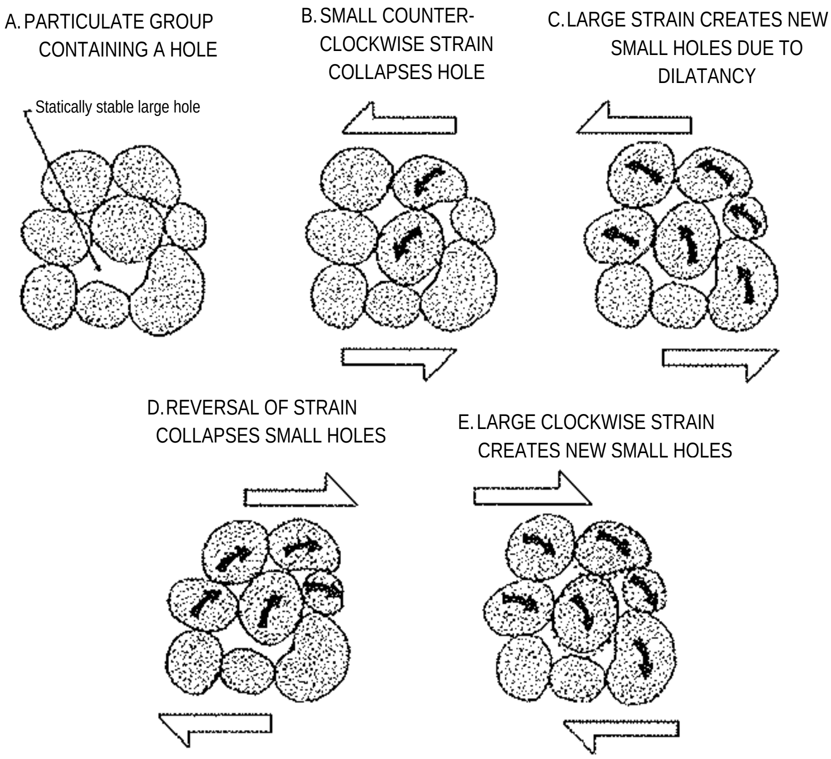

Figure 2.1 Schematic of liquefaction mechanism at the mesoscale (Youd, 2003)

Maltman and Bolton (2003) described this liquefaction as a process of sub-surface sediment mobilization where sensitive sediments behave mechanically akin to a fluid. Furthermore, this process is likely to occur in loose saturated soil deposits at effective confining pressures between 1 and 5 MPa (Maltman & Bolton, 2003) as a consequence of elevating their pore water pressure without adequate response to dissipate it (Chaney & Pamukcu, 1991; Youd et al., 2001). Thus, wherever excess pore water pressure arises during deposition, the sediment is weakened and the possibility of undergoing mobilization arises (Maltman & Bolton, 2003).

In addition, Maltman and Bolton (2003) described a basic liquefaction mechanism at a macroscale. Their macroscale schematic liquefaction mechanism, incorporating a relationship between porosity and effective stress, is illustrated in Figure 2.2.

Figure 2.2 Schematic diagram of liquefaction mechanism in macroscale (Maltman & Bolton, 2003)

Figure 2.2 shows that an incompletely lithified or loose sediment, e.g. point A, will be consolidated normally if the sediment's intrinsic drainage is sufficient to keep pace with increasing total load, following a line such as A-C. If drainage is prohibited, the total load is borne by the pore fluid and then the sediment will decrease in volume and tend to deform pervasively until it reaches the critical state as at path A-B. This deformation process is defined as liquefaction (Maltman & Bolton, 2003). On the other hand, a dense sediment, e.g. at point D, will increase in volume when it is sheared. The dense sediment tends to shear along discrete surfaces until it achieves the critical state, following a path such as D-B. This dense sediment is usually over-consolidated and completely lithified. Line C-D is an unloading path. There is little regain in porosity upon unloading.

2.2.2 A critical state line and state parameter in soil liquefaction

An essential finding related to the liquefaction process was first introduced by Casagrande in 1936 when he described the effect on soil volume that would result from a change in shear stress (Altaee & Fellenius, 1994). Utilising direct shear tests, Casagrande found that loose sands contract and dense sands dilate until approximately the same void ratio is reached at large strains (Jefferies & Been, 2006). Further research incorporating Casagrande's findings with particular reference to liquefaction was undertaken by several researchers. The next milestone was the development of the *steady state concept* by Poulos (1981), who defined the steady state concept as the state in which the soil mass is continuously deforming at constant volume, constant normal effective stress, constant shear stress, and constant velocity.

The important postulation in the steady state concept is that when a soil mass is strained in an undrained condition, at some point it will reach steady state deformation in which the shear resistance becomes constant and is the lowest value that a contractive soil mass can have at its particular void ratio (Castro et al., 1992). The end of this continuous deformation is known as the critical state (Jefferies & Been, 2006). Every soil mass has a unique critical state surface in void ratio – effective stress space (Wang & Sassa, 2002). This critical state surface separates non liquefiable (dilative) from liquefiable (contractive) behaviour within a non-cohesive soil mass (Pyrah et al., 1998).

The boundary separating these two different types of behavior, the critical state surface, is typically identified using consolidated, undrained monotonic triaxial tests, as the steady state of granular soils occurs after liquefaction of the sample has been induced (Altaee & Fellenius, 1994). Figure 2.3 shows the typical results of a series of tests performed on samples at differing initial confining stresses and densities plotted as a function of void ratio (e) and log effective confining stress, and incorporating a normalizing state parameter, ψ, proposed by Jefferies & Been (2006). Jefferies & Been (2006) explained that the state parameter is used to distinguish between the initial void ratio and critical state void ratio at the same confining stress. A positive state parameter value implies contractive behaviour or liquefaction risk, whereas a negative state parameter suggests dilative behaviour or a strain hardening response.

In the context of Figure 2.3, the initial soil condition is either loose or dense depending upon whether it is plotted above or below the line. Dense soils have a negative ψ and will dilate when sheared, whereas loose soils have a positive ψ and will contract (Kolymbas, 1998; Jefferies & Been, 2006). Furthermore, Jefferies & Been (2006) claimed that the state parameter, ψ, is able to capture the most important aspects of liquefaction in all its forms and express the soil behaviour regardless of soil type, fines content and age effects.

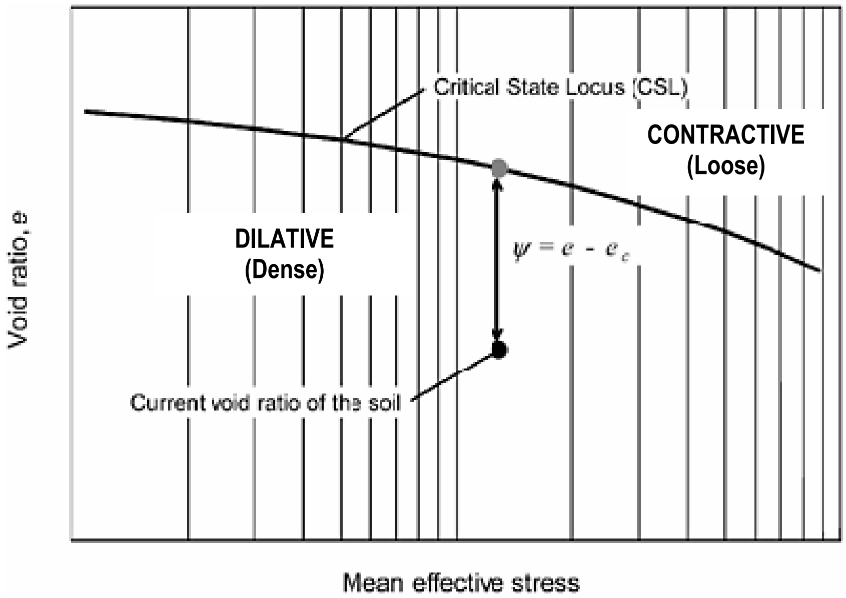

Figure 2.3 Diagrammatic of a critical state line and definition of state parameter ψ (Jefferies & Been, 2006)

The drainage condition of a soil mass contributes to its behaviour. As a soil mass is sheared under drained conditions, the soil will contract or dilate until its state reaches the critical state surface and further shearing causes no additional change in volume/void ratio. However, when it is sheared under undrained conditions, loose soils move towards the critical state surface by decreasing their effective stress or increasing pore water pressures (Seed, 1999). Jefferies & Been (2006) later stated that it is not necessary to have undrained conditions for soils to liquefy after they found that liquefaction occurred at the Lower San Fernando Dam.

2.2.3 Liquefiable soil types

Relatively loose granular soils with few fines are potentially susceptible to liquefaction, while fine-grained soils, such as silts and clays, are considered non-liquefiable. The most widely used method for defining potentially liquefiable soils based on soil types over the past two decades has been the modified Chinese criteria (Seed et al., 2003). Furthermore, Youd (2003) stated that the modified Chinese criteria (*MCC*) provide generally conservative predictions of liquefaction behaviour. The *MCC* state that fine (cohesive) soils, plot above the A-line, are potentially liquefiable if: (1) the fine particles are less than 0.005 mm in the Chinese definition, and form less than or are equal to 15% of the soil content; (2) the liquid limit is less than or equal to 35%; and (3) the current in-situ water content is greater than or equal to 90% of the liquid limit (Figure 2.4).

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Figure 2.4 Modified Chinese criteria (Seed et al., 2003)

Andrews and Martin (2000) converted the *MCC* into American society for testing and materials (*ASTM*) standards as there is a different size criterion for fines material between *ASTM* and the Chinese standard. In *ASTM*, fines material is defined as those particles less than 0.002 mm, rather than the 0.005 mm used in the Chinese standard. Their results are summarized in Table 2.1. According to Andrews and Martin (2000): (1) soils that have less than approximately 10% clay fines (< 0.002 mm), and a liquid limit (*LL*) in the minus #40 sieve fraction of less than 32%, should be considered potentially liquefiable; (2) soils with more than approximately 10% clay fines and a *LL* more than or equal to 32% are unlikely to be susceptible to classic cyclically-induced liquefaction; and (3) soils that measure in between these criteria should be assessed as to whether they are potentially liquefiable.

In fact, there have been significant findings of fine grained soils that have liquefied and there are a number of well-documented field cases of liquefaction of coarse gravelly soils (Prakash & Puri, 2003). Two major earthquakes in 1999 in Turkey and Taiwan provided considerable new field data about liquefaction. Extensive soil liquefaction occurred throughout the city of Adapazari in the 1999 Kocaeli (Turkey) earthquake, and the cities of Wu Feng, Yuan Lin and Nantou in the 1999 Chi-Chi (Taiwan) earthquake (Seed et al., 2003).

Table 2.1 Liquefaction susceptibility of silty and clayey sands (Andrews & Martin, 2000)

Damage, such as settlement and the loss of bearing capacity, occurred at sites where the soil appeared to be more cohesive than had been expected based on the *MCC*. A liquefaction assessment of the areas affected by both earthquakes conducted by Seed et al. (2003) suggested that: (1) soils with higher plasticity might be susceptible to significant cyclic pore pressure increase and consequent loss of strength than is suggested by the *MCC*; and (2) there is a gradual transition in behaviour to soils of even higher plasticity, which are unlikely to be prone to similarly severe cyclic pore pressure generation and strength loss. Thus, dramatic changes in both understanding and practice are occurring.

A number of researchers [e.g. Bray et al. (2001), Sancio et al. (2002), and Sancio et al. (2003)] stated that the *MCC* is flawed and misleading. They argued that it is not the percent of finer particles that is important, but their activity or behaviour. For example, fine quartz particles may be smaller than either 2 or 5 mm, but as largely nonplastic, quartz soils respond as a cohesionless material in terms of liquefaction under cyclic loading.

Seed et al. (2003) presented provisional recommendations for identifying soils prone to liquefaction, suggesting that: (1) Soils within Zone A be considered potentially susceptible to cyclically induced liquefaction; (2) Soils within Zone B may be liquefiable; and (3) Soils in Zone C (not within Zones A or B) are not generally susceptible to cyclic liquefaction, but should be checked for potential sensitivity.

Figure 2.5 Recommendations regarding assessment of liquefiable soil types (Seed et al., 2003)

In detail, Seed et al. (2003) explained that in the case of coarser grained soils, such as gravel, particle behaviour is different from the behaviour of soils with finer grains. In terms of resisting liquefaction, the coarser grained soils have advantages in two ways: (1) coarse, gravelly soils can be much more pervious, and so they can rapidly dissipate cyclically-generated pore pressures; and (2) due to the mass of their larger particles, the coarse gravelly soils are seldom deposited "gently" and so do not often occur in very loose states, as is more often the case with finer sandy soils.

However, the apparent drainage advantages of coarse, gravelly soils can be negated if their drainage potential is circumvented by either: (1) their being surrounded and encapsulated by finer, less pervious materials; (2) if drainage is internally impeded by the presence of finer soils in the void spaces between the coarser particles (it should be noted that the D_{10} particle size, not the mean or D_{50} size, most closely correlates with the permeability of a broadly graded soil mix); or (3) if the layer or stratum of coarse soil is of large dimension, so that the distance over which drainage must occur (rapidly) during an earthquake is large. In these cases, coarse soils should be considered to be potentially liquefiable, and should be evaluated accordingly.

2.3 ASSESSING LIQUEFACTION POTENTIAL OF SOILS

As mentioned earlier, liquefaction has devastating effects on structures (Greene et al., 1994; Power & Holzer, 1996), such as the tilting of high rise buildings, subsidence, surface rupture and subway collapse in places such as Kathmandu Valley, Chi Chi, Taiwan, Izmit (Kochaeli), Turkey and Kobe (Japan), for example (Piya, 2004; Sonmez et al., 2008). It requires significant engineering to manage the risks posed by this hazard so that the benefits achieved are acceptable in terms of effectiveness and cost. Beaulieu and Olmstead (1999) stated that the only way to reduce the vulnerability of structures to the hazard of liquefaction was to characterise and identify the hazard prior to construction since mitigation strategies might not be effective, given the fact that hazardous soil behaviour and the distribution of potentially liquefiable soils are not fully understood. Therefore, an evaluation of the liquefaction potential of soils is a crucial initial step for preventing casualties and losses in earthquake prone regions (Andrus et al., 1999).

The current state-of-the-art in liquefaction susceptibility prediction involves in-situ testing (Kulasingam et al., 1999; Martin & Lew, 1999) rather than laboratory testing because the former takes account of soil structure, since an actual site will normally consist of soils of all different particle sizes, inclusions and discontinuities (Johnston, 1983). In addition, there are several soil characteristics which are impossible to model in the laboratory, such as the age of the soil profile, the degree of consolidation and cementation, and the strain history, which affect the potential of a soil to liquefy under cyclic loading (Glaser & Chung, 1995). Thus, in-situ testing is very useful and usually preferred in liquefaction evaluation.

The most common procedure around the world for evaluating liquefaction resistance is the “simplified procedure”, developed originally by Seed and Idriss (1971). The simplified procedure is based on empirical considerations and has provided useful methods for identifying the liquefaction potential of soils. Youd et al. (1998) explained that using the simplified procedure, estimation of two primary seismic variables is required to evaluate liquefaction resistance in soils. The variables are the seismic demand placed on a soil layer, expressed as the cyclic stress ratio (*CSR*), and the capacity of a soil layer to resist liquefaction, expressed as the cyclic resistance ratio (*CRR*).

2.3.1 Simplified procedures for evaluation of cyclic stress ratio (*CSR*)

The cyclic stress ratio (*CSR*) is a measure of the intensity of cyclic loading during an earthquake. In analysing an earthquake, vibration at a particular depth in a soil deposit can be expressed with *CSR* obtained using a formula developed by Seed and Idriss in 1971 (Youd et al., 1998; Andrus et al., 1999; Finn, 2001):

$$CSR_{M=7.5} = \left(\tau_{av} / \sigma'_{vo}\right) = 0.65\left(a_{\max} / g\right)\left(\sigma_{vo} / \sigma'_{vo}\right) r_d \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.1a)$$

where a_{max} is the peak horizontal acceleration at the ground surface generated by the earthquake; g is the acceleration due to gravity; σ_{vo} and σ'_{vo} are total and effective vertical overburden stresses, respectively; and r_d is a stress reduction coefficient/factor at the depth of interest. Equation 2.1a has been modified by Hwang et al. (2004) and Idriss and Boulanger (2004) to take into consideration the duration effect of different earthquake magnitudes, *MSF (M)*, as follows:

$$CSR_{M=7.5} = \left(\tau_{av} / \sigma'_{vo}\right) = 0.65\left(a_{\max} / g\right)\left(\sigma_{vo} / \sigma'_{vo}\right) r_d \ / \ MSF(M) \ \ldots\ldots\ldots\ldots \ (2.1b)$$

2.3.1.1 Peak ground acceleration

In the simplified procedure analyses of liquefaction triggering a peak horizontal ground acceleration (*PGA*) is used to approximate the intensity of ground shaking (Youd et al., 2001). A site specific *PGA* can be estimated using one of two two basic approaches: deterministic and probabilistic (Martin & Lew, 1999; Lopez-Caballero & Modaressi-Farahmand-Razavi, 2010). In the deterministic approach, a specific magnitude and epicenter or distance to the site from an earthquake is determined beforehand. Subsequently, this scenario is used to compute the ground motion using applicable attenuation relations such as the attenuation relationship for a limited range of soft soil sites offered by Idriss in 1991 (Youd et al., 2001). Finally, a correction of ground motion variability is characterised by the standard deviation of the attenuation relation to either the median (50th percentile) or median-plus-one-standard-deviation (84th percentile) (Martin & Lew, 1999).

In a probabilistic approach, numerous potential earthquake magnitudes and locations believed to be related to all of the presumed sources are considered. Furthermore, the probabilistic approach considers the rate of earthquake occurrence, the probabilities of earthquake magnitudes, locations, and rupture dimensions and all possible ground motions for each earthquake and their associated probabilities of occurrence based also on the variability of the ground motion attenuation relation. Finally, probabilistic analysis is conducted using statistical models and a large number of calculations (Martin & Lew, 1999), followed by more elaborate probabilistic analyses using logic trees or Monte Carlo simulations to obtain the uncertainties in the seismic response (Martin & Lew, 1999; Lopez-Caballero & Modaressi-Farahmand-Razavi, 2010). The probabilistic approach yields a stochastic portrayal of how likely different levels of ground motion are at the specific site (Martin & Lew, 1999).

Even if the probabilistic approach is more representative than the deterministic one, Martin & Lew (1999) suggested that deterministic analyses are still useful provided their significance at a specific site is understood. In addition, the 1996 national center for earthquake engineering research (*NCEER*) and 1998 *NCEER/NSF* Workshops on the Evaluation of Liquefaction Resistance of Soils suggested several procedures for estimating the deterministic a_{max} at potentially liquefiable sites as follows:

- The first and most favoured method for estimating a_{max} is through empirical correlations of a_{max} with the presumed earthquake magnitude, distance from the presumed epicenter and the geological/geotechnical site conditions.

- In the second method, a_{max} may be estimated using computer programs such as *SHAKE* or *DESRA* or *EERA* from local site response analysis for sites that are not compatible with available attenuation relationships.

- The third and least desirable method for estimating a_{max} is through amplification ratios, as the ratios are influenced by strain level, earthquake magnitude and frequency content (Youd et. al., 2001).

In Australia, modeling the attenuation of earthquake risks such as *PGA* or peak ground velocity (*PGV*) is difficult due to incomplete earthquake data sets or the short history of earthquake observation (Gaull et al., 1990; Lam et al., 2003; Brown & Gibson, 2004) and the lack of quality instrumental earthquake data from close distances (Love et al., 1995; Lam et al., 2003). In addition, a number of important factors, such as the impedance ratio, i.e. the relationship between the high energy periods of bedrock motion and the periods of their upper layer, and the amount of damping in the soil layer contribute to the amplification of the incoming ground motion caused by the earthquake at specific sites (Finn, 2001; Finn & Wightman, 2003); and need to be considered when determining the value of ground motion in seismic assessment.

This amplification phenomenon was observed in damage patterns in Mexico City after the 1985 Michoacan earthquake, and major damage occurred on soft soil sites in the San Francisco–Oakland region after the 1989 Loma Prieta quake. The *PGA* of the incoming motions in rock during the Michoacan earthquake of generally less than 0.04 *g* were amplified about five times (Finn & Wightman, 2003) and the quake caused severe damage to structures. In the 1989 Loma Prieta earthquake, major damage occurred on soft soil sites in the San Francisco–Oakland region where the spectral accelerations were amplified from two to four times over adjacent rock sites (Housner 1989 cited by Finn & Wightman 2003).

Therefore, recognising the soil response of seismic ground motions is necessary in order to understand how the harmonic waves from the bedrock (Okamoto, 1973 cited by Finn & Wightman, 2003) are affected by the geometrical and geological structures of the softer surface deposits during wave transmission to the surface ($A=a_t/a_r$). The basic mechanism of amplification can be demonstrated by examining the effect of an undamped elastic surface layer on incoming bedrock motions as shown in Figure 2.6. This model considers a soil deposit as an elastic layer ($T = 4H/V_{ss}$) with a thickness, H, a shear wave velocity, V_{ss}, and a density, ρ_s. The shear wave velocity and density of the bedrock in the model are denoted by V_{sr} and ρ_r, respectively. Thus, κ, the impedance ratio, is $\rho_s V_{ss}/\rho r V_{sr}$; a_t is the surface acceleration; and a_r is the incoming bedrock acceleration to the upper layer.

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Figure 2.6 Elastic layer on elastic half-space (Finn & Wightman, 2003)

Finn & Wightman (2003) observed that most instruments for monitoring earthquakes are located on rock or stiff soil sites. As a consequence, they only provide a database of ground motions for such sites. In the case of softer sites, the motion of the bedrock or stiff soil beneath the soft overlying soil is estimated. Then the amplification of these motions at ground level is extrapolated. If the soil layer has a critical damping ratio, β_s, the amplification ratio, A, between the surface acceleration, a_t, and bedrock acceleration, a_o, is:

$$A = \frac{1}{\kappa + \beta_S \pi / 2} \quad \text{......(2.2)}$$

The amplification of earthquake waves in soft soil was studied by Idriss (1990) during the Loma Prieta earthquake and the result of the study is shown in Figure 2.7 (Finn, 2001; Finn & Wightman, 2003). The median curve for *PGA* on rock sites less than 0.2 *g* is based on data recorded during the 1985 Michoacan and the 1989 Loma Prieta earthquakes. For peak rock accelerations greater than 0.2 *g*, part of the median curve is based on one-dimensional site response analyses using the *SHAKE* computer program developed by Schnabel et al. in 1972 (Finn, 2001; Finn & Wightman, 2003).

The curve in Figure 2.7 shows that the bedrock accelerations were amplified in soft soils until the peak rock acceleration reached about 0.4 *g*. The increased nonlinearity of the soft soil response at the higher accelerations reduces the amplification ratios because of the increase in hysteretic damping and the reduction in effective shear moduli. The soils database used by Idriss (1990) varies significantly in its properties, and the sites from which the data were drawn vary in geological structure. The database is, therefore, too general to allow the curve to be used to estimate amplification factors at other sites encountered in practice (Finn & Wightman, 2003).

Figure 2.7 Amplification of ground motions in soft soils and associated rock sites (Idriss, 1990)

2.3.1.2 Stress reduction coefficient/factor

A stress reduction coefficient/factor, r_d, is a function of site stratigraphy and soil properties that accounts for the flexibility of the soil column (Idriss & Boulanger, 2004).

The parameter r_d also represents the characteristics of the input motions or excitations, for example, intensity and frequency content (Cetin et al., 2004; Idriss & Boulanger, 2004). The stress reduction coefficient r_d is a parameter describing the ratio of cyclic stresses in a flexible soil column to the cyclic stresses in a rigid soil column. It was originally proposed by Seed and Idriss (1971), and is illustrated in Figure 2.8. The stress reduction coefficient has a value of 1.0 at the ground surface, and tends to reduce with depth. It is also important to note that r_d does not vary linearly with depth, but instead may transition somewhat sharply, especially at boundaries of substrata of differing stiffness.

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Figure 2.8 Schematic for determine the stress reduction coefficient r_d (Idriss, 1999)

Seed and Idriss (1971) derived the following equations to calculate the stress reduction function for routine practice and non-critical projects. They were recommended as highly applicable and appropriate for the task by a panel of experts convened by the *NCEER* in 1996 (Youd et al., 1998; Youd, et al., 2001):

$$r_d = [1.0 - 0.00765z] \qquad z \le 9.2m \quad (2.3a)$$

$$r_d = [1.174 - 0.0267z] \qquad 9.2 < z \le 23m \quad (2.3b)$$

$$r_d = [0.744 - 0.008z] \qquad 23 < z \le 30m \quad (2.3c)$$

$$r_d = [0.50] \qquad z > 30m \quad (2.3d)$$

where z is the depth below the surface in metres of the location where the stress is being evaluated. The r_d versus depth curves based on these equations are plotted in Figure 2.9 (Youd et al., 1998).

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Figure 2.9 Stress reduction coefficient, r_d, versus depth developed by Seed & Idriss (1971, cited by Youd et al., 1998)

Figure 2.9 shows that the original average r_d values obtained from a range of earthquake magnitudes by Seed and Idriss (1971). The values range from 1 at the ground surface to about 0.85 at a depth of about 12 m. Unfortunately, the interval of ground surface to 12 m is the range of critical soil strata for salient liquefaction and non-liquefaction field performance case histories (Cetin et al., 2004). Furthermore, Idriss (1999) warned, the uncertainty in r_d increases with increasing depth, as illustrated in the graph.

A further comprehensive study to evaluate the variation of r_d by incorporating the earthquake magnitude was conducted by Golesorkhi in 1989 (Idriss, 1999). Extending this work, Idriss in 1999 performed a large number of parametric site response analyses in order to derive r_d as a function of depth and earthquake magnitude, M, (Idriss & Boulanger, 2004). The following relationships resulted from this work:

$$\ln(r_d) = \alpha(z) + \beta(z)M \qquad (2.4a)$$

$$\alpha(z) = -1.012 - 1.126\sin\left(\frac{z}{11.73} + 5.133\right) \qquad (2.4b)$$

$$\beta(z) = 0.106 + 0.118\sin\left(\frac{z}{11.28} + 5.142\right) \qquad (2.4c)$$

in which z is depth in metres and M is the moment magnitude. These equations are considered applicable to a depth, z, ≤ 34 m. If z > 34, the more appropriate expression is as follows:

$$r_d = 0.12\exp(0.22M) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (2.5)$$

Plots of calculated r_d using Equation 2.11 for M = 5½, 6½, 7½ and 8 incorporating the average of the range published by Seed and Idriss in 1971 are presented in Figure 2.10.

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Figure 2.10 Variation of r_d with depth and earthquake magnitude (Idriss, 1999)

Figure 2.10 indicates that the average of the range published by Seed and Idriss (1971) is in good agreement with the curve calculated using Equation 2.11 with M= 8 for depths shallower than about 4 m, but it transitions to the curve with M= 7½ for depths greater than about 8 m. This shows that the earlier r_d recommendations by Seed and Idriss (1971) understate the variance, and provide generally high estimates of r_d from the ground surface up to 12 m depth.

2.3.1.3 Magnitude scaling factor (*MSF*)

Most of the prominent liquefaction studies used a 7.5 earthquake magnitude in their analyses. Thus, a magnitude scaling factor, *MSF*, is necessary to adjust the induced *CSR* of an earthquake with magnitude M equivalent to the *CSR* of earthquake magnitude M=7.5 (Idriss & Boulanger, 2004). *MSF* represents the effects of the duration of the shaking or the equivalent number of stress cycles of defined magnitude. *MSF* is defined as:

$$MSF = CSR_M \,/\, CSR_{M=7.5} \quad \text{...} \quad (2.6)$$

Idriss and Boulanger (2004) explained that the values of *MSF* were derived by combining the: (1) relationship between the number of equivalent uniform cycles and earthquake magnitude, and (2) relationship between the *CSR* required to cause liquefaction and the number of uniform stress cycles resulting from laboratory cyclic testing. As noted earlier, collecting a representative sample of granular soil is very difficult. In 1999 Idriss re-evaluated his previous *MSF* derivation using higher quality samples obtained by frozen sampling techniques. The *MSF* relation produced by this re-evaluation was then expressed by Idriss (1999) as follows:

$$MSF = 6.9\exp\left(\frac{-M}{4}\right) - 0.058 \quad \text{..} \quad (2.7a)$$

$$MSF \leq 1.8 \quad \text{..} \quad (2.7b)$$

The values of *MSF* attained by Equation 2.7 are presented in Figure 2.11, together with those projected by other researchers to examine the relationship between them.

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Figure 2.11 Magnitude scaling factor, *MSF*, proposed by various researchers (Idriss & Boulanger, 2004)

The re-evaluated *MSF* values are greater than the previous *MSF* values proposed by Seed and Idriss (1982) and Seed et al. (2003). The other relationships proposed by Ambraseys

(1988) and Arango (1996) offer significantly larger *MSF* values for earthquake magnitudes $M < 7$, but these disparities are partly attributable to differences in the assumed r_d relationships (Idriss & Boulanger, 2004). Even if the *MSF* relationship by Idriss (1999) is limited to a maximum value of 1.8 at small earthquake magnitudes ($M \leq 5¼$), this relationship is recommended for use in practice as it includes the main features of dynamic soil behaviour (Idriss & Boulanger, 2004).

2.3.2 Simplified procedures for evaluation of cyclic resistance ratio (*CRR*)

Several procedures utilising in-situ testing have been developed to determine *CRR* (Youd et al., 1998; Andrus et al., 1999). Each method has its own benefits and disadvantages in terms of the number of test measurements at the liquefaction site, the capability of the in-situ test and the measured test parameters (Youd et al., 1998). As the site characteristics influencing soil liquefaction potential are complex phenomena involving many factors, as noted by Sitharam et al. (2004), tests for soil liquefaction potential are rarely carried out using a single, particular procedure (Martin & Lew, 1999).

Given the complexity of analysing the liquefaction phenomenon, the evaluation of the *CRR* in this research utilised the electric cone penetration test (*CPT*) and the flat dilatometer test (*DMT*). The *CPT* is an ideal in-situ test to evaluate the potential for soil liquefaction because of its repeatability, reliability, continuous data acquisition and cost effectiveness (Lunne et al., 1997). Furthermore, the *CPT* method is widely used and well accepted (Youd et al., 1998). However, several factors affect the *CRR* of soils, such as stress state, age, cementation, and structure, which are difficult, if not impossible, for the *CPT* to measure (Totani et al., 2001). Therefore, the *DMT* was used as the complementary test method. A study by Totani et al. (2001) indicated that the *DMT* parameter K_D (horizontal stress index) is influenced by stress history, ageing, cementation and soil structure.

2.3.2.1 THE CONE PENETRATION TEST (*CPT*) METHOD

Introduction

Cone penetration testing, which has been practised since about 1917, basically involves pushing a steel cone attached to rods into the sub-surface for measuring the resistance of the soil layer (Marr, 1981; Sutcliffe & Waterton, 1983). The first electric cone penetrometer was probably developed in Berlin during the Second World War (Broms &

Flodin, 1988 cited by Lunne et al., 1997). Muhs (1978) in Lunne et al. (1997) reviewed the main improvements of the electric *CPT* relative to the mechanical cone penetrometer, namely the ability of the equipment to eliminate errors caused by friction between the inner and outer rods; longer continuous testing up to 1 metre length with a steady rate of penetration that minimises undesirable soil movement; and more reliable measurements. An overview of the *CPT* testing layout is shown in Figure 2.12.

Figure 2.12 Overview of the *CPT* testing per ASTM D 5778 procedures (Mayne, 2007b)

Equipment

The hardware required by a geotechnical in-situ data acquisition system utilising the *CPT* includes the following components: an electric cone penetrometer; hydraulic pushing system with rods; cable or transmission device; depth recorder and data acquisition unit (Mayne, 2007b). The data acquisition unit usually includes two separate components, the *microprocessor interface* and the *micro-computer* (Jaksa & Kaggwa, 1994).

A cone of standard dimensions has a cross sectional area of 1,000 mm^2 with an apex angle of 60° and a friction sleeve with a surface area of 15,000 mm^2 and a length of 133.7mm, as shown in Figure 2.13. Inside the electrical cone penetrometer are two separate strain gauge load cells which are connected to the tip and sleeve of the cone

(Jaksa & Kaggwa, 1994). These load cells are used to simultaneously and continuously record the tip resistance and sleeve friction.

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Figure 2.13 Schematic diagram of the electric cone penetrometer (After Holtz & Kovacs, 1981)

Mayne (2007b) reported that the hydraulic pushing system can be a standard drill rig or a dedicated *CPT* hydraulic system mounted on vehicles, a skid arrangement, or a portable unit. Generally, the capacity of the hydraulic system for *CPT* work varies widely from 18kN (two tons) to 200 kN (22 tons). The cone penetrometer is connected to the grip or adapter of the hydraulic pushing system by cone rods designed to reach the testing depth. A cone rod is 35.7 mm outer diameter and made from hollow steel. Usually they are one metre length with tapered threads. A stack of 30 to 40 one metre long rods is usually necessary in common geotechnical site investigations.

Most *CPT* systems use a cable threaded through the inside of the cone rods for transmission of data to the acquisition data unit. The cable is also used to provide 5 - 20 V to the cone penetrometer. The standard cables for five channels (two wires per channel) used for the current research are a 10-pin type. Some *CPT* systems employ 12, 16, 24, and 32 pins for specific purposes (Mayne, 2007b).

There are several methods to record depth during cone penetration testing, such as a depth wheel, displacement transducer, potentiometer (spooled wire), gear box, ultrasonics sensor, and an optical reader (Mayne, 2007b). In this research, a depth box device was developed to measure accurately the depth of the cone (Jaksa & Kaggwa, 1994). It consists of a thin metallic cable wound around a metal drum, while the other end of the cable is attached to the drilling rig's hydraulic ram. An alarm button is connected to the depth box in order to transmit a signal to the microprocessor interface for sampling to begin.

Over the years various data acquisition systems have been developed for cone penetration testing. Mayne (2007b) has pointed out that initially data acquisition consisted of simple pen plotters, then analog–digital converters to matrix dot printers emerged. The latest data acquisition units have evolved to fully digital systems with microchip technologies. This project used data acquisition units which consist of a microprocessor interface and a micro-computer. The data acquisition units consisted of the following components (Jaksa & Kaggwa, 1994):

- microprocessor unit (*MPU*)
- 8 kb (kilobytes) x 8 bit *EPROM* (**e**rasable **p**rogrammable **r**ead **o**nly **m**emory) chip
- 8 kb x 8 bit RAM (**r**andom **a**ccess **m**emory)
- operational amplifiers; RS232 interface
- liquid crystal displays (*LCD*)

The data acquisition unit was able to perform a variety of tasks, such as multiplexing (the MPU reads two input channels); *I/O* port data transmission; signal conditioning and amplification; analogue to digital (*A/D*) conversion; and data storage and transfer. All the measurements, such as tip resistance, sleeve friction and their respective depth were scaled, displayed and saved to a hard disk file on an *IBM* compatible micro-computer.

Procedure

The *CPT* procedure is standardised all over the world through the guidelines, standards and regulations of various organisations (Jaksa et al., 2002) such as the International Society of Soil Mechanics and Foundation Engineering (*ISSMFE*-1989), the American Society for Testing and Materials (ASTM-D3441-75T-1987) and Standards Australia (AS 1289.6.5.1-1999). The test consists of pushing a cone of standard dimensions vertically into the ground at a constant rate of 10-20 mm/s while recording its resistance continuously or intermittently (Lunne et al., 1997). The basic data measured by a standard *CPT* are the tip resistance, q_c, sleeve friction, f_s and respective depth of the penetrometer (Lunne et al., 1997).

The following sections describe the procedure of the *CPT* as well as some other necessary aspects to obtain reliable test results, as suggested by Lunne et al. (1997).

- *Pre-drilling, on-land testing*

  In certain cases, such as testing an area with a top soil that consists of fill or hard soils, it may be necessary to pre-drill in order to avoid damaging the cone equipment. This may be carried out using a solid dummy probe with a diameter slightly larger than the cone penetrometer or manual drilling an adequate hole to a designated depth.

- *Verticality*

  The thrust machine must be set up for a thrust direction as near to vertical as is practicable, with a maximum deviation of the push rods of only 2°. This precision is aimed at avoiding damage to the equipment due to a sudden deflection and to ensure that the penetrometer remains in its vertical path. However, deflection caused by the impact of hard strata or inclusions is not uncommon. Generally, 1° of deflection per metre without noticeable damage is acceptable.

- *Reference measurements*

  The reference measurements are practically useful for tracking the performance and maintenance of the cone penetrometers. This can be done by measuring the sensors at zero load before and after each sounding to confirm that the sensor on the penetrometer is not significantly influenced by the change of temperature, and to maintain the penetrometer temperature as close as possible to the existing ground temperature at the project site. The measurement results will be useful for determining whether a necessary correction is needed or not.

- *Rate of penetration*

  Creep and particle crushing may influence the rate of penetration. But the rate of penetration should be maintained at 20 mm/s ± 5 mm/s. As the standard rate of penetration is maintained, the effect of fully undrained and fully drained soil behaviour during the test will not be of concern.

- *Interval readings*

  Most of *CPT* equipment produces continuous data related to tip resistance, q_c, sleeve friction, f_s and the respective depth of the penetrometer, even though the interval of readings is project or equipment dependent.

- *Depth measurements*

  Most of the *CPT* equipment records the depth automatically using a special depth recorder installed in the system. But a manual check for the actual penetration depth compared to the registered depth is necessary. The discrepancy between of the depth recorded manually and that registered by the system recorder must not exceed ±100mm.

Jaksa (1995) has summarized the standard *CPT* procedure detailed in several references such as *ISOPT*-1, ASTM D3441, and AS 1289.F5.1. The procedure is briefly as follows:

1. Initially, set the thrust machine over the test point/peg and orient it as vertically as practicable.
2. Attach the cone penetrometer with the first length of the rod assembly and connect it to the thrust machine using an adapter. A rod guide installed at the base of the thrust machine is necessary to maintain the verticality of the axis of the rod.
3. Aligned with the rod guide, the cone penetrometer is pushed down a short distance into the ground soil and permitted to remain in this position for about 5 to 10 minutes to allow the temperature of the cone tip to equilibrate with the ground temperature.

4. Withdraw the cone and adjust the values of cone tip, sleeve friction and pore water pressure if a pore water sensor is included in the penetrometer, i.e. a piezocone. While making these adjustments, it is necessary to protect the cone from direct sunlight. Record all the values as the initial reading.
5. Start the reading by advancing the cone into the subsurface at a constant rate.
6. Stop advancing the cone once the thrust mechanism has reached the end of its travel.
7. Disconnect the rod assembly from the thrust machine by opening up the adaptor.
8. Raise the thrust machine and attach an additional rod.
9. Repeat steps 5 to 8 until the required depth is reached.
10. Remove and dismantle the rod assembly after completing the test up to the first length of the rod assembly.

Applications and data interpretation

The *CPT* is an invasive soil test that currently is widely used to define soil strata type, soil properties, and strength parameters (Mullins, 2006). This in-situ testing is highly repeatable, insensitive to operators, and best suited for uncemented soils, sands, or clay, both on land and offshore. Due to the probability of cone damage and thrust limitations, the *CPT* is rarely used in gravels, and weak and weathered rock profiles (Jaksa, 1995).

Although in-situ testing retrieves no sample for laboratory testing or visual inspection, it has the capacity to produce enormous amounts of physical information (Mayne, 2007b). In addition, Orchant et al. (1988) suggested that the information obtained from the *CPT* can be used to interpret the following geotechnical characteristics:

- classification of soils
- relative density of sands
- friction angle of sands
- undrained shear strength of cohesive soils
- overconsolidation ratio of soils
- Young’s modulus of elasticity

- compressibility of clay
- bearing capacity of pile and shallow footing
- liquefaction potential of soils.

Determination of the CRR from the CPT

Initially, a procedure of liquefaction evaluation based on electric *CPT* in-situ testing was introduced based on a *CPT-SPT* (Standard Penetration Test) correlation to estimate the *SPT* blow count (N) values using *CPT* data. However, a National Center for Earthquake Engineering Research (*NCEER*) report (Martin & Lew, 1999) identified the *CPT* as a prime candidate for reconnaissance exploration and indicated that the *CPT* can be used to develop preliminary soil and liquefaction resistance profiles.

The cyclic resistance ratio *CPT*-based correlations adopted for the current study contain a significant advance over previously available correlations using *CPT* data. The adopted correlations were developed using a database incorporating high quality field performance case histories, which had not been available to previous researchers. The recommended liquefaction assessment graph (Finn, 2001; Youd et al., 2001), which was developed from the normalized *CPT* cone resistance, q_{c1}, is shown in Figure 2.14.

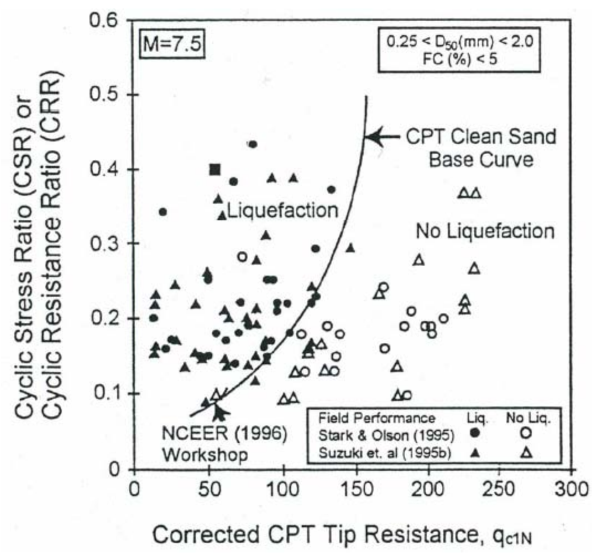

Figure 2.14 Curve recommended for liquefaction evaluation in earthquake magnitude M=7.5 modified from *NCEER* 1998 base on *CPT* data (Finn, 2001; Youd et al., 2001)

The *CRR* curve in Figure 2.14 can be calculated using the Robertson and Wride (1998) equations as follows (Youd et al., 2001):

$$CRR_{7.5} = 0.833\left[\left(q_{c1N}\right)_{cs}/1{,}000\right] + 0.05 \quad \text{if } \left(q_{c1N}\right)_{cs} < 50 \text{ ……………} \quad (2.8a)$$

$$CRR_{7.5} = 93\left[\left(q_{c1N}\right)_{cs}/1{,}000\right]^3 + 0.08 \quad \text{if } 50 \le \left(q_{c1N}\right)_{cs} < 160 \text{ ……..} \quad (2.8b)$$

The liquefaction assessment criteria and procedure developed by Robertson and Wride (1998) is recommended by the 1996 *NCEER* and 1998 *NCEER/NSF* Workshops on Evaluation of Liquefaction Resistance of Soils. The *CPT* method suggested by Robertson and Wride (1998) requires a normalised tip resistance to approximately 1 atm (100 kPa), which can be calculated using the following equations:

$$q_{c1N} = C_Q\left(q_{c,1}/P_a\right) \text{ ……………………………………………………} \quad (2.9a)$$

$$q_{c,1} = C_q \cdot q_c \text{ ……………………………………………………….} \quad (2.9b)$$

$$C_Q = \left(P_a/\sigma'_{vo}\right)^n \text{ ……………………………………………………..} \quad (2.9c)$$

where C_Q is the normalising factor of cone penetration resistance that has a maximum value of 1.7 (Youd et al., 2001); P_a is 1 atm of pressure in the same units as σ'_{vo}; n is an exponent that varies with soil type; q_c is the cone tip resistance described earlier.

Generally, the exponent, n, varies from 0.5 for clean sands to 1.0 for silts and sandy silt soils. It may be estimated by using a soil behaviour index, I_c, proposed by Robertson (1990) (Figure 2.15). However, this chart was developed for clayey soil types. Therefore, an adjustment is necessary to apply it to different soil types.

To adjust the soil index for use with other soils, Robertson and Wride (1998) developed an equation as follows:

$$I_c = \left[\left(3.47 - \log Q\right)^2 + \left(1.22 + \log F\right)^2\right]^{0.5} \text{ ……………………………..} \quad (2.10a)$$

where $$Q = \left[\left(q_c - \sigma_{vo}\right)/P_a\right]\left[\left(P_a/\sigma'_{vo}\right)^n\right] \text{…………………………………….}(2.10b)$$

$$F = \left[f_s/\left(q_c - \sigma_{vo}\right)\right] \times 100\% \text{ ………………………………..……} \quad (2.10c)$$

and f_s is sleeve resistance.

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Figure 2.15 A chart illustrating the soil behaviour index, I_c, based on *CPT* data (Youd et al., 2001)

Furthermore, Robertson & Wride (1998) suggest the following steps to account for the effects of soil behaviour.

I. When using Eq. 2.10 to calculate I_c, if n = 1 (Eq. 2.10b) but the value of I_c is greater than 2.6, check the F value:

   a. If F>1% the analysis is complete and the layer is likely to be non-liquefiable.

   b. If F<1%, the $q_{c1N}=Q_{(1)}$ value can be used as the normalised dimensionless cone penetration resistance. The $Q_{(1)}$ is the value of Q for the clayey soil type.

II. When using Equation 2.10 to calculate I_c, if n = 1 (Eq. 2.10b) but the value of I_c is less than 2.6, the soil can be classified as a granular material and C_Q and Q are recalculated using the exponent n = 0.5.

   a. If the recalculated I_c is < 2.6, this I_c is used in the liquefaction analysis.

b. If the recalculated I_c is > 2.6, this I_c is once more recalculated using an exponent n = 0.75 and this last I_c value is used in the liquefaction analysis.

All the I_c values are used to obtain the fines content correction factor fines content, K_c, as defined by Robertson & Wride (1998) as follows (Eq. 2.11):

$$K_c = 1.0 \text{ for } I_c \leq 1.64 \quad (2.11a)$$

$$K_c = 1.0 \text{ for } 1.64 < I_c < 2.36 \text{ and } F < 0.5\% \quad (2.11b)$$

$$K_c = -0.403 I_c^4 + 5.581 I_c^3 - 21.63 I_c^2 + 33.75 I_c - 17.88 \text{ for } I_c > 1.64 \quad (2.11c)$$

The next step is to calculate the equivalent of the clean-sand penetration resistance, q_{c1N}. This can be achieved by normalising the penetration resistance q_{c1N} using the following equation:

$$q_{c1N,CS} = K_c q_{c1N} \quad (2.12)$$

The resulting $q_{c1N,CS}$ is then inserted into Equation 2.8 which is then applicable.

2.3.2.2 THE FLAT DILATOMETER TEST (*DMT*) METHOD

Introduction

The dilatometer test (*DMT*) (ASTM D 6635) measures the lateral deflection of soils by applying pressure through a pneumatic hose to a vertical plate inserted at the desired level. This in-situ testing was developed by Professor Silvano Marchetti in Italy (Robertson & Campanella, 1986). In 1980 he published the test procedure and correlations of the test results with various soil properties (Marchetti, 1997; Totani et al., 2001). The three *DMT* parameters used in subsequent analyses are: material index, I_D, horizontal stress index, K_D, and dilatometer modulus, E_D (Robertson & Campanella, 1986). An overview of the *DMT* testing layout is shown in Figure 2.16.

Equipment

Flat dilatometer testing consists of a high strength dilatometer steel blade, pneumatic-electrical cable, control unit with a pressure gauge readout system, a pressure source such as a nitrogen gas tank, and a calibration device. The tapered dilatometer steel blade is approximately 240 mm long, 95 mm wide, 15 mm thick, with a 16°-18° wedge tip. A 60mm diameter expandable steel membrane is flush with the face of the blade (Smith, 1993; Sabatini et al., 2002). The *DMT* pneumatic-electrical cable contains a pneumatic hose and an electrical wire. The pneumatic hose is connected between the blade and the pressure source, and the wire is connected to an audible alarm within a control panel. The alarm will notify the operator to take specific pressure readings (Smith, 1993). Figure 2.17 shows the basic *DMT* and the associated equipment.

Figure 2.16 Overview of the *DMT* testing layout (Marchetti et al., 2001)

Procedure

The *DMT* procedure was outlined by Marchetti et al. (2001). The following sections describe the procedure, as well as the necessary steps required to obtain reliable data, according to the author.

MEMBRANE CALIBRATION

An essential initial step prior to in-situ testing is membrane calibration. Marchetti et al. (2001) stated that calibration is necessary in order to overcome membrane stiffness effects. This calibration can be done by a simple procedure using a syringe to generate a vacuum or pressure to obtain ΔA and ΔB. The *DMT* calibration setup is shown in Figure 2.18.

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Figure 2.17 *DMT* unit and the associated equipment which are: a. nitrogen gas tank, b. pneumatic hose, c. electrical cable, d. steel blade and e. syringe (Marchetti et al., 2001)

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Figure 2.18 *DMT* calibration setup (Marchetti et al., 2001)

STEP-BY-STEP IN-SITU TESTING PROCEDURE (*A, B, C* READINGS)

In general, *DMT* in-situ testing involves expanding a 60 mm diameter circular membrane on the face of the blade using nitrogen gas pressure to provide the A- and B-readings that correspond to the deformation of the membrane. The A-reading (A) is the lift-off pressure where the membrane just begins to move laterally; and the B reading (B) is the expansion pressure where the membrane expands by 1.1 mm into the surrounding soil. A closing pressure or the C-reading may be recorded during deflation of the membrane. A schematic of the *DMT* working principle is shown in Figure 2.19.

Figure 2.19 *DMT* working principle (Marchetti et al., 2001)

Typically, discrete penetration tests are carried out at 200 mm intervals. The pressure reading must be started within 15 seconds of the blade reaching the desired depth; the A-reading must be taken within 15-30 seconds of the test beginning (opening the micrometer flow valve); and the B-reading must be taken within the next 15 to 30 seconds. After the B-reading is obtained, the pressure is vented to prevent overexpansion of the membrane. The C-reading is recorded when the membrane is flush with the face of the blade during the slow venting of the gas pressure. After deflation of the membrane has been completed, the blade is pushed to the next test depth and the inflation cycle is repeated. This procedure is illustrated as Figure 2.20.

Applications and data interpretation

The tip of the *DMT* blade is sharpened to facilitate easy penetration. Therefore, this in-situ testing method is applicable for most soils. Elsayed (2006) concluded that generally the flat plate *DMT* performed well in his project on soft soil (peat). Schnaid et. al. (2000) found a good agreement between a self-boring pressuremeter and the *DMT* in granite saprolites in Hong Kong. However, precautions are necessary when performing the *DMT* in soils that contain gravel or rock since the membrane is fairly delicate and can be susceptible to damage. Moreover, in terms of the limitations, no soil sample can be obtained from dilatometer testing and there is some slight disturbance to the soil being tested (Marchetti, 1980). In addition, this test measures the soil pressure in only one direction compared to the pressuremeter test, which measures properties circumferentially.

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Figure 2.20 The *DMT* in-situ testing step by step procedures illustration (adapted from Marchetti et al., 2001)

Generally, the *DMT* results can be interpreted into soil parameters for engineering practice after the raw data (readings A and B) have been corrected for offset in the measurement gauge and membrane stiffness (Marchetti et al., 2001). The original correlations were developed by Marchetti (1980). Most of these correlations have been confirmed by subsequent research and are widely used. Totani et al. (2001) explained that the *DMT* could also be applied to determine the undrained shear strength of the soil and its constrained modulus; predict the settlement of shallow footings; monitor soil improvement; detect weak zones; evaluate sand liquefaction; and estimate the horizontal coefficient of the consolidation of clays, including their permeability. The basic *DMT* data calculation formulae and its correlations with several geotechnical soil properties are summarised in Table 2.2.

Table 2.2 The basic *DMT* data calculation formula and its correlations (Marchetti et al., 2001)

Marchetti and Crapps (1981) developed a chart for determining the soil type and unit weight γ from I_D and E_D as shown in Figure 2.21.

Determination of the CRR from the DMT

The salient factors supporting the use of K_D as an index of liquefaction resistance are listed by Monaco et al. (2005) and Maugeri & Monaco, (2006) as follows:

- **Sensitivity of *DMT* in monitoring soil densification**

  A study of soil densification by Schmertmann et al. (1986) and Jendeby 1992 cited by

Marchetti et al. (2001) found the *DMT* is approximately twice as sensitive as the *CPT*.

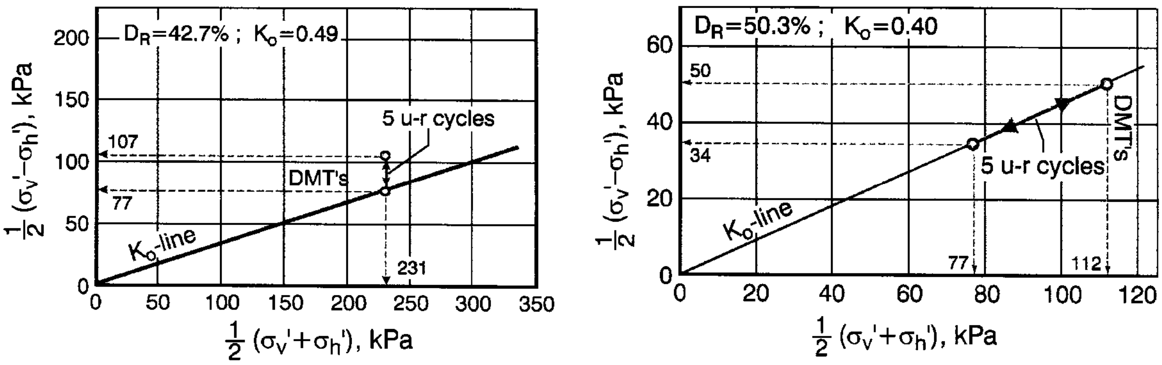
- **Sensitivity of *DMT* to pre-straining**

  Research by Jamiolkowski and Lo Presti (1998 cited in Maugeri & Monaco, 2006) on Ticino sand has shown that K_D of the *DMT* is much more sensitive to pre-straining than to penetration resistance. The study found that the increase in K_D caused by pre-straining is approximately 3 to 7 times the increase in penetration resistance, q_D. This is shown in Figure 2.22.

Figure 2.21 Use of the dilatometer in the identification of soil type (Marchetti et al., 2001)

- **Correlation K_D - Relative density**

  Reyna & Chameau (1991) derived the relative density, D_R, of normally consolidated uncemented sands from K_D as shown in Figure 2.23. The correlation is in very good agreement with additional high quality frozen samples at Ohgishima and Kemigawa examined by Tanaka & Tanaka (1998).



	I_D (-)	K_D (-)	E_D (MPa)	M_D (MPa)	q_D (MPa)
Before	2.50	1.03	27.6	23.5	14.5
After	2.50	1.43	33.4	28.5	16.1

K_D increase +39 % and q_D increase +11 %

	I_D (-)	K_D (-)	E_D (MPa)	M_D (MPa)	q_D (MPa)
Before	2.62	1.98	29.0	30.3	16.0
After	2.41	2.38	31.8	37.8	16.4

K_D increase +20 % and q_D increase +3 %

Figure 2.22 Results of calibration chambers testing (pre-straining cycles) by Jamiolkowski and Lo Presti 1998 cited by Maugeri & Monaco (2006)

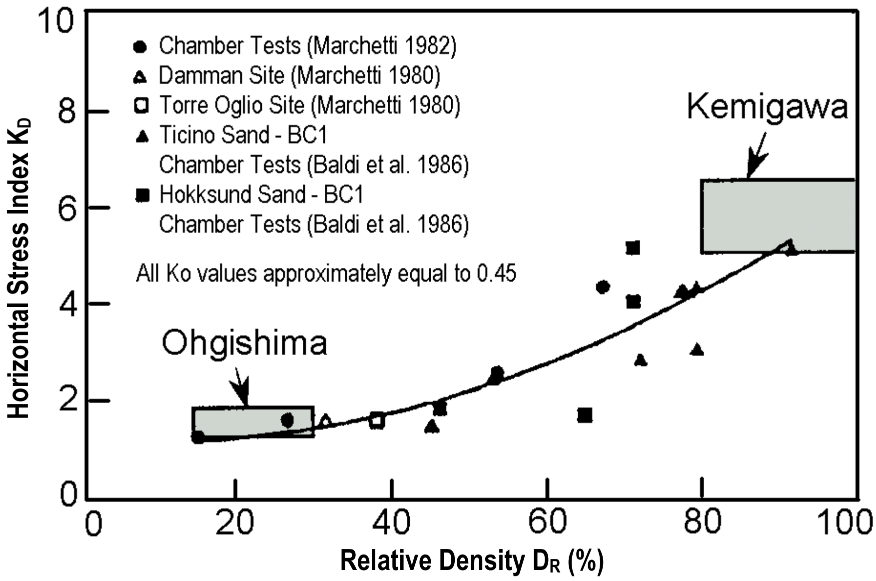


Figure 2.23 Correlation K_D-D_R for *NC* uncemented sands by Reyna & Chameau in 1991 & Tanaka & Tanaka in 1998 (Maugeri & Monaco, 2006)

- **Correlation K_D – in-situ state parameter**

  Recent research supports viewing K_D from the *DMT* as an index reflecting the in-situ state parameter ψ. Yu (2004) identified the average correlation K_D and the in-situ state parameter, ψ as shown in Figure 2.24.

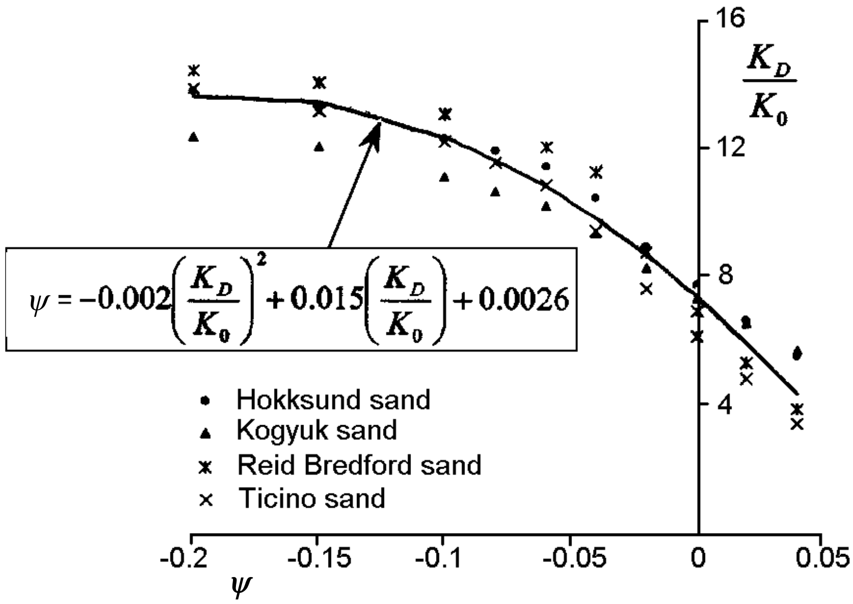


Figure 2.24 Average correlation K_D - in situ state parameter ψ by Yu in 2004 (Maugeri & Monaco, 2006)

The advantages of the *DMT* for assessing the liquefaction potential of soils are the primary reason for using this technique in the present research. In the estimation of the *CRR* of the soil, Marchetti (1982) suggested the horizontal stress index, K_D, as the appropriate parameter. The tentative basic correlation was suggested as:

$$CRR = \left(\tau_l / \sigma'_{vo}\right) = \left(K_D / 10\right) \quad (2.13a)$$

This basic correlation has since been refined by Monaco et al. (2005). The *CRR*-K_D correlation proposed by Monaco et al. (2005) demonstrates very good agreement with *CRR* derived from *SPT* and *CPT* data. The correlation between *CRR* and K_D by Monaco et al. (2005) is shown in Figure 2.25 as the bold curve and approximated by the equation:

$$CRR = 0.0107K_D^3 - 0.0741K_D^2 + 0.2169K_D - 0.1306 \quad (2.13b)$$

Figure 2.25 also incorporates *CRR*-K_D correlations by Marchetti (1982), Robertson and Campanella (1986), Reyna and Chameau (1991) and *CPT* and *SPT* data converted using relative density as the intermediate parameter. The *CRR*-K_D curves apply to 7.5 earthquake magnitude scale and clean sand.

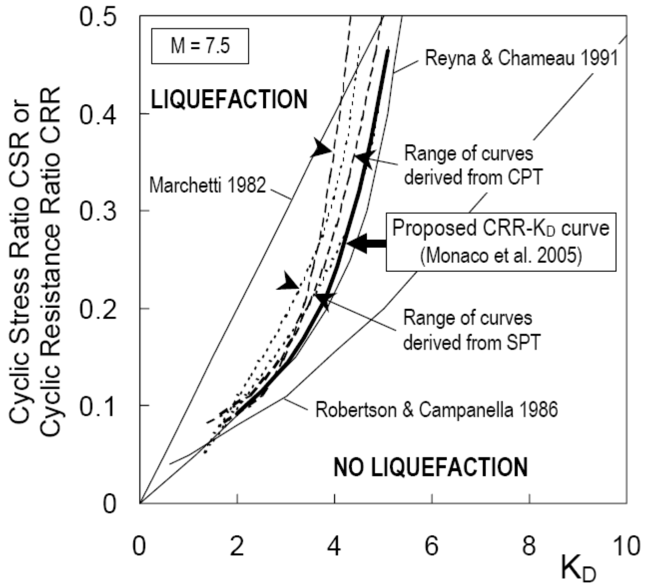


Figure 2.25 *CRR-K_D* curves from *DMT* (Monaco et al., 2005, cited by Monaco and Marchetti, 2007)

The equation by Monaco et al. (2005) was validated utilising data points from various liquefaction sites as shown in Figure 2.26.

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Figure 2.26 Validation *CRR-K_D* curves (Monaco et al., 2005)

However, Monaco and Marchetti (2007) mentioned that the *CRR-K_D* correlation developed by Monaco et al. (2005) was based on a limited factual liquefaction case history record, thus significant additional verification is required.

2.4 INFLUENCE OF AGEING ON LIQUEFACTION

2.4.1 Introduction

Natural sediments are essentially very complex mixtures of relatively strong grains with an intervening fluid. The sediments undergoing burial tend to progressively increase in strength by the mixture of inter-particles (lithification) and chemical inter-reactions (diagenesis). The lithification displaces the fluid filling the voids with solid particles and packs the particles closer together. This process strengthens the buried sediments by promoting inter-grain contact (frictional strength). Diagenesis involves several processes such as cementation, recrystallisation and pressure solution (Maltman & Bolton, 2003), and numbers of different processes can contribute to strengthen the sediments over time in a process referred to as age-hardening (Dexter et al., 1988). Two important processes of age-hardening are particle rearrangement and particle cementation. As successive layers of sediment build up, they are compacted while being cemented by minerals that precipitate from solution after their deposition.

2.4.2 Particle rearrangement

Particle rearrangement and its effect on the strength of the soil deposit was explained by Dexter et al. (1988). They suggested that when soil is disturbed, its particles are displaced from their previous equilibrium positions of low free energy to new positions of higher free energy. A high free energy soil is weaker than a low free energy soil. When the disturbance has ceased, the particles will gradually rearrange towards a minimum free energy configuration, with the intensity depending very much on the soil water content and its physical chemistry.

Particle rearrangement is seemingly not possible in conditions of low and high water content. Therefore, no age-hardening occurs in sediments that are very dry or very wet. Utomo and Dexter (1981, cited by Dexter et al., 1988) found that at optimum water content, around the lower plastic limit (*PL*) of the soil, the colloids are able to rearrange and flocculate, resulting in age-hardening. In terms of physical chemistry, soils with a significant negative mean charge density at the surface of the colloids might be expected to increase age-hardening by particle re-arrangement at optimum water content.

The consolidation of buried sediments is also a result of particle rearrangement. It involves a time-dependent mechanical reduction in sediment volume, usually pore volume, in response to increased loading. In practice, consolidation normally takes place due to the weight of progressive additions of overlying sediment, that is, the increasing lithostatic load (Maltman & Bolton, 2003).

2.4.3 Particle cementation

Grains of sediment can change to be other minerals during diagenesis. The voids between the grains can also be filled by other minerals during the process. For these reasons, the porosity of sediments usually decreases during diagenesis, except in rare cases, such as conditions conducive to the dissolution of minerals and dolomitisation (Maltman & Bolton, 2003). There are various processes of diagenesis and one of most important and common is particle cementation (Dexter et al., 1988). This cementation process is assisted by fluids and it takes place progressively (Maltman & Bolton, 2003). Thus, cementation is continually growing in the groundwater zone or zone of cementation.

Dexter et al. (1988) stated that particle cementation is a process that reinforces and strengthens particle-particle bonds which must be initiated by contact between soil particles. When the soil is fully saturated, the contact is prevented by the fluid. Thus, the fluid is strongly adsorbed on the particle surfaces. Any circumstances that cause the soil to dry out and the lithostatic load to increase brings the soil particles closer together, even into direct contact. This allows the cementing material or other variety of dissolved mineral such as carbonates, quartz, iron oxides and clays components adjacent to such a contact to bond with any of the particles involved. The rate of dissolution of these minerals can be a factor limiting age-hardening (Dexter et al., 1988).

The cementation also occurs in cracks, fissures or other openings of existing soils/rocks. This was shown by Kemper & Rosenau (1984, cited by Dexter et al., 1988) in their research on air-dried Portneuf soil. They found slow age-hardening of that soil due to the cementation process.

In addition, the surrounding conditions contribute to cementation in the soil. Bentley & Smalley (1978) identified several mechanisms that might be cementing agents: (a) direct precipitation from saturated pore waters; (b) mineral continuity growing at the edge of mineral crystals; and (c) amorphous material crystallisation.

2.4.4 Determination of the age of the soil deposit

The time scale of the soil formation process is extremely variable, ranging from days to millions of years. The relationship between soil formation and time is known as chronofunction (Retallack, 2001). The study of chronofunction is very useful for understanding the sequence of deposit in any stratigraphic soil, and for estimating any processes during sequence-forming, as well as predicting the maturity of soil formations.

Generally, both relative and absolute time scales are considered in chronofunction. The current research, however, was only used absolute scales. Therefore, discussion in the sub-sections below is related to the absolute time scale, particularly for dating Holocene (i.e. less than 10,000 years old) deposits.

The absolute age of Holocene soil deposits is usually determined using dating techniques such as dendrochronology, radiocarbon dating, amino acid racemisation and termoluminescence (*TL*). Yeats et al. (1997) explained that **dendrochronology** uses the pattern of growth rings in dead trees found in the soil layer as an indication of age where a growth curve can be established after the examination of several specimens. In conventional **radiocarbon dating** the amount of C_{14} is estimated by measuring the radiation emitted as C_{14} decays naturally to N_{14}. If biological materials such as shells and bones are available in the soil, **amino acid racemisation** is applicable to estimate its relative dates (Judith et al., 2001). **Thermoluminescence** (*TL*) dating of sediments involves the measurement of the accumulation of absorbed radiation energy in inorganic crystals such as quartz and feldspar (Mejdahl, 1986; Richter, 2006).

Although *TL* dating depends upon the length of exposure of the soil particle for sun bleaching, the radioactivity of the depositional environment and the sensitivity of the material, *TL* dating has tremendous potential for dating soil deposits. It is not liable to environmental changes that can, and do, affect dendrochronology and amino acid dating or limited by the half-life of a decay process, as are radiocarbon and uranium series dating methods (Wintle & Huntley, 1982).

2.4.5 Influence of age on *CRR*

Soil strength generally increases with time (Dexter et al.,1988). Several researchers such as Pike (2003), Leon et al. (2006) and Andrus et al. (2009) found that *CRR* also increases with age. The ageing of soil deposits is by and large attributed to cementation or binding between particles and slippage and rearrangement of soil grains (Dexter et al., 1988; Leon et al., 2006). Pike (2003) and Leon et al. (2006, cited by Monaco and Marchetti, 2007) concluded that age is likely to have a much greater effect on liquefaction resistance increase than on penetration resistance. They argued that tip and sleeve resistance measurements in *SPT* and *CPT* are poor indicators of the existing conditions of sand deposits when age is found. The inability of the *SPT* and *CPT* to capture the effects of age is ascribed by Leon et al. (2006) to their insufficient sensitivity to detect minor changes in soil fabric that can increase liquefaction resistance, since the disturbance during these tests may destroy or seriously damage the microstructure effects that result from age. This circumstance may lead to excessively conservative estimation of *CRR* values from the *SPT* and *CPT* methods.

A study by Leon et al. (2006) in sand deposits found that ignoring age effects by using *CRR* evaluated from in-situ testing *insensitive* to age, such as *SPT*, *CPT* and V_S (shear wave velocity), underestimated *CRR* by as much as 60%. Lewis et al. (1999, cited by Monaco & Marchetti, 2007) concurred, noting that the use of empirical correlations developed for young soil deposits in older granular deposits results in very conservative design. In some circumstances a final design based on inadequate in-situ testing will be uneconomical or encourage very costly remedial measures or even cancellation of a project.

In addition, Monaco and Schmertmann (2007) observed that disregarding age is the equivalent of omitting a primary parameter in the *CRR* correlation. Monaco & Marchetti (2007) suspected that the omission of age may contribute to the dispersion of the *CRR* predictions.

Taking into consideration the effect of soil age in soil liquefaction evaluation has been initiated by various researchers to correct the current *CRR* correlations which were developed for young soils. Leon et al. (2006) proposed the use of correction factors when he studied sand sites in South Carolina. However, their correction factors may not be applicable for other sites because the *CRR* gain due to age can vary widely from site to site (Monaco & Marchetti, 2007).

A comprehensive study was conducted by Lewis et al. (2008) to identify the ageing factor affecting soil strength at the Savannah River Site in South Carolina, USA, a nuclear energy reservation established in the 1950s. Their findings fit approximately into the ageing correction factor between Equation 2.14a as the lower boundary which was developed by Kulhawy & Mayne (1990), and Equation 2.14b as the upper boundary from their own data. Details of Lewis et al.'s (2008) study can be seen in Figure 2.27.

$$C_A = 1.2 + 0.05\log(t/100) \quad (2.14a)$$

$$C_A = 1.92 + 0.23\log(t/100) \quad (2.14b)$$

where C_A is strength gain factor and t is age (years).

Arango et al. (2000), Lewis et al. (2004) and (Andrus et al., 2004b cited by Andrus et al., 2009) have recommended that an age correction factor be applied to the *CRR* value for the *CPT* method as follows:

$$CRR_K = CRR \times K_{DR} \quad (2.15a)$$

where CRR_K is cyclic resistance ratio corrected for age; and K_{DR} is factor to correct the effect of ageing.

In terms of the determination of the age factor, Hayati and Andrus (2009) suggested the following equation:

$$K_{DR} = 0.13\log_{10}(t) + 0.83 \quad (2.15b)$$

where t is time since initial soil deposition or last critical disturbance.

2.5 LIQUEFACTION EFFECT ON SOILS

The fact that loose deposits are still liable to liquefaction in seismic regions which have been subjected to a number of earthquakes previously suggests that a cyclic loading, such as experienced during an earthquake, is incapable of densifying loose deposits to a stable mass (Ambraseys & Sarma, 1969), although it has been generally expected that a liquefied soil will compact after the onset of liquefaction (Kolymbas, 1998).

A liquefied soil behaves like a heavy viscous fluid rather than a solid (Kolymbas, 1998; Sawicki & Mierczynski, 2008). The viscosity of a completely liquefied soil is about 105 times that of water (Miyajima & Kitaura, 1994). Several major differences between a solid and a liquid material were described by Knappman (1999) as follows:

- Firstly, there is an elastic constant in a solid state but a liquid state has viscosity.
- Secondly, a solid material is able to withstand shear forces whereas a liquid material is unable to withstand them.
- Thirdly, a liquid is inclined to continue to flow while a solid is likely to rebound into its original form.

Figure 2.27 Strength gain factor with age (Lewis et al. 2008)

Thus, when the soil deposit is in a liquefied state and softened condition, ground deformations occur readily in response to either static or dynamic loading (Seed et al., 2003; Youd, 2003). The nature and severity of the deformation is a function of the loading conditions, the amplitudes and frequencies of seismic waves, the thickness and extent of the liquefied stratum, the relative density and permeability of the liquefied sediment, and the permeability of surrounding sediment layers (Youd, 2003).

Seed et al. (2003) described in detail numerous deformations induced by liquefaction, which have been illustrated below. The researchers mentioned that there are two groups of displacement/deformation liquefaction-induced soils which are categorised by the distance of the offset of the displacement. The first one is a large displacement as illustrated in Figure 2.28, which has an offset more than 1 metre. These displacements are principally the result of slumping induced by gravity, as rearrangement of the geometry of the soil is essential to re-establish a new static equilibrium. Small to moderate displacements are a dislocation of less than a single metre in soil deposits induced by liquefaction. Unlike the case of large liquefaction-induced displacements, which are dominated by gravity forces after the cessation of trembling, small to moderate displacements are mainly exaggerated by cyclic inertial forces produced by strong shaking.

Figures 2.29(a) and (b) illustrate a number of mechanisms involved in small to moderate lateral deformations. Figure 2.29(a) illustrates a limited lateral spreading towards a free face, and Figure 2.29(b) demonstrates an example of limited lateral spreading downslope.

The modes of vertical displacement caused by liquefaction are illustrated in Figures 2.30 and 2.31. Figures 2.30(a) and (b) illustrate settlements due to reduction or loss of soil volume. Figures 2.31(a) through (d) illustrate modes of settlement due to deviatoric ground movements and Figures 2.31(e) through (g) illustrate structural settlements due to full or partial bearing failures.

Sand blows or sand boils and mud volcanoes are other peculiar effects of liquefaction of soils (Kolymbas, 1998). The generation of pore water pressure by soil movement during earthquakes frequently results in pent up energy being released by way of sand boils, erosion and movement of sediments (Chaney & Pamukcu, 1991).

Castro (1987, cited by Rauch, 1997) classified the possible consequences of liquefaction in a soil deposit (Table 2.3). He developed his classification based on the relative magnitude of static driving shear stresses that may arise due to a surface slope or a foundation bearing load. He separated the table into three columns as follows: in-situ stress condition; soil behaviour; and typical field observation findings.

Figure 2.28 Schematic examples of large displacements (Seed et al., 2003)

Figure 2.29 Limited liquefaction-induced lateral translation (Seed et al., 2003)

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Figure 2.30 Schematic illustration of selected modes of liquefaction-induced vertical displacements (Seed et al., 2003)

Figure 2.31 Schematic illustration of selected modes of liquefaction-induced vertical displacements (Seed et al., 2003)

Table 2.3 Classification of soil liquefaction consequences (after Castro, 1987 cited by Rauch, 1997)

In-situ stress condition	**Soil behaviour**	**Typical field observation**
No driving shear stress	Volume decrease Pore pressure increase	Ground settlement Sand boils and ejection from surface fissures
Driving shear greater than residual strength	Loss of stability Liquefaction	Flow slides Sinking of heave buildings Floating of light structures
Driving shear less than residual strength	Limited shear distortion Soil mass remains stable	Slumping of slopes Settlement of buildings Lateral spreading

2.6 SUMMARY

Liquefaction may appear to be a very simple phenomenon but in fact there are many parameters that govern and control the liquefaction process, such as the intensity of the earthquake and its duration, the level of the groundwater table, soil type, relative soil density and permeability, particle size distribution, particle shape, depositional environment of the soil, drainage conditions, confining pressures, age and cementation of the soil deposits, stress history and additional loads (Sitharam et al., 2004). Taking into account the advantages of in-situ testing over the laboratory testing, the cone penetration test (*CPT*) is a superior tool for liquefaction assessment. Due to its continuous sampling and its more reliable measurements, the *CPT* offers enhanced liquefaction assessment over its predecessor, the standard penetration test (*SPT*). However, soil ageing, which affects the cyclic resistance ratio (*CRR*) is difficult, if not impossible, to evaluate using *CPT* due to disturbance during the test. This situation may lead to an excessively conservative estimation of *CRR* values from the *CPT* method. In 2008 an ageing correction factor was proposed to deal with this issue.

On the other hand, in 1980 the flat dilatometer test (*DMT*) was introduced by Marchetti and several researchers claimed that the *DMT* parameter K_D (horizontal stress index) is influenced by ageing of the soils. As a consequence, the *DMT* has also been used for liquefaction assessment.

The following chapter describes the characteristics of the site study, the framework of the site investigation, and the basic results of the field and laboratory work of this research.

Chapter Three

PROJECT SITE INVESTIGATION

3.1 INTRODUCTION

In order to evaluate the potential for liquefaction, a site was established and a field study undertaken. The field study aimed to establish the sub-surface profile and to characterise the variety of soil layers.

3.2 PROJECT SITE LOCATION

Priority was given to choosing an area which had a very high liquefaction susceptibility, contained Holocene soil deposits and has potentially a peak ground acceleration (*PGA*) >0.2 *g*. A site at Gillman, South Australia, Figure 3.1, was chosen for conducting the field study.

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Figure 3.1 Field study incorporating a general geological setting (Love, 1996)

The selected site was located in of the area of Port Adelaide, north-east of the city and within the Adelaide Plains. The area of study exhibited a flat, low lying morphology, and is less than five metres above mean sea level. The topsoil consists of a mixture of gravel, sand and silt.

The physiography of the site environs was classified by Aitchison et al. (1954) as an estuarine plain. It stretches along the coast of the Gulf of St. Vincent from Glenelg to Outer Harbour. This estuarine plain is a swampy area with an elevation of less than six metres and sporadic red sand-dunes in the Adelaide Plains.

In general, the selected site satisfied the objectives of the research as it was located within a zone of relatively high seismicity in Australia, as shown in Figure 3.2. Most researchers stated that seismicity in Australia is associated with intra-plate movement along faults.

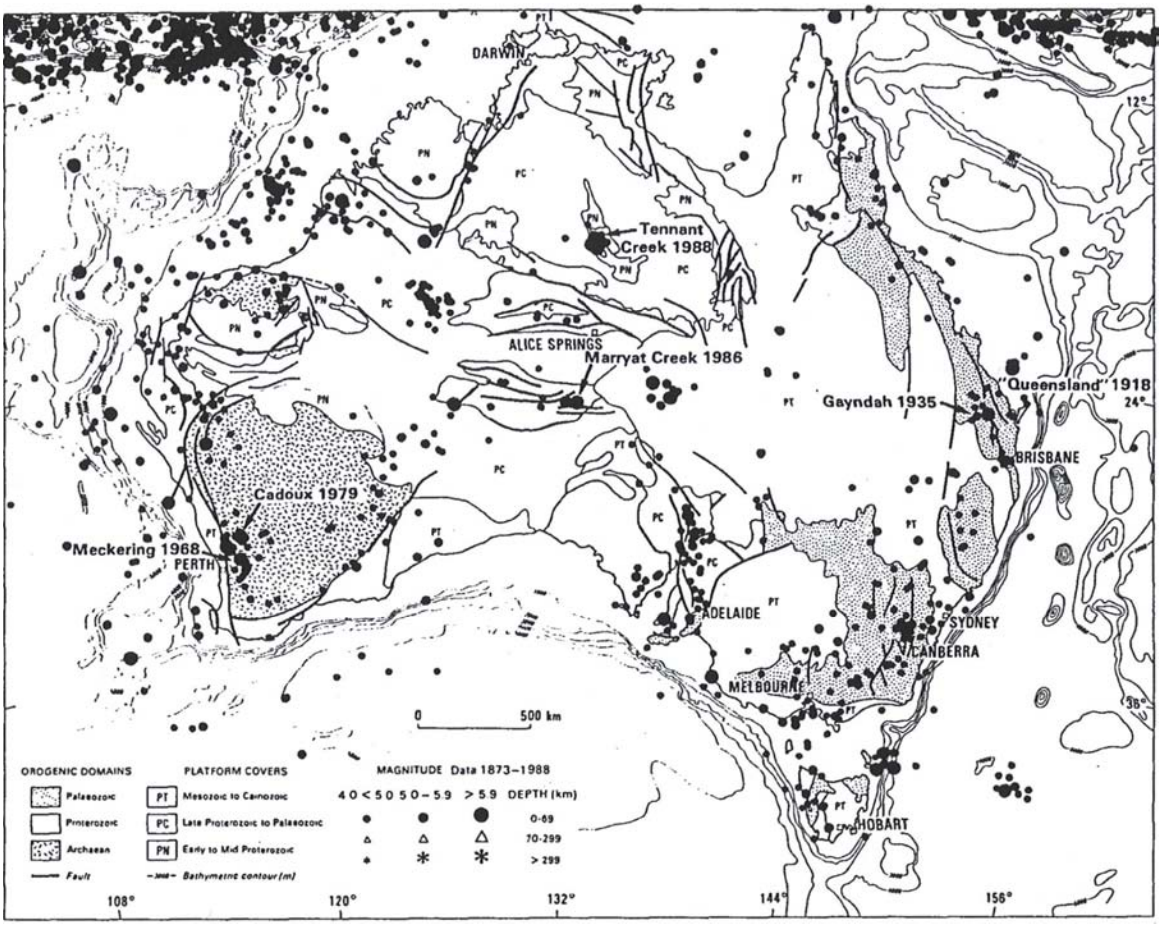

Figure 3.2 Australian earthquake epicentres with ML≥4 from 1859 to 1988 (Gaull et al., 1990)

To satisfy the objectives of the research, the selected study site also lies in a formation that is very susceptible to liquefaction, as established by Poulos et al. (1996) in an initial liquefaction susceptibility study in the Adelaide area. The researchers established three categories of liquefaction susceptibility in Adelaide: low, high and very high. Most of the Adelaide area, which is far from the coast line, falls into the low category except for the areas surrounding watercourses. Several coastal areas such as Port Adelaide, Henley Beach and Glenelg are in the zone of very high risk of liquefaction. The detail zoning incorporated in the study with reference to the study site is shown in Figure 3.3.

Figure 3.3 Adelaide liquefaction potential assessment (Poulos et al., 1996)

A detailed liquefaction study of the St. Kilda Formation was carried out by Mitchell (2009) to the east of Outer Harbour, Port Adelaide. His liquefaction analysis was based on two assumptions: a 5.8 earthquake magnitude and 0.15 *g* peak ground acceleration. Two types of in-situ testing methods (*SPT* and *CPT*) were performed at four different locations on the site. Mitchell (2009) found two ambiguous results. Liquefaction evaluation from his *SPT* data exhibited a contractive behaviour, whereas analysis from the *CPT* data showed a dilative behaviour. He subsequently conducted extensive side-by-side in-situ testing comparing *SPT* and *CPT*, and suspected that systematic human error caused the *SPT* data to be lower than the expected values.

3.3 STUDY CHARACTERISTICS OF THE SITE

Historical and existing information related to the project site provided the appropriate subsurface conditions and the likelihood of earthquakes occurring at the site. Moreover, the site allowed an efficient site-specific experimental program to be developed. It included the geological history, stratigraphy of the soil strata and geotechnical characteristics of the site. Knowledge of these aspects of the site allowed the extent and properties of unconsolidated deposits that could be prone to liquefaction to be understood. Such information was recorded on maps or cross-sections or in descriptions related to the nature, thickness, and origin of deposits of the formations at the site.

3.3.1 Geological history of project site and the surrounding area

A geological history of a region provides an understanding of the present day configuration of the existing morphology and an insight into the continuing processes that occur. The period of geological history of most relevance in this research is the Quaternary, the most recent of the three periods of the Cenozoic Era in the geological time scale. The Quaternary Period includes two recent geologic epochs: the Pleistocene and the Holocene, and has lasted approximately 2.6 million years.

Over that period, erosion and deposition processes along Adelaide’s shoreline were influenced by three separate sea level transgressions (Figure 3.4) which are indicated by the unconformity between the Hallett Cove Sandstone and the Burnham Limestone, between the Burnham Limestone and the Glanville Formation, and between the Glanville Formation and the St. Kilda Formation (Sheard & Bowman, 1996).

Figure 3.4 Sequence stratigraphy of Adelaide in the Quaternary Period (Sheard & Bowman, 1996)

However, a study by Belperio and Rice (1989) found that the sedimentary processes closely linked to variations in the sedimentary framework of the study site were influenced by only two separate sea level transgressions. These two marine episodes are separated by the Glanville Formation and the St. Kilda Formation (Figure 3.5).

Figure 3.5 Quaternary sedimentary deposits within the study site (Belperio & Rice, 1989)

As seen in Figure 3.5, Belperio and Rice (1989) stated that the underlying firm formation at the project site was the Hindmarsh Clay which was deposited in the Pleistocene epoch. The Hindmarsh Clay is estimated to be up to 70 m thick in this area. This formation consists of fluvial and alluvial sandy clays and clayey sands that were deposited in distal piedmont fan environments in the latter part of the epoch. Soil in the Hindmarsh Clay from the earlier part the epoch is highly impermeable, stiff, plastic, red-brown sandy clay.

3.3.2 Seismicity of the study site

Several earthquakes had already occurred near the study site that were typical of the general seismicity in the Australian Continent. The Adelaide Earthquake, for example, occurred on February 28, 1954. It was associated with intra-plate activity along the Burnside-Eden Fault and had a Richter magnitude of 5.5 (Selby, 1984; Love, 1996), as shown in Figure 3.6.

Figure 3.6 Major fault zones and epicenters around Adelaide (Selby, 1984)

Recent research suggests that there is some movement associated with geodynamic activity within the Adelaide geosynclines, as shown in Figure 3.7.

Figure 3.7 Adelaide geodynamic activity since 1870 (Selby, 1984)

3.3.3 Soil profile of the study site and the surrounding area

The study site lies in the Adelaide Plains. There are three formations deposited less than 10,000 years ago in the Adelaide Plains: the St. Kilda Formation, Golden Grove Dune Sand Formation and the Recent Undifferentiated Alluvium/Colluvium (Sheard & Bowman, 1996). The St. Kilda Formation consists of predominantly marine units whereas the others, Golden Grove Dune Sand Formation and Recent Undifferentiated Alluvium/Colluvium, mostly consist of terrestrial deposits. Of particular interest for this study was the St. Kilda Formation as it lays along the areas that exhibit very high liquefaction susceptibility (Poulos et al., 1996).

Belperio & Rice (1989) divided the St. Kilda Formation into nine facies which are sandy shore-face facies, back-barrier sand facies, tidal-channel sand facies, sub-tidal seagrass bank facies, inter-tidal sand flat facies, mangrove facies, supra-tidal marsh facies, sub-tidal lagoon facies and transgressive facies. The relationships between the major facies types that make up the Holocene coastal marine sequence of the St Kilda Formation are shown schematically in Figure 3.8.

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Figure 3.8 Holocene sedimentary facies of St Kilda Formation (Belperio & Rice, 1989)

The St. Kilda Formation is mostly composed of a loose unconsolidated mixture of sea shells and organic matter. These Quaternary deposits lie on a stable formation approximately 10 m thick. These non-lithified sediments pose two main threats: amplification and liquefaction. No explicit amplification study has been carried out on the St. Kilda Formation. To date, there is only general and very broad information regarding amplification in Adelaide, which is by Love (1996). He didn't write much about the amplification ratio for Adelaide, but he discussed the average response spectra amplification of 2.3 for the Adelaide region. Liquefaction of these deposits has received more attention than amplification. In the last decades there were at least two liquefaction assessments that cover the study site. One was by Poulos et al. (1996) and the other by Mitchel (2009). These studies involved a variety of conventional site investigation techniques such as the *SPT* and *CPT*.

In addition, Sheard and Bowman (1996) conducted a detailed evaluation on soils, stratigraphy and engineering geology of near surface materials of the Adelaide Plains. Of particular interest were their two composite grain size analyses of the St. Kilda Formation. Sieve analyses of marine sand composites are shown in Figure 3.9. Analyses of the aeolian sands of the St. Kilda Formation are shown Figure 3.10.

Figure 3.9 Composite grain size analysis for marine sand of the St. Kilda Formation (Sheard & Bowman, 1996)

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Figure 3.10 Composite grain size analysis for aeolian sand of the St. Kilda Formation (Sheard & Bowman, 1996)

Both results show that the sand of the St. Kilda Formation is the most liquefiable soil when assessed using a screening criterion developed by Ishihara et al. (1989, cited by Kavazanjian et al., 1997), as shown in Figure 3.11.

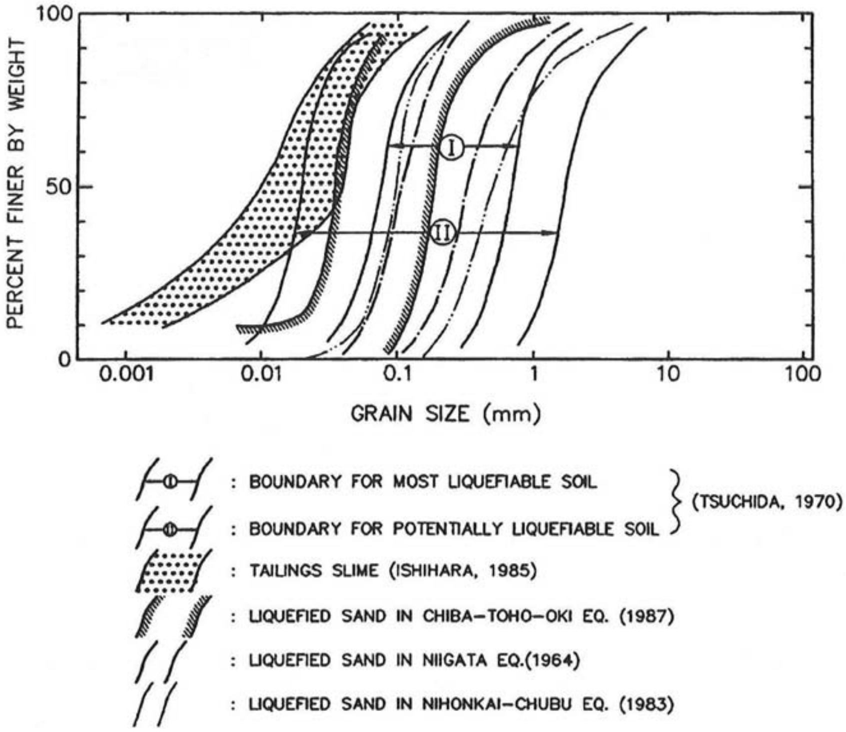


Figure 3.11 Grain size analysis curves of potentially liquefiable sands (after Ishihara et al. 1989 cited in Kavazanjian et al., 1997)

3.4 SUB-SURFACE EXPLORATION PROGRAM

After examining the site characteristics described above, it was expected that there would be some differences at various locations across the study site, in particular for the Holocene deposits. This situation had to be considered when developing the sub-surface exploration program and involved decisions regarding the sampling/investigation method, boring/in-situ testing locations/layout, the depth of the sub-surface exploration, and the number and types of laboratory tests.

3.4.1 Sub-surface soil sampling

Sub-surface sampling is a critical component of any site exploration program. Sampling is performed to satisfy several objectives, including: identification of the sub-surface distribution of materials, including the presence and stratigraphy of the various layers; determination of the engineering properties of each layer by laboratory testing from the retrieved samples; evaluation of the groundwater characteristics; and providing access for any in-situ testing equipment.

There are many types of techniques used in current practice for soil sampling. In this research, the sampling was achieved using a geoprob continuous direct push method. The sub-surface samples were obtained by successively pushing the 1.5 metre long geoprob sampler into the borehole and placing the soil into a core box.

3.4.2 In-situ testing layout

In-situ testing is generally conducted to ascertain the geotechnical properties of the soil layers, as well as to identify the soil layers. Two methods were used in this research: the cone penetration test (*CPT*) and the flat dilatometer test (*DMT*). The layout of the in-situ testing is shown in Figure 3.12. The testing was arranged in such a manner as to comply with the *ISSMFE* (1989) standard, which states that *CPT*s shall not be performed within horizontal spacing of less than 25 boring diameters to existing boreholes or at least two metres from other penetration tests.

Figure 3.12 Layout plan of in-situ testing of the present study (adapted from Kaggwa et al., 1996)

As shown in Figure 3.12, there is a cluster of in-situ tests within a radius of four metres which consist of three *CPT*s, one *DMT* and two continuous sampling bores. These in-situ tests were carried out as close as possible to enable reliable comparisons to be made and to minimise spatial variability.

Two continuous sample cores were necessary to provide samples for visual inspection and laboratory analysis. These continuous samples also enabled the soil profile to be logged. Therefore, the combination of adjacent *CPT*, *DMT* and continuous sampling promised to be very helpful for the simultaneous evaluation of soil parameters for the liquefaction assessment at the designated location. All the in-situ tests and laboratory tests were carried out in accordance with the relevant international standards (Swedish Geotechnical Society, 1992; Standards Australia, 1993, 2004; Marchetti et al., 2001).

3.4.3 The depth of the sampling and the in-situ testing

In some cases, liquefaction has been known to occur at depths greater than 15 m (Martin & Lew, 1999). However, in most cases a depth of 15 m has been used for the evaluation of liquefaction or until non-liquefiable soils are encountered. In this research, the termination depth of the sub-surface program was taken to be the firm foundation of the Hindmarsh CLAY Formation. At the project site it was expected that the firm foundation would be found at a depth of approximately 10.5 m to 12.0 m.

3.4.4 Geotechnical laboratory testing program

The purpose of laboratory testing was to determine the physical properties of the soil materials and quantify the engineering parameters that were used in the liquefaction evaluation. Laboratory testing for this liquefaction assessment was divided into two categories: laboratory testing for correction of the soil types and laboratory testing for determination of the critical state line. The correction of soil types consisted of sieve analysis, natural moisture content and Atterberg limit tests.

The types of laboratory testing for soil classification and soil type screening are listed in Table 3.1. Initially, disturbed samples of soils were classified according to the Unified Soil Classification System (*USCS*) (AS 1726-1993). Upon visual verification of the soil samples, moisture content, sieve analyses and Atterberg limit tests were performed.

Table 3.1 Laboratory tests for soil types evaluation

Type of laboratory testing	Reference
Natural moisture content	AS 1289.2.1.1
Liquid limit	AS 1289.3.9
Plastic limit	AS 1289.3.2.1, 3.3.1
Sieve analysis	AS 1289.3.6.1
Specific gravity	ASTM D 854-00

3.5 PERFORMANCE AND RESULTS OF THE IN-SITU TESTING AND SAMPLINGS

The in-situ testing and sampling were conducted on soil deposits which were located in the St. Kilda Formation. This field work was carried out during two different periods: 10th June 2010 and 28th – 29th June 2010. As shown in Figure 3.13, the site investigation consisted of cone penetration tests (*CPT*s), flat dilatometer tests (*DMT*s) and continuous sampling with standard penetration tests (*SPT*s). *CPT* #1 and sampling with *SPT* #1 were completed on 11th June 2010. *CPT* #2, *CPT* #3 and *DMT* #1 were performed on 28th June 2010 and sampling with *SPT* #2, was completed on 29th June 2010, as summarised in Figure 3.13. In addition, some aspects of the site investigation are shown in Figures 3.14 to 3.16.

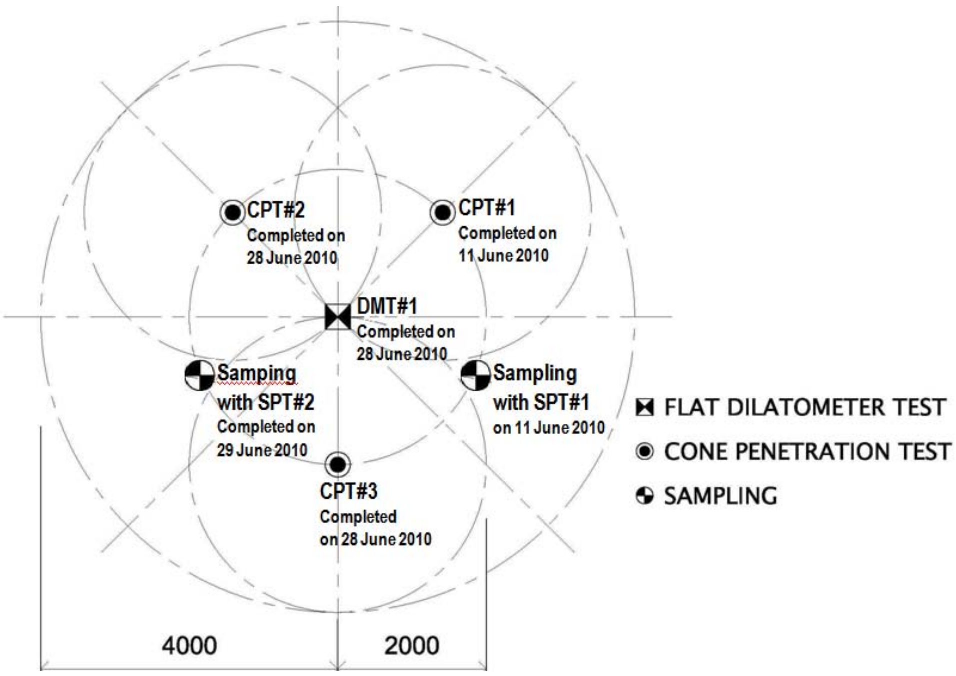


Figure 3.13 Detail schedule of completion of the in-situ testing and continuous sampling

Figure 3.14 Continuous sampling activities at Sampling #1 and Sampling #2

Figure 3.15 *CPT* in-situ testing activities at *CPT* #1

Figure 3.16 *DMT* in-situ testing activities at *DMT* #1

Detail of the results of the field work, including sampling and in-situ testing, are discussed below.

3.5.1 Borehole engineering log

A detailed and accurate description of soils is important in establishing their general engineering properties. The description should identify the type of soil, consistency/relative density, moisture conditions and colour. The borehole engineering log contains visual identification techniques which are consistent with the *USCS* (AS 1726-1993). The description of the soils consists of soil composition, condition of the soil and additional soil features observed. However, slight discrepancies may exist between the identification recorded in the field log and the classifications determined later in the laboratory.

Detailed borehole engineering logs are presented in Appendix A. Extracts from the Appendix A are shown in Figures 3.17 and 3.18.

DEPTH (M)	FORMATION	THICKNESS (M)	**DESCRIPTION OF STRATA** **Strength, soil type, colour, particle size, secondary and minor components, structure and other features**
1,0	FILL	0.80	Firm; gravelly SILT with fine to medium sand at the base; light to dark brown, yellowish brown; dry to greater than the plastic limit; gravel is fine to coarse grained, sub-rounded to angular; a trace of brick and rock fragments (FILL) (0.80)
		0.55	Very stiff; silty CLAY; yellowish brown, mottled with grey & reddish brown; greater than the plastic limit; (FILL) (1.35)
2,0	MADE GROUND	1.35	Medium dense; silty SAND mixture with silty clay; light to dark grey, dark brown; moist to wet; sand is fine to coarse grained, sub-rounded to rounded a trace of rock fragments; odour (MADE GROUND) (2.70)
3,0 4,0	St. Kilda Formation	2.00	Very loose; clayey SAND; grey, light brown; wet; sand is fine grained, rounded some sea shells (4.70)
5,0		0.95	Firm to stiff; sandy CLAY; grey; greater than the plastic limit; sand is fine grained, rounded a trace of roots (5.65)
6,0		0.35	Stiff to very stiff; CLAY; brown; greater than the plastic limit (6.00)
7,0 8,0 9,0		3.00	Loose to medium dense; silty to clayey SAND; light brown, light yellow, yellow; wet; sand is fine to coarse grained, sub-rounded to rounded a trace of gravel & sea shells (9.00)
10,0	Hindmarsh CLAY	1.50	Stiff to very stiff; sandy CLAY; brown, spotted grey & light brown; greater than the plastic limit sand is fine grained, rounded a trace of fine gravel (10.5)

Figure 3.17 Summary of borehole engineering log at BH #1

DEPTH (M)	FORMATION	THICKNESS (M)	DESCRIPTION OF STRATA Strength, soil type, colour, particle size, secondary and minor components, structure and other features
	FILL	0.70	Firm; gravelly sandy SILT with a greater sand content at the base; brown, light brown, light grey; moist to wet; gravel is fine to coarse grained, angular; sand is fine to coarse grained, angular to sub-angular (FILL) (0.70)
1,0	MADE GROUND	0.50	Stiff; gravelly CLAY; brown, cream, grey, reddish brown; gravel is fine to coarse grained, angular; much less than the plastic limit; a trace of gravel size brick fragments (MADE GROUND) (1.20)
2,0	Recent deposit	1.00	Very loose; silty SAND mixture with silty clay; light to dark grey, dark brown; moist to wet; sand is fine to coarse grained, sub-rounded to rounded a trace of rock fragments; odour (2.20)
3,0 4,0	St. Kilda Formation	2.10	Very loose; silty SAND; grey, light yellow; wet; sand is fine to medium grained, rounded (4.30)
5,0		0.70	Very soft to soft; sandy CLAY; grey; much greater than the plastic limit; sand is fine to medium grained, rounded to sub-rounded (5.00)
6,0		1.10	Soft to very stiff; CLAY; brown, grey; much less to much greater than the plastic limit; with traces of sand pockets and decay of woods slightodour at upper part (6.10)
		0.20	Soft; sandy CLAY; grey, light brown; sand is fine to medium grained, sub-rounded to rounded; much greater than the plastic limit (6.30)
7,0 8,0		2.20	Loose; silty SAND; light yellow, cream; wet; sand is fine to coarse grained, sub-angular to angular some fine to coarse gravel (8.50)
9,0		0.60	Stiff to very stiff; silty CLAY; light grey; much greater than the plastic limit (9.10)
10,0 11,0	Hindmarsh CLAY	1.90	Firm to stiff; CLAY with some silt and a trace of sand content at the middle of the layer; brown, light grey; greater to much greater than the plastic limit (11.0)
12,0		0.80	Stiff; sandy CLAY; brown, mottled grey; much greater than the plastic limit; sand is fine to medium grained, rounded (11.8)
		0.65	Firm to very stiff; CLAY; brown, spotted grey; much less than the plastic limit (12.45)

Figure 3.18 Summary of borehole engineering log at BH #2

3.5.2 *DMT* in-situ testing results

As mentioned earlier, generally, *DMT* test results can be used to evaluate sand liquefaction for engineering practice after the raw data (readings A and B) have been corrected for offset in the measurement gauge and membrane stiffness (parameter ΔA and ΔB) (Marchetti et al., 2001). Detailed *DMT* measurements are shown in Appendix B. Furthermore, interpretation of dilatometer modulus, soil density and shear wave velocity has been carried out. The results from the *DMT* soundings are shown in Figure 3.19. Plots of those three main dilatometer indices material index, I_D, dilatometer modulus, E_D, and horizontal stress index, K_D, are given as a function of depth.

3.5.3 *CPT* in-situ testing results

As discussed in Chapter 2, in routine practice, three measurements of cone penetration test parameters are made: cone tip resistance; sleeve friction; and friction ratio. Details of these basic *CPT* measurements are included in Appendix C. The correlation of *CPT* data with other soil properties such as soil interpretation, soil unit weight and shear wave velocity is normally carried out on the basis of a combination of these values. The results of the *CPT*s are shown in the Figures 3.20, 3.21 and 3.22.

3.6 LABORATORY TESTING RESULTS

The laboratory tests were carried out to obtain the geotechnical properties of the soils for the soil types evaluation in the liquefaction assessment. The laboratory tests were conducted according to the relevant standards as shown in Table 3.2. Details of the laboratory test results are given in Appendix D. A summary of the results are presented into Tables 3.2 and 3.3.

Carbonate content testing results

In addition to the laboratory tests mentioned previously, a carbonate content soil test was also performed, as several researchers, such as Jha (1994), Belperio & Rice (1989) and Sheard & Bowman (1996) have identified that some of the St. Kilda Formation contains carbonaceous content and this may influence the soil's liquefaction behaviour. In this study, the carbonate content of the soil was obtained by treating a dried and crushed specimen, approximately 100 g in weight and, adding to it, approximately 200 ml of hydrochloric acid (HCl) until the reaction between the calcium carbonate and the

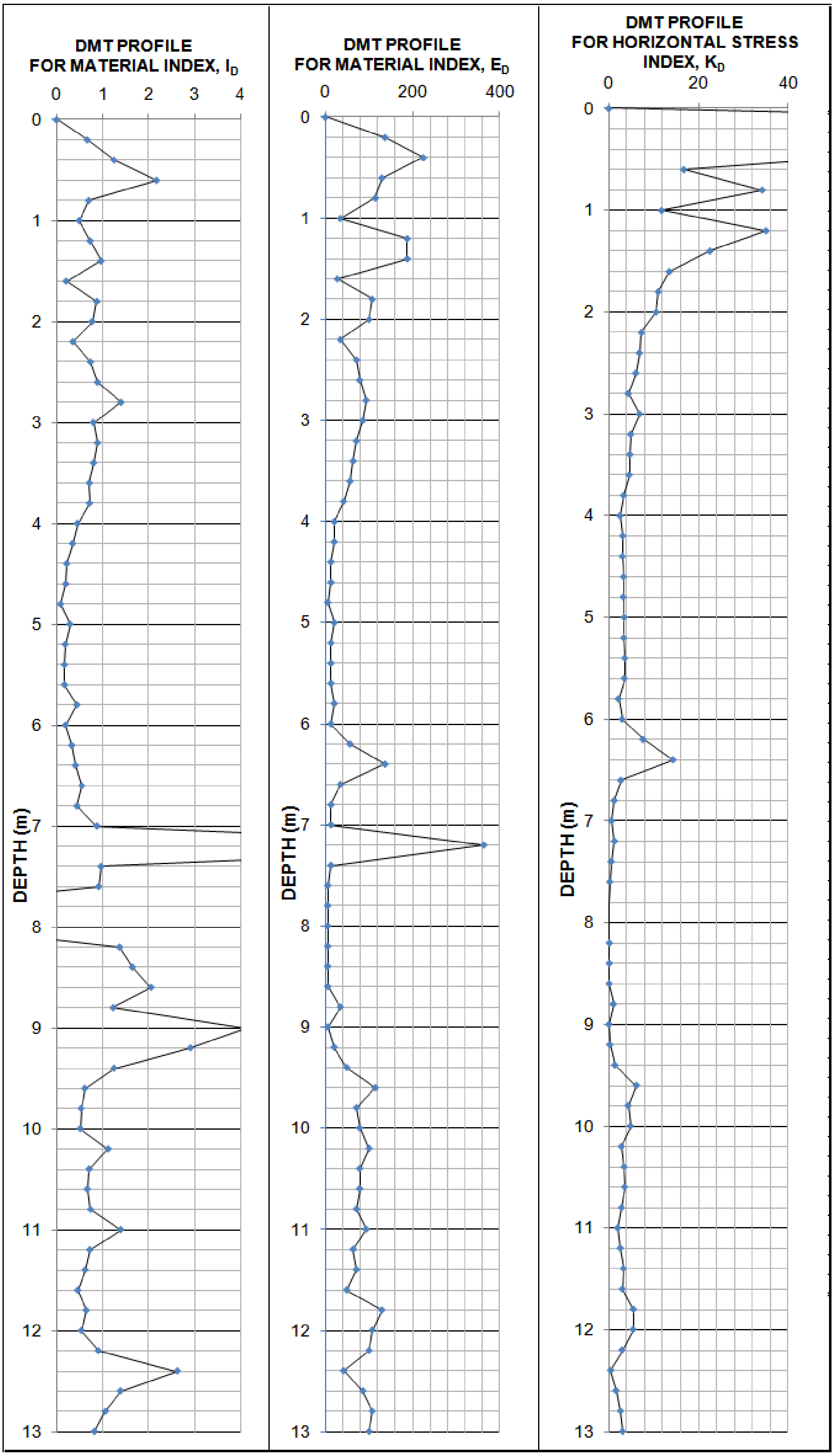


Figure 3.19 Estimate I_D, E_D and K_D in depth from the in-situ *DMT* testing

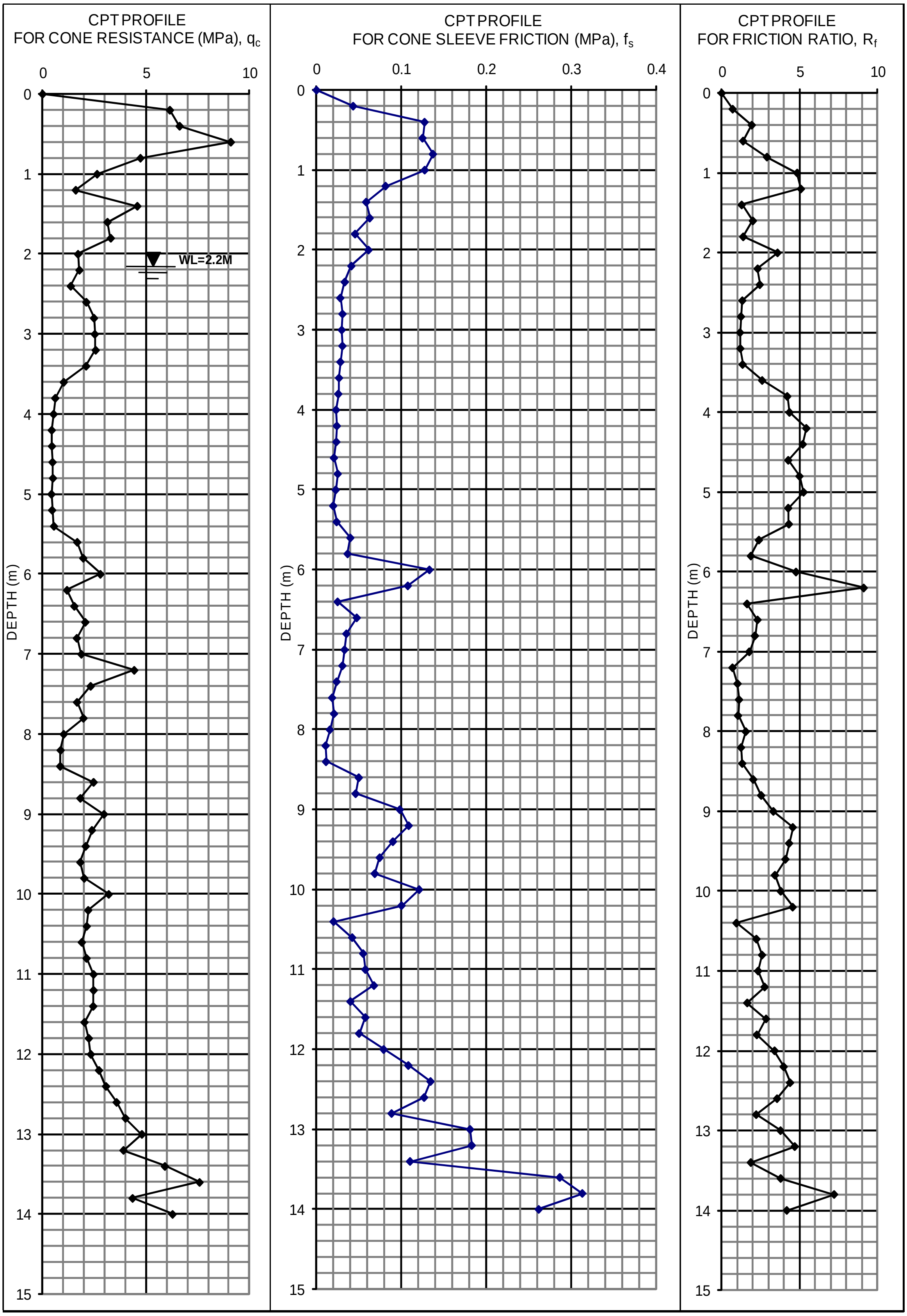


Figure 3.20 *CPT* #1 in-situ testing results

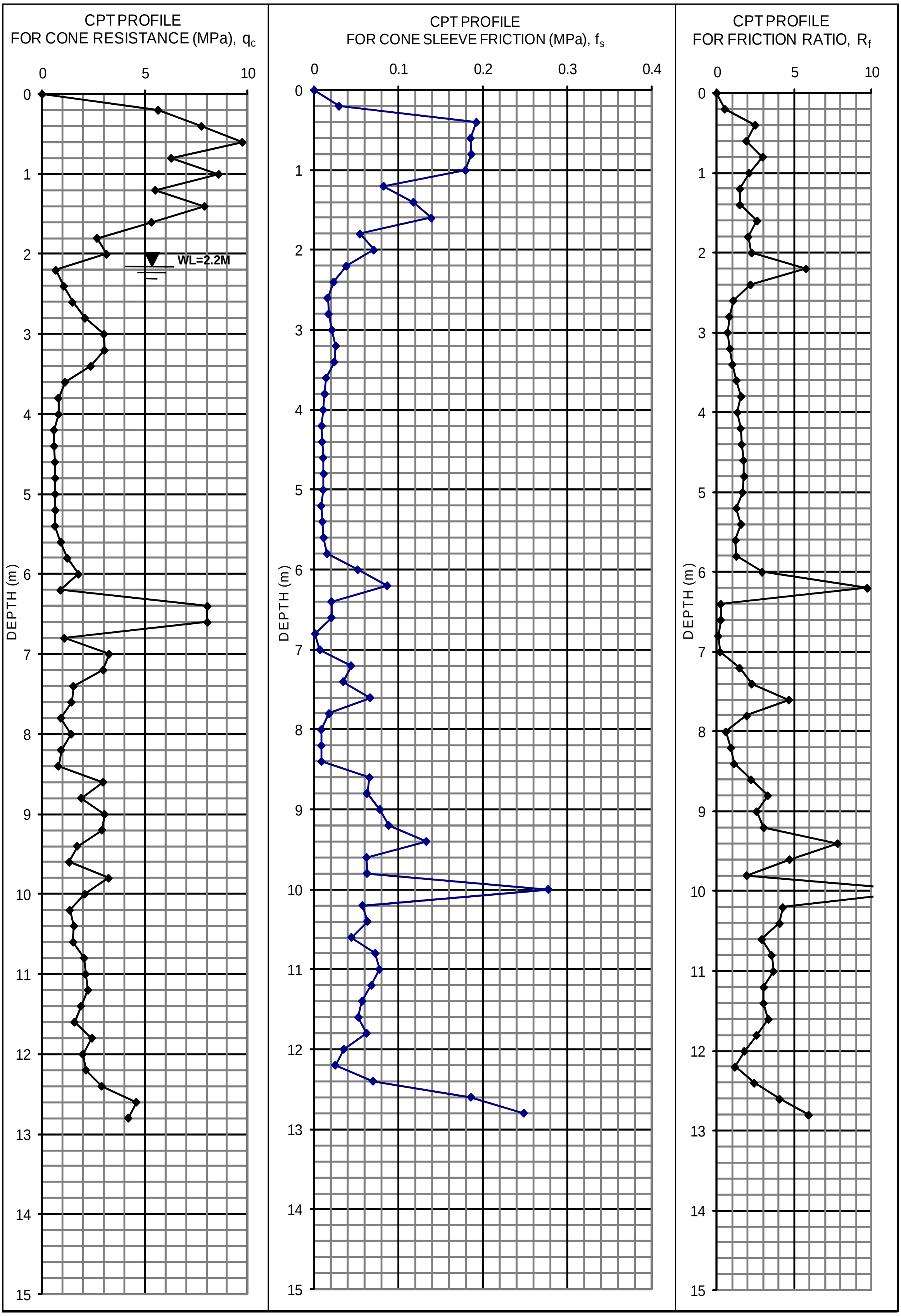


Figure 3.21 *CPT* #2 in-situ testing results

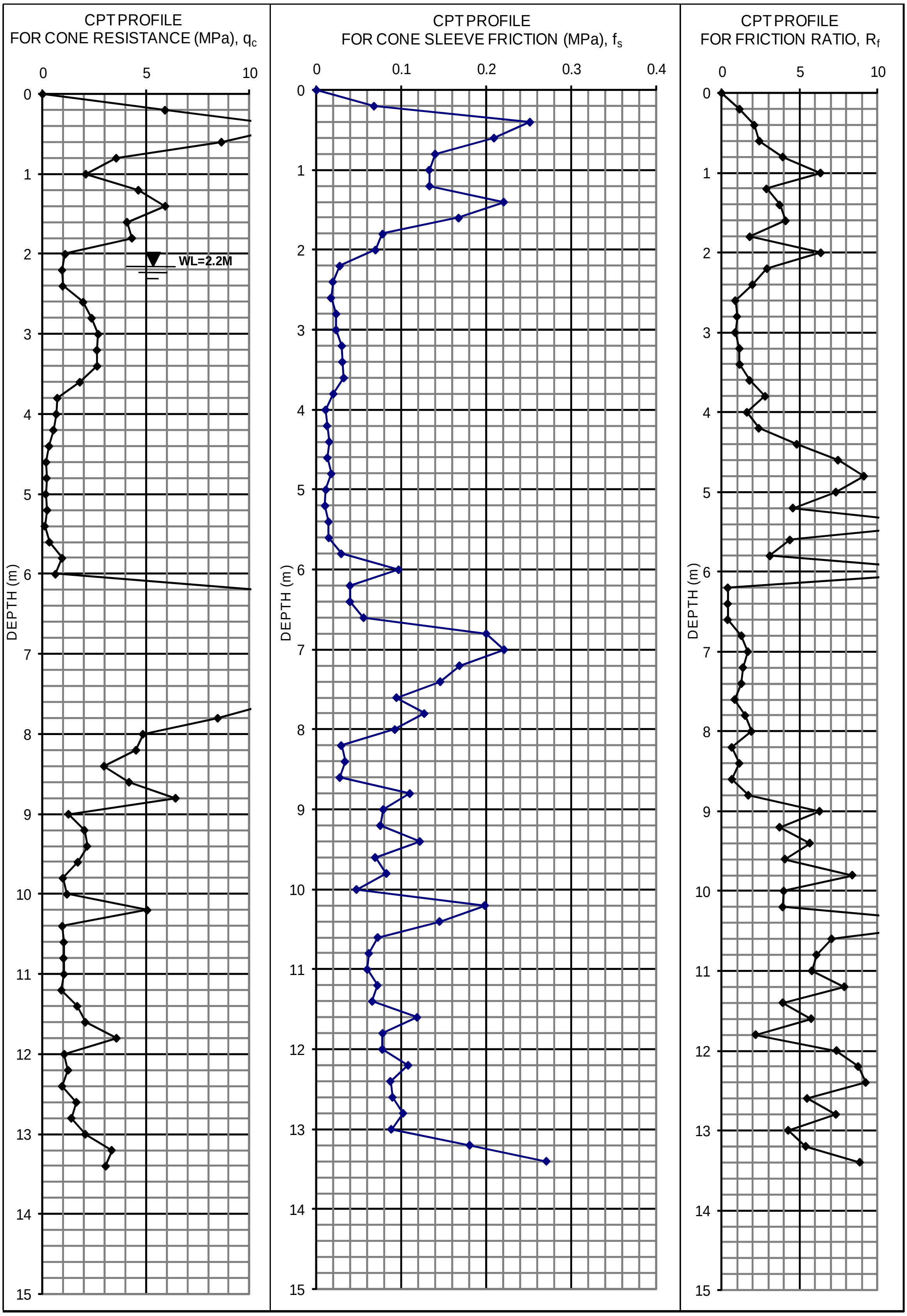


Figure 3.22 *CPT* #3 in-situ testing results

Table 3.2 Laboratory testing results for the fine content correction for *BH* #1

Depth (m)	USCS Classification	BH #1 standard laboratory testing results						
		MC (%)	LL (%)	PL (%)	PI (%)	Gravel (%)	Sand (%)	Fine (%)
0.00 – 1.35	CL - Inorganic clays of low plasticity, Sandy CLAY	7.9	28.0	14.1	13.9	6.3	43.7	50.0
1.35 – 2.70	SM – Silty SAND	39.2	23.4	19.5	3.8	7.3	64.2	28.5
2.70 – 4.70	SM – Silty SAND	50.4	35.2	32.3	2.9	3.2	72.4	24.4
4.70 – 6.00	CL - Inorganic clays of low plasticity, Sandy CLAY	51.9	30.4	18.0	12.4	1.8	44.6	53.6
6.00 – 9.00	SM – Silty SAND	33.1	29.3	25.7	3.6	6.4	75.8	17.8
9.00 – 10.50	CI - Inorganic clays of medium plasticity, Silty CLAY	22.6	37.5	18.0	19.5	2.2	3.4	94.4

NOTE:
- MC (Moisture Content)
- LL (Liquid Limit)
- PL (Plastic Limit)
- PI (Plasticity Index)
- Fines content (<0.075mm)

hydrochloric acid was complete. The basic chemical reaction involved in this test is shown as follows:

$$CaCO_3 + 2\,HCl \rightarrow Ca{\downarrow}Cl_2 + H_2O + CO_2{\uparrow}$$

The carbonate content testing was only carried for the granular soils found in this study and the results are shown in Table 3.4.

The soils examined by Jha (1994) were found to possess a carbonate content of between 12.4% to 23.6%. However, as shown in Table 3.4, the carbonate content of the soils at the Gillman study site is significantly lower than those examined by Jha (1994), with a carbonate content of only between 2.5% and 4.1%. Thus, the influence of the presence of carbonaceous material on the overall soil characteristics is expected to be marginal.

Table 3.3 Laboratory testing results for the fine content correction for *BH* #2

Depth (m)	USCS Classification	BH #2 standard laboratory testing results						
		MC (%)	LL (%)	PL (%)	PI (%)	Gravel (%)	Sand (%)	Fine (%)
0.00 – 0.70	SM - Silty SAND	8.6	23.0	22.8	0.2	9.4	73.6	17.0
0.70 – 1.20	CL - Inorganic clays of low plasticity, Gravelly/sandy CLAY	10.2	27.6	14.2	13.4	10.3	19.6	70.1
1.20 – 2.20	SM – Silty SAND	36.0	23.5	19.5	4.2	6.5	66.6	26.9
2.20 – 4.30	SM – Silty SAND	67.3	35.2	31.0	4.2	6.3	71.7	22.1
4.30 – 6.30	CI – Inorganic clays of medium plasticity, Sandy CLAY	69.4	44.7	24.7	20.0	9.1	40.7	50.3
6.30 – 8.50	SM – Silty SAND	26.6	28.8	25.7	3.1	12.3	68.8	18.9
8.50 – 9.10	CL - Inorganic clays of low plasticity, Gravelly/sandy CLAY	24.5	28.7	14.1	14.6	0.7	25.6	73.7
9.10 – 12.45	CL - Inorganic clays of low plasticity, Gravelly/sandy CLAY	15.2	30.8	13.7	17.2	3.1	28.5	68.4

NOTE:
- MC (Moisture Content)
- LL (Liquid Limit)
- PL (Plastic Limit)
- PI (Plasticity Index)
- Fines content (<0.075mm)

Table 3.4 Results of carbonate content test

BH No.	Depth of soil sample (m)	USCS classification of soil sample	Dried weight sample before reaction (g)	Dry weight sample after reaction (g)	Percentage of carbonate content (%)
BH #1	1.35 – 2.70	SM – Silty SAND	100.1	96.0	4.1
	2.70 – 4.70	SM – Silty SAND	99.7	96.0	3.7
	6.0 – 9.0	SM – Silty SAND	100.3	97.2	3.1
BH #2	1.20 – 2.20	SM – Silty SAND	99.7	96.7	3.0
	2.20 – 4.30	SM – Silty SAND	101.3	98.1	3.2
	6.30 – 8.50	SM – Silty SAND	99.9	97.4	2.5

3.7 SUMMARY

A site at Gillman, *SA*, was chosen to conduct the field testing and to collect samples for subsequent laboratory testing. The site was chosen because it has been identified as possessing a very high risk of potential liquefaction during an earthquake event.

The soil profiles derived from the two boreholes, which were separated by a distance of approximately 3 m, are similar, but there is a discrepancy in terms of the level of the various layers encountered. These discrepancies are consistent with the variability and stratigraphy of natural soils.

Generally, the soil profile of the site consists of fill materials at the upper surface which are a mixture of sandy SILT and sandy CLAY with some gravel in the top part of the layer. This top layer is about 1.4 m thick and is FILL MATERIAL. Underlying the top soil to about 4.6 m depth is silty SAND, followed by sandy CLAY to about 6.2 m depth. This fine grained soil was underlain by silty SAND to about 8.8 m depth. Finally, there was CLAY with a little sand and traces of gravel from 8.8 m below ground level to the bottom of the hole (12.4 m). Thus, this simplified soil profile indicated that there were two liquefaction susceptible layers at the study site. The first liquefaction susceptible layer is from 1.2 to 4.2 m below the ground level and the second layer is between 6.0 and 8.8 m depth.

The results of the field work are used in the next chapters. The following chapter details a site-specific ground response analysis which is very important to obtain the site-specific peak ground acceleration (*PGA*) in particular.

Chapter Four

SITE-SPECIFIC GROUND RESPONSE ANALYSIS

4.1 INTRODUCTION

Generally, the preferred method of estimating site-specific peak ground acceleration (*PGA*), a_{max}, is to use the applicable attenuation function of the site (National Center for Earthquake Engineering Research, *NCEER*, 1996 & 1998) because this method accounts for the specific conditions of the site, such as earthquake history, distance from the epicenter and geological/geotechnical site conditions. Developing an attenuation relationship in a low seismicity region such as Australia, however, is very challenging because of the incomplete seismic catalog. Insufficient recorded data for the Adelaide region could lead to the estimation of an inappropriate attenuation relationship. Therefore, a site-specific *PGA* estimated by using a site-specific ground response analysis was developed, as this method has proven able to depict seismic wave behaviour in soft local soil deposits.

This chapter explains the ground response analysis at the study site. The results were used for further analysis in the liquefaction assessment. At the beginning of the chapter the background of the analytical model for site-specific response analysis is briefly discussed. In addition, the basic sequence of the site-specific ground response analysis is presented.

The following sections of the chapter explain in detail the sequence of steps used in the site-specific ground response analysis for this research. It begins with site characterisation, followed by obtaining and converting the earthquake input motions. After that, the method used to run the computer programs (*SHAKE91* and *EERA*) is explained, which includes assigning the input data, running and comparing the results, and checking the input commands and input data of both software packages. Following this, several samples of the software outputs are presented and the end of the chapter discusses the results of the site-specific ground response analysis.

4.2 SITE-SPECIFIC GROUND RESPONSE ANALYSIS

Site-specific peak ground acceleration (*PGA*) is crucial for assessing the liquefaction potential of soil using the simplified procedure proposed by Seed & Idriss (1971). Thus, a site-specific ground response analysis has to be taken into consideration for this seismic hazard assessment. In addition, it has been well established that rock-based earthquake motions can be amplified on soft soil sites and cause severe structural damage, such as in the 1985 Mexico earthquake, the 1988 Armenian earthquake, and the 1989 Loma Prieta earthquake in California.

Analytical models for a site-specific ground response analysis demonstrated that they are able to simulate reasonably well the soil behaviour due to dynamic loading. One of the most widely used models is the equivalent linear approximation of nonlinear response technique which is included in the *SHAKE* (Schnabel et al., 1972) and Equivalent-linear Earthquake Response Analysis (*EERA*) (Bardet et al., 2000) computer programs.

The *SHAKE* program has been one of the most commonly used computer programs in geotechnical earthquake engineering since it became available in 1972. *SHAKE* has the advantage of simplicity and a compact file system. The program has been modified several times to suit the rapid changes in computer technology since it was first published by Schnabel et al. (1972). The latest modification was undertaken by Idriss & Sun in 1992. At this point they named it *SHAKE91* (Idriss & Sun, 1992). Therefore, this computer program was chosen for use in this study.

The *EERA* program was developed from the basic principles of the *SHAKE* program. It was selected as the comparator of the *SHAKE* for this study because the program takes full advantage of the latest development of *FORTRAN* 90 and the Windows platform. *EERA* is not a stand-alone program. It is an add-on program embedded in Microsoft Excel. A contemporary computer program, *EERA* is suitable for use in conducting a site-specific ground response analysis (Bardet et al., 2000).

During the site-specific ground response analysis using *SHAKE91* and *EERA*, a sequence of steps (Figure 4.1) is followed to interpret the earthquake motions in the stable ground surface or bedrock to account for their effects on the soil profile at any specific site. The first step is site characterisation, which involves in-situ testing, soil sampling and laboratory testing as outlined in Chapter 3. The output of the site characterisation process is a simplified soil profile which represents the designated site. Simultaneously with the site characterisation the earthquake's motions are manipulated to suit the input format of the computer programs. Both the simplified soil profile and compatible earthquake motions are used as input to the program during ground response analysis. These processes are discussed in the following sub-sections.

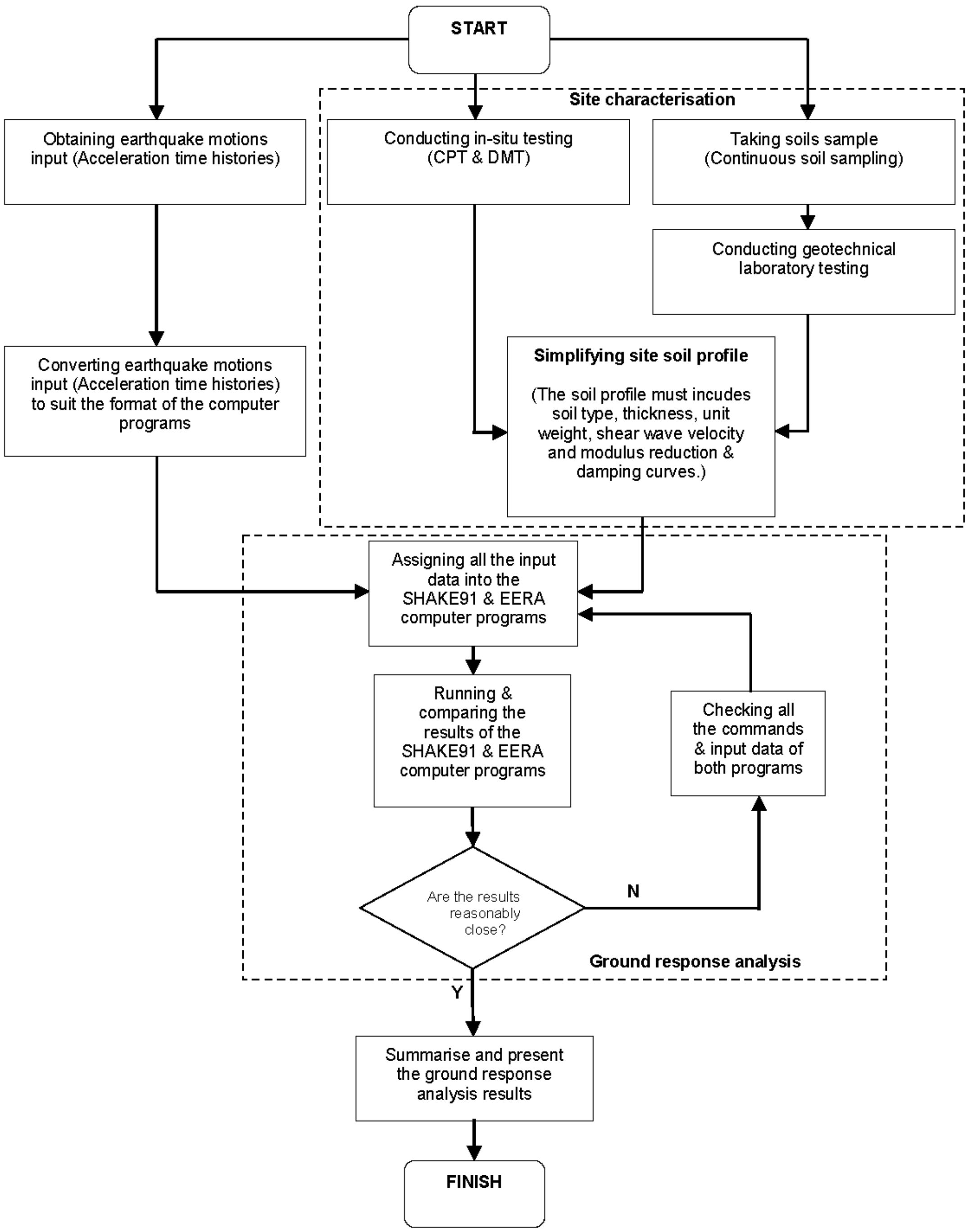


Figure 4.1 Sequence of steps for site-specific ground response analysis

4.2.1 Characterisation of the site

Site characterisation was based on the results of the *CPT* and *DMT* in-situ testing, continuous sampling and laboratory testing. Then a simplified representative soil profile was selected for the analysis. This simplified soil profile described the soil type, its unit weight and its thickness. Dynamic soil parameters, shear wave velocity, the shear modulus-strain curve, and the damping-strain curve were then developed. Each of these parameters is described in the following sections.

4.2.1.1 Soil profiles

Three different approaches have been used to obtain the soil profile of the site: (1) a visual description supported by laboratory testing; (2) *DMT* results; and (3) *CPT* results. Each of the estimated soil profiles was used independently for the liquefaction assessment.

Visual description of the laboratory soil profiles

Two continuous samples were taken and visual descriptions of the samples from the borehole recorded. The descriptions are given in Appendix A and are summarised in Figures 3.2 and 3.3. Several laboratory tests were undertaken to augment the visual description and soil classification. Natural moisture content, sieve analysis, liquid limit and plastic limit were all measured. The summary of the laboratory test results is given in Table 3.2 and details are provided in Appendix D.

The soil profiles derived from the two boreholes, which were separated by a distance of approximately 3 m, were similar, but there was a discrepancy in terms of the level of each layer in the boreholes. These discrepancies are consistent, however, with the variability and stratigraphy of natural soils. A simplified, single soil profile was derived from BH #1 and BH #2, as shown in Figure 4.2.

Estimated soil profile from DMT data

The basic soil classification method of the *DMT* makes use of the Material Index, I_D, proposed by Marchetti (1980). Marchetti's criterion for each classification is as follows:

a) CLAY, if: $0.1 < I_D < 0.6$ ……………………………………………....(4.1a)

b) SILT, if: $0.6 < I_D < 1.8$ ……………………….................................. (4.1b)

c) SAND, if: $1.8 < I_D > 10$ ……….……………………......………….. (4.1c)

Figure 4.3 shows the estimated soil profiles using the I_D of the *DMT*. In addition, the *DMT*'s p_0 and p_1 profiles are incorporated into the Figure 4.3 as well.

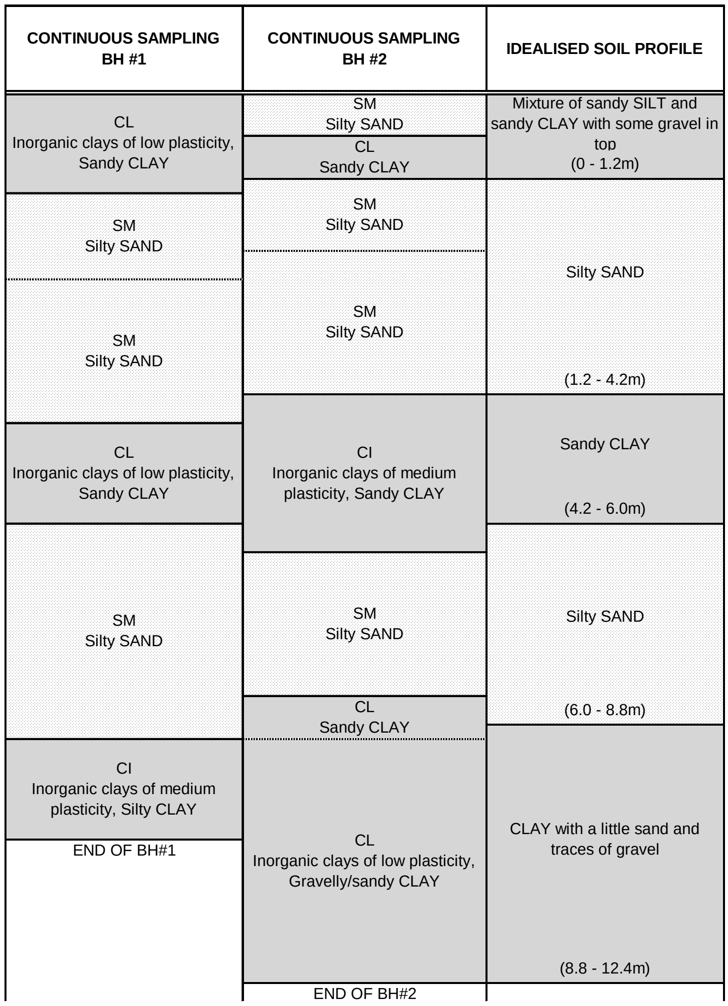


Figure 4.2 Soil profiles from continuous sampling at Gillman, SA

Estimated soil profile from CPT data

Robertson et al. (1986) provided a framework for soil classification using *CPT* data which is based on the relationship between the cone tip resistance and the friction ratio. Soils with a low tip resistance and high friction ratio tend to be classified as fine-grained material, whereas soils with a high cone tip value and low friction ratio are usually identified as coarse-grained soil. The results of the *CPT*-based soil classification method are presented in Figures 4.4, 4.5 and 4.6, as obtained from the *CPT* #1, *CPT* #2 and *CPT* #3, respectively.

Another way in which to estimate the soil columns from *CPT* data is by using the cone tip resistance and the friction ratio profiles as shown in Figure 4.7. A general guideline for interpreting the soil classification using this method is to regard coarse-grained soils as those with a moderate-high cone resistance and a low friction ratio, while the fine-grained soils are likely to have low-moderate cone resistance and a high friction ratio. Soil interpretation using this method indicated that there were likely to be two liquefiable layers at the study site. These were from 1.2 to 4.2 m below ground level and from 6.0 to 9.0 m below ground level. The first layer exhibited very loose to loose soil density, whereas the second layer seemed to range from a loose to medium dense condition.

Discussion and comparison of soil profiles

The water table at the study site was very shallow at only 2.2 m below ground level. This is likely to result in high natural moisture contents from the water table downward.

All methods used to develop the soil profiles at the study site are simplified and presented in Figure 4.8. As shown in the figure, the soil classification using Marchetti's criterion was unable to detect the presence of the coarse-grained soils found in the continuous sampling. Marchetti's soil classification, based on I_D only, shows that there is a 0.8 m thick SAND layer at the study site between approximately 8.4 to 9.2 m in depth.

The simplified soil profile derived from the p_0 and p_1 profiles of the *DMT*, as shown in Figure 4.8, is much better than the Marchetti soil classification. The *DMT* seems able to detect several features related to the current research. Two compressible layers were found 4.0 to 6.0 m below ground level and 7.4 to 8.6 m below ground level. It was expected that the two layers would be the two liquefaction susceptible layers found in the visual description extracted from the laboratory soil profiles. Another interesting feature was the finding of a thin crust layer at 7.2 m below ground level.

The soil profile derived from the *DMT* data, therefore, revealed that soil classification using the material index, I_D, of the *DMT* agreed poorly with the soil profiles of the boreholes. However, a simplified soil profile from the *DMT's* p_0 and p_1 could be used for the ground response analysis in this study. A similar finding was also found by Jha (1994) during his research in an area approximately 1 km north of this study site.

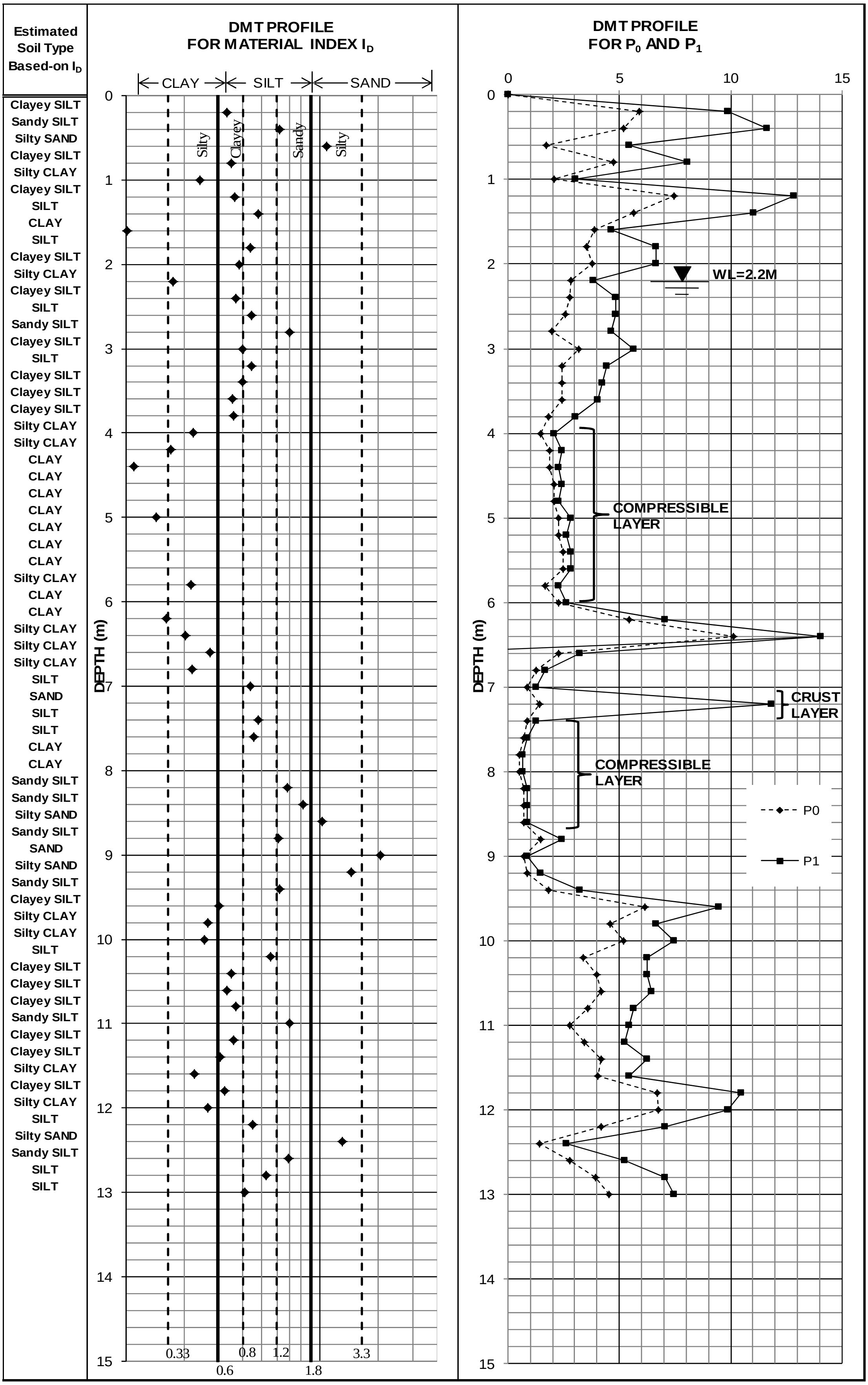
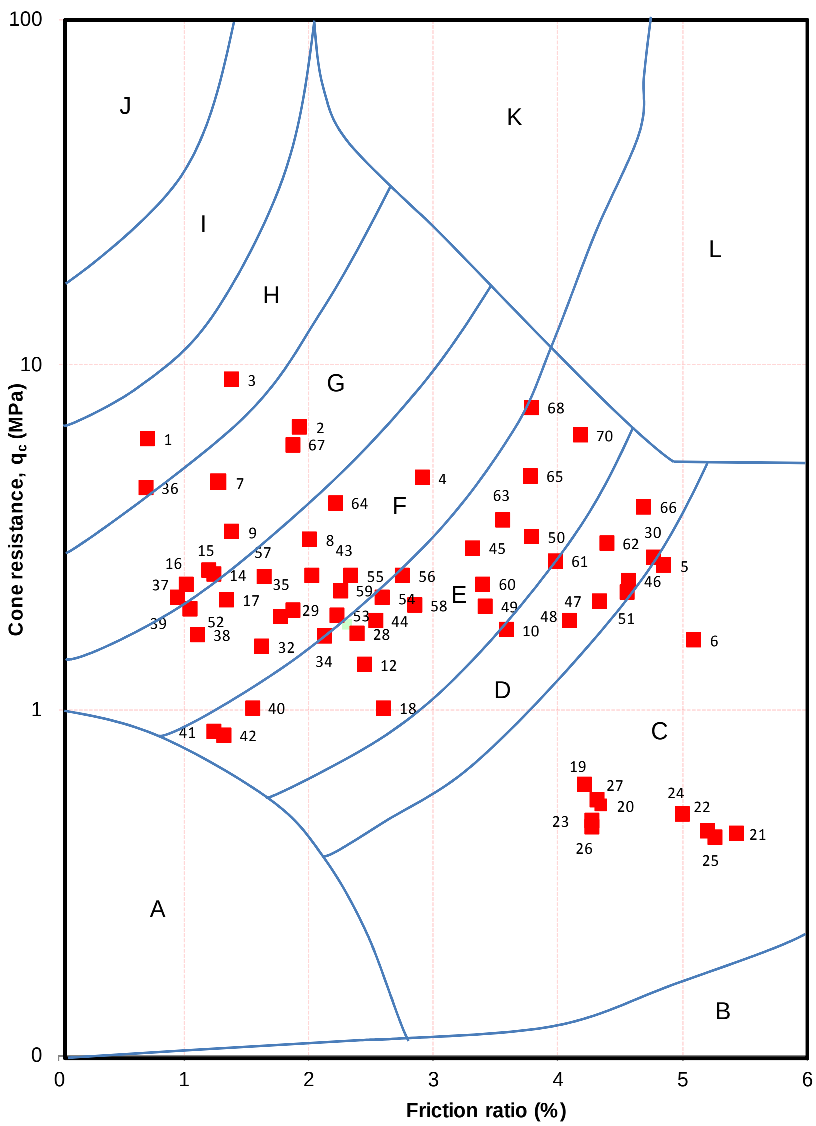


Figure 4.3 Estimated soil profiles from *DMT* data from Gillman, SA

Proposed soil clasification system from CPT data (Robertson et al., 1986)



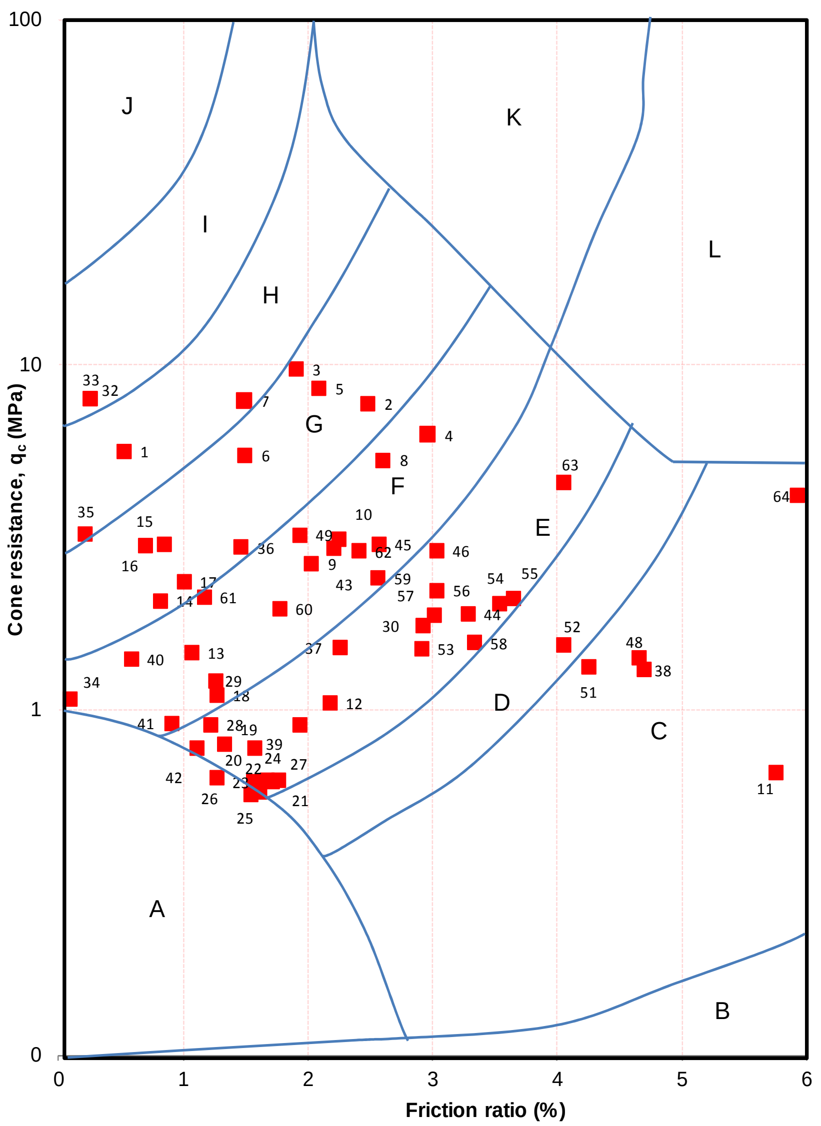
Note:

A- Sensitive fine grained
B- Organic material
C- Clay
D- Silty clay to clay
E- Clayey silt to silty clay
F- Sandy silt to clayey silt
G- Silty sand to sandy silt
H- Sandy to silty sand
I- Sand
J- Gravelly sand to sand
K- Very stiff fine grained
L- Sand to clayey sand

	Interpretation of soil type behaviour	DEPTH (m)
(1)	Sandy to silty sand	
(2)	Silty sand to sandy silt	
(3)	Sandy to silty sand	
(4)	Sandy silt to clayey silt	
(5)	Silty clay	1
(6)	Clay	
(7)	Silty sand to sandy silt	
(8)	Sandy silt to clayey silt	
(9)	Silty sand to sandy silt	
(10)	Silty clay	2
(11)	Silty clay	
(12)	Clayey silt to silty clay	
(13)	Sandy silt to clayey silt	
(14)	Sandy silt	
(15)	Sandy silt	3
(16)	Sandy silt	
(17)	Sandy silt to clayey silt	
(18)	Clayey silt to silty clay	
(19)	Clay	
(20)	Clay	4
(21)	Clay	
(22)	Clay	
(23)	Clay	
(24)	Clay	
(25)	Clay	5
(26)	Clay	
(27)	Clay	
(28)	Clayey silt to silty clay	
(29)	Sandy silt to clayey silt	
(30)	Silty clay to clay	6
(31)	Clay	
(32)	Sandy silt to clayey silt	
(33)	Sandy silt to clayey silt	
(34)	Clayey silt to silty clay	
(35)	Sandy silt to clayey silt	7
(36)	Sandy to silty sand	
(37)	Silty sand to sandy silt	
(38)	Sandy silt to clayey silt	
(39)	Sandy silt to clayey silt	
(40)	Clayey silt to silty clay	8
(41)	Clayey silt to silty clay	
(42)	Clayey silt to silty clay	
(43)	Sandy silt to clayey silt	
(44)	Clayey silt to silty clay	
(45)	Clayey silt to silty clay	9
(46)	Clay	
(47)	Silty clay to clay	
(48)	Silty clay to clay	
(49)	Silty clay to clay	
(50)	Clayey silt to silty clay	10
(51)	Silty clay to clay	
(52)	Sandy silt to clayey silt	
(53)	Clayey silt to silty clay	
(54)	Clayey silt to silty clay	
(55)	Clayey silt to silty clay	11
(56)	Clayey silt to silty clay	
(57)	Silty sand to sandy silt	
(58)	Clayey silt to silty clay	
(59)	Clayey silt to silty clay	
(60)	Clayey silt to silty clay	12
(61)	Silty clay to clay	
(62)	Silty clay to clay	
(63)	Clayey silt to silty clay	
(64)	Sandy silt to clayey silt	
(65)	Clayey silt to silty clay	13
(66)	Silty clay to clay	
(67)	Silty sand to sandy silt	
(68)	Sandy silt to clayey silt	
(69)	Clay	
(70)	Clayey silt to silty clay	14

Figure 4.4 Soil classification using the Robertson et al. (1986) method for *CPT* #1 data at Gillman, SA

Proposed soil clasification system from CPT data (Robertson et al., 1986)



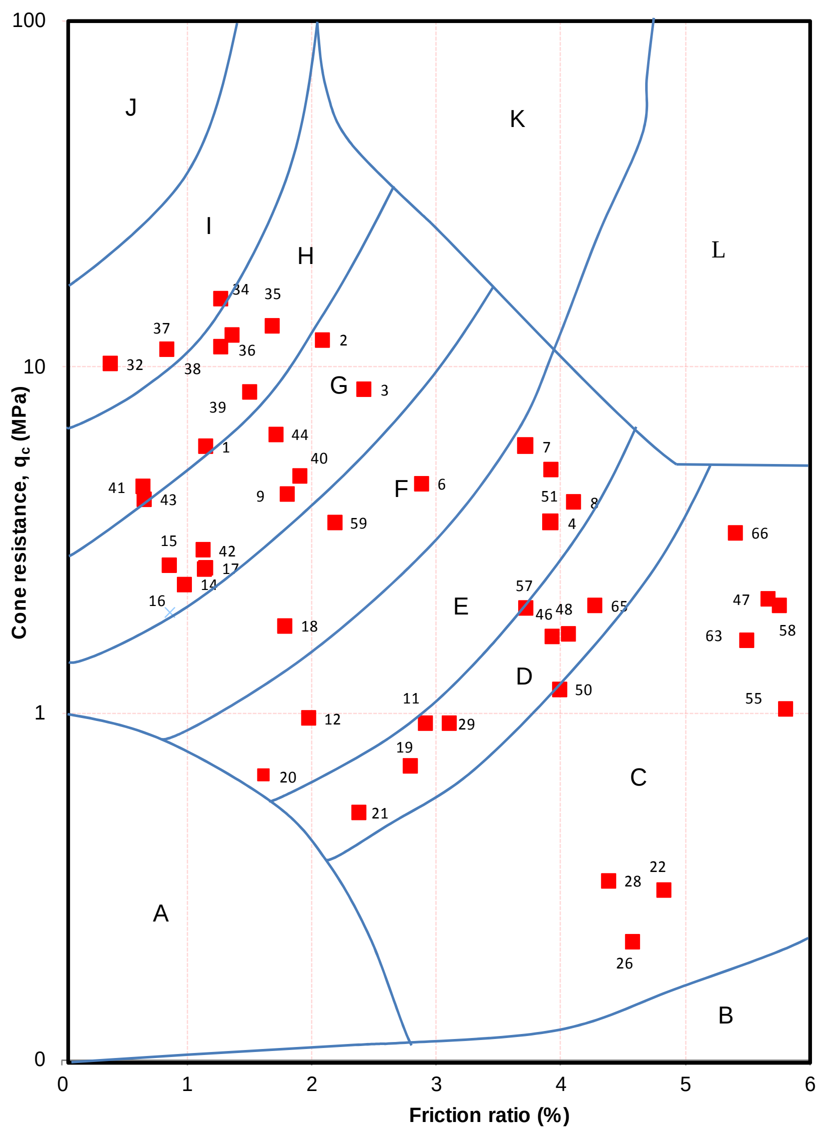
Note:

A- Sensitive fine grained
B- Organic material
C- Clay
D- Silty clay to clay
E- Clayey silt to silty clay
F- Sandy silt to clayey silt
G- Silty sand to sandy silt
H- Sandy to silty sand
I- Sand
J- Gravelly sand to sand
K- Very stiff fine grained
L- Sand to clayey sand

Interpretation of soil type behaviour		DEPTH (m)
(1)	Sandy to silty sand	
(2)	Silty sand to sandy silt	
(3)	Silty sand to sandy silt	
(4)	Sandy silt to clayey silt	
(5)	Silty sand to sandy silt	1
(6)	Silty sand to sandy silt	
(7)	Silty sand to sandy silt	
(8)	Clayey silt to silty clay	
(9)	Clayey silt to silty clay	
(10)	Sand	2
(11)	Clay	
(12)	Sandy silt to clayey silt	
(13)	Sandy silt to clayey silt	
(14)	Silty sand to sandy silt	
(15)	Silty sand to sandy silt	3
(16)	Silty sand to sandy silt	
(17)	Silty sand to sandy silt	
(18)	Sandy silt to clayey silt	
(19)	Clayey silt to silty clay	
(20)	Clayey silt to silty clay	4
(21)	Clayey silt to silty clay	
(22)	Clayey silt to silty clay	
(23)	Clayey silt to silty clay	
(24)	Clayey silt to silty clay	
(25)	Clayey silt to silty clay	5
(26)	Clayey silt to silty clay	
(27)	Clayey silt to silty clay	
(28)	Clayey silt to silty clay	
(29)	Sandy silt to clayey silt	
(30)	Clayey silt to silty clay	6
(31)	Clay	
(32)	Sand	
(33)	Sand	
(34)	Sandy silt to clayey silt	
(35)	Silty sand to sandy silt	7
(36)	Silty sand to sandy silt	
(37)	Clayey silt to silty clay	
(38)	Clay	
(39)	Clayey silt to silty clay	
(40)	Sandy silt to clayey silt	8
(41)	Sandy silt to clayey silt	
(42)	Clayey silt to silty clay	
(43)	Sandy silt to clayey silt	
(44)	Clayey silt to silty clay	
(45)	Sandy silt to clayey silt	9
(46)	Clayey silt to silty clay	
(47)	Clay	
(48)	Clay	
(49)	Sandy silt to clayey silt	
(50)	Clay	10
(51)	Clay 1	
(52)	Clay	
(53)	Clayey silt to silty clay	
(54)	Clayey silt to silty clay	
(55)	Clayey silt to silty clay	11
(56)	Clayey silt to silty clay	
(57)	Clayey silt to silty clay	
(58)	Clayey silt to silty clay	
(59)	Sandy silt to clayey silt	
(60)	Sandy silt to clayey silt	12
(61)	Sandy silt to clayey silt	
(62)	Sandy silt to clayey silt	
(63)	Clayey silt to silty clay	
(64)	Clay	12.8

Figure 4.5 Soil classification using the **Robertson et al. (1986) method for *CPT* #2 data at Gillman, SA**

Proposed soil clasification system from CPT data (Robertson et al., 1986)



Note:

A- Sensitive fine grained
B- Organic material
C- Clay
D- Silty clay to clay
E- Clayey silt to silty clay
F- Sandy silt to clayey silt
G- Silty sand to sandy silt
H- Sandy to silty sand
I- Sand
J- Gravelly sand to sand
K- Very stiff fine grained
L- Sand to clayey sand

Interpretation of soil type behaviour		DEPTH (m)
(1)	Silty sand to sandy silt	
(2)	Silty sand to sandy silt	
(3)	Silty sand to sandy silt	
(4)	Clayey silt to silty clay	
(5)	Clay	1
(6)	Sandy silt to clayey silt	
(7)	Clayey silt to silty clay	
(8)	Clayey silt to silty clay	
(9)	Silty sand to sandy silt	
(10)	Clay	2
(11)	Silty clay to clay	
(12)	Clayey silt to silty clay	
(13)	Silty sand to sandy silt	
(14)	Silty sand to sandy silt	
(15)	Silty sand to sandy silt	3
(16)	Silty sand to sandy silt	
(17)	Silty sand to sandy silt	
(18)	Sandy silt to clayey silt	
(19)	Silty clay to clay	
(20)	Clayey silt to silty clay	4
(21)	Silty clay to clay	
(22)	Clay	
(23)	Clay	
(24)	Clay	
(25)	Clay	5
(26)	Clay	
(27)	Clay	
(28)	Clay	
(29)	Silty clay to clay	
(30)	Clay	6
(31)	Sand	
(32)	Sand	
(33)	Sand	
(34)	Sandy to silty sand	
(35)	Sandy to silty sand	7
(36)	Sandy to silty sand	
(37)	Sand	
(38)	Sandy to silty sand	
(39)	Sandy to silty sand	
(40)	Silty sand to sandy silt	8
(41)	Sandy to silty sand	
(42)	Silty sand to sandy silt	
(43)	Sandy to silty sand	
(44)	Silty sand to sandy silt	
(45)	Clay	9
(46)	Silty clay to clay	
(47)	Clay	
(48)	Silty clay to clay	
(49)	Clay	
(50)	Clay	10
(51)	Clayey silt 1	
(52)	Clay	
(53)	Clay	
(54)	Clay	
(55)	Clay	11
(56)	Clay	
(57)	Silty clay to clay	
(58)	Clay	
(59)	Sandy silt to clayey silt	
(60)	Clay	12
(61)	Clay	
(62)	Clay	
(63)	Clay	
(64)	Clay	
(65)	Silty clay to clay	13
(66)	Clay	
(67)	Clay	13.4

Figure 4.6 Soil classification using the Robertson et al. (1986) method for *CPT* #3 data at Gillman, SA

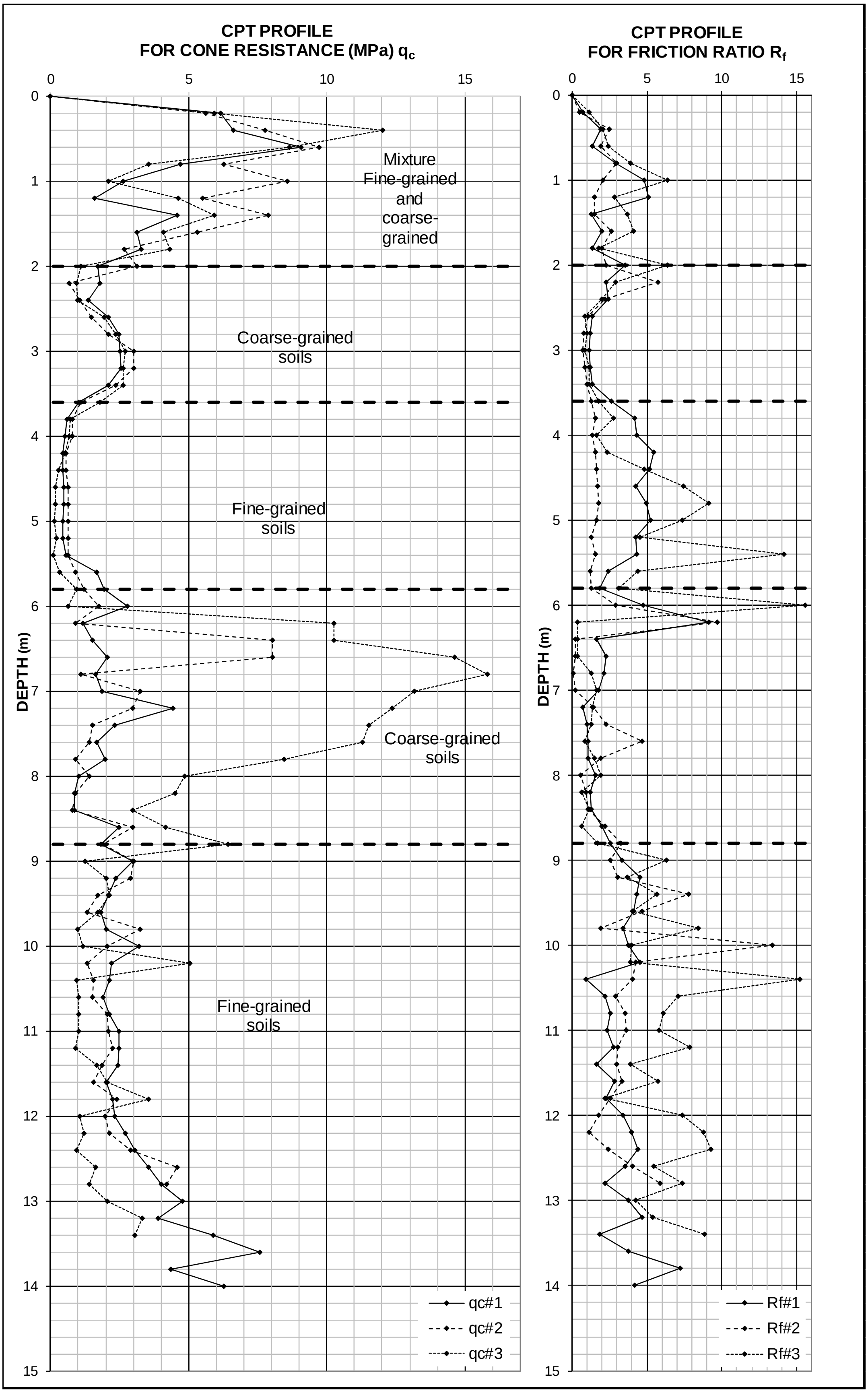


Figure 4.7 Cone resistance and friction ratio profiles from all *CPT* data at Gillman, SA

Soil profiles derived from *CPT* data using both Robertson et al.'s (1986) method and interpretation of the cone tip resistance and friction ratio profiles exhibit a good agreement with the simplified soil profile developed from continuous sampling shown in Figure 4.8. Of interest were two coarse-grained layers found using both types of profiling. The first layer is approximately 1.2 to 4.2 m below ground level and the second one from 6.0 to 9.0 m below ground level. However, only the soil profile developed from the profiles of the cone resistance and friction ratio was used to represent *CPT* for the ground response analysis in this study.

In the present study, the selected soil profile either from *DMT* or *CPT*, as mentioned above, was used individually during site-specific ground response analysis, which follow later in the thesis.

4.2.1.2 Shear wave velocity

Site-specific shear wave velocity, V_s, is necessary for a site response analysis and it is usually obtained by site measurement using the spectral analysis of surface waves (*SASW*) technique (GovindaRaju et al., 2004) or a seismic *CPTU* (Mayne, 2006; Paoletti et al., 2010). However, direct in-situ measurement using these methods was not feasible in this research as these items of equipment were not available. Therefore empirical methods using *CPT* and *DMT* data were considered for the analyses.

Shear wave velocity from CPT data

Currently, the published literature includes many empirical relationships to describe the correlation between *CPT* data and V_s. Some of the models are dependent on the soil type, while others depend on depth, fines content or geological age. The various published empirical relationships to estimate the shear wave velocity from the *CPT* data, such as Barrow & Stokoe (1983), Hegazy & Mayne (1995), Lyisian (1996), Mayne (2006) and Andrus et al. (2007), are shown in Table 4.1. These five empirical methods were used to estimate V_s from the three *CPT* soundings. Each of the estimated shear wave velocities is plotted with respect to depth in Figure 4.9.

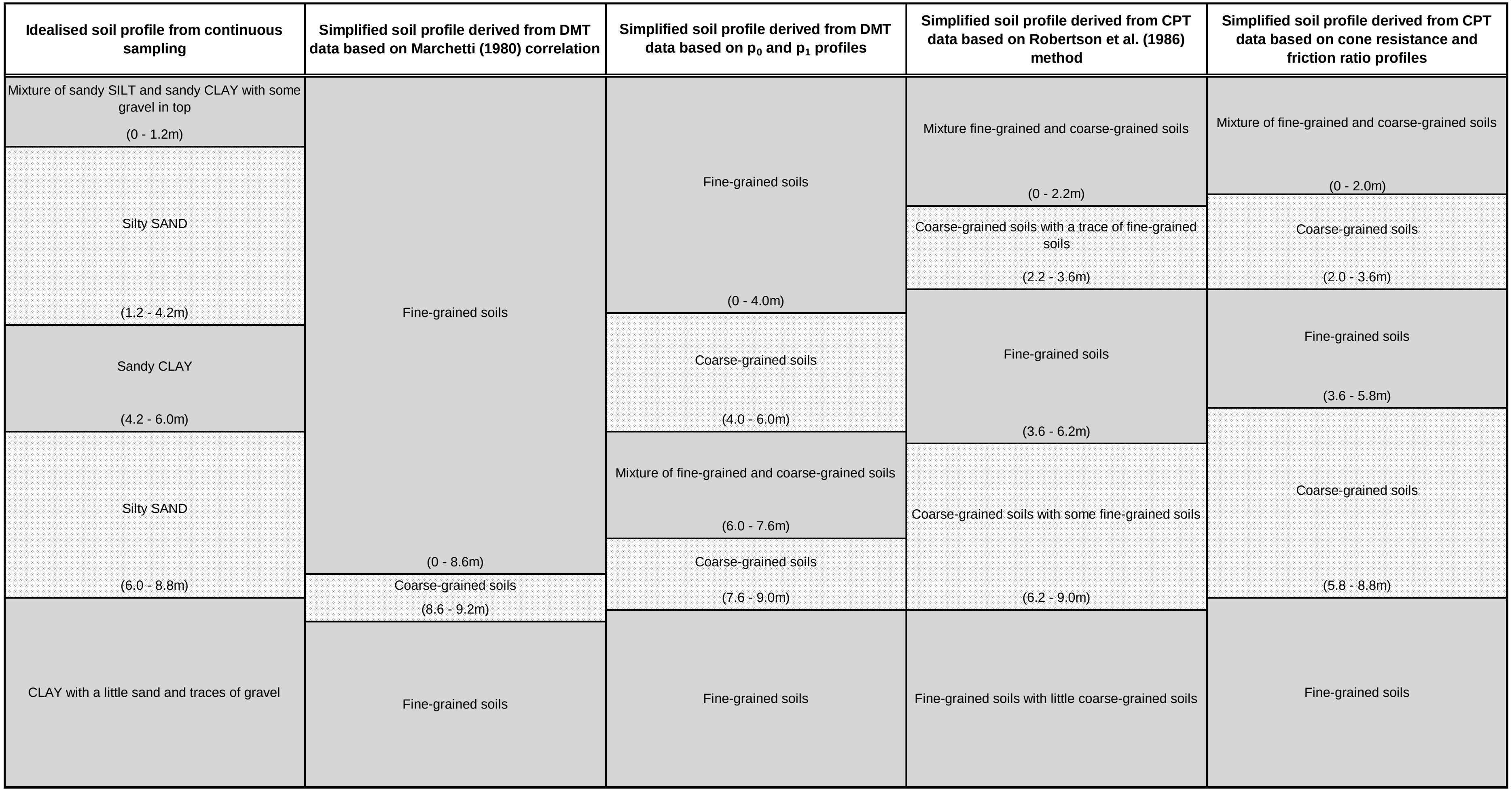


Figure 4.8 Comparison of simplified soil profiles from all in-situ data at Gillman, SA

Table 4.1 Relationships to estimate shear wave velocity from *CPT* data

Relationships	Remarks	Reference
$V_s = 154 + (0.64 \times q_c)$	V_s in m/s q_c in kg/cm^2	Barrow & Stokoe (1983)
$V_s = [(10.1 \times \log q_c) - 11.4]^{1.67} \times [f_s / q_c \times 100]^{0.3}$	V_s in m/s q_c & f_s in kPa	Hegazy & Mayne (1985)
$V_s = 55.3 \times q_c^{0.377}$	*Vs* in m/s q_c in MPa	Lyisian (1996)
$V_s = 118.8 \times \log(f_s) + 18.5$	*Vs* in m/s f_s in kPa	Mayne (2006)
1) For I_c<2.05 $V_s = 8.27 \times q_c^{0.285} \times I_c^{0.406} \times Z^{0.122}$ 2) For 2.05<I_c<2.60 $V_s = 4.63 \times q_c^{0.342} \times I_c^{0.688} \times Z^{0.092}$ 3) For I_c>2.60 $V_s = 0.208 \times q_c^{0.654} \times I_c^{1.910} \times Z^{-0.108}$	*Vs* in m/s q_c in kPa *Z* in metres	Andrus et al. (2007)

The plot reveals that the shear wave velocity estimations using these published relationships show a relatively wide variation in results. Consequently, the results were grouped into two different categories: lower and upper bound estimations. The relationships between q_c and estimated V_s of both bounds, as shown in Figure 4.10, are as follows:

$$V_s = 193.16 \times (q_c^{0.1998}) \text{ for the upper bound} \quad (4.2a)$$

$$V_s = 60.648 \times (q_c^{0.2686}) \text{ for the lower bound} \quad (4.2b)$$

To select the most representative shear wave velocities for this study site from the *CPT* data, extensive studies by Madiai & Simoni (2004) in Italy and Tsiambaos & Sibatakakis (2010) in Greece were examined. Madiai & Simoni (2004) found that an empirical *CPT*-shear wave velocity correlation proposed by Hegazy & Mayne (1985) had good agreement with their direct measurement using down-hole and cross-hole shear wave velocity testing. In addition, a curve of *CPT*-shear wave velocity relationship proposed by Tsiambaos & Sabatakakis (2010) was incorporated into Figure 4.10. The result implies that the correlation of the upper bound yields closer *V*s values to the Tsiambaos & Sabatakakis' correlation for all soil types than the correlation of the lower bound as shown in Figure 4.11. Therefore, the simplified upper bound relation is used to estimate the shear wave velocity from the *CPT* data for the site response analysis as presented in Table 4.2.

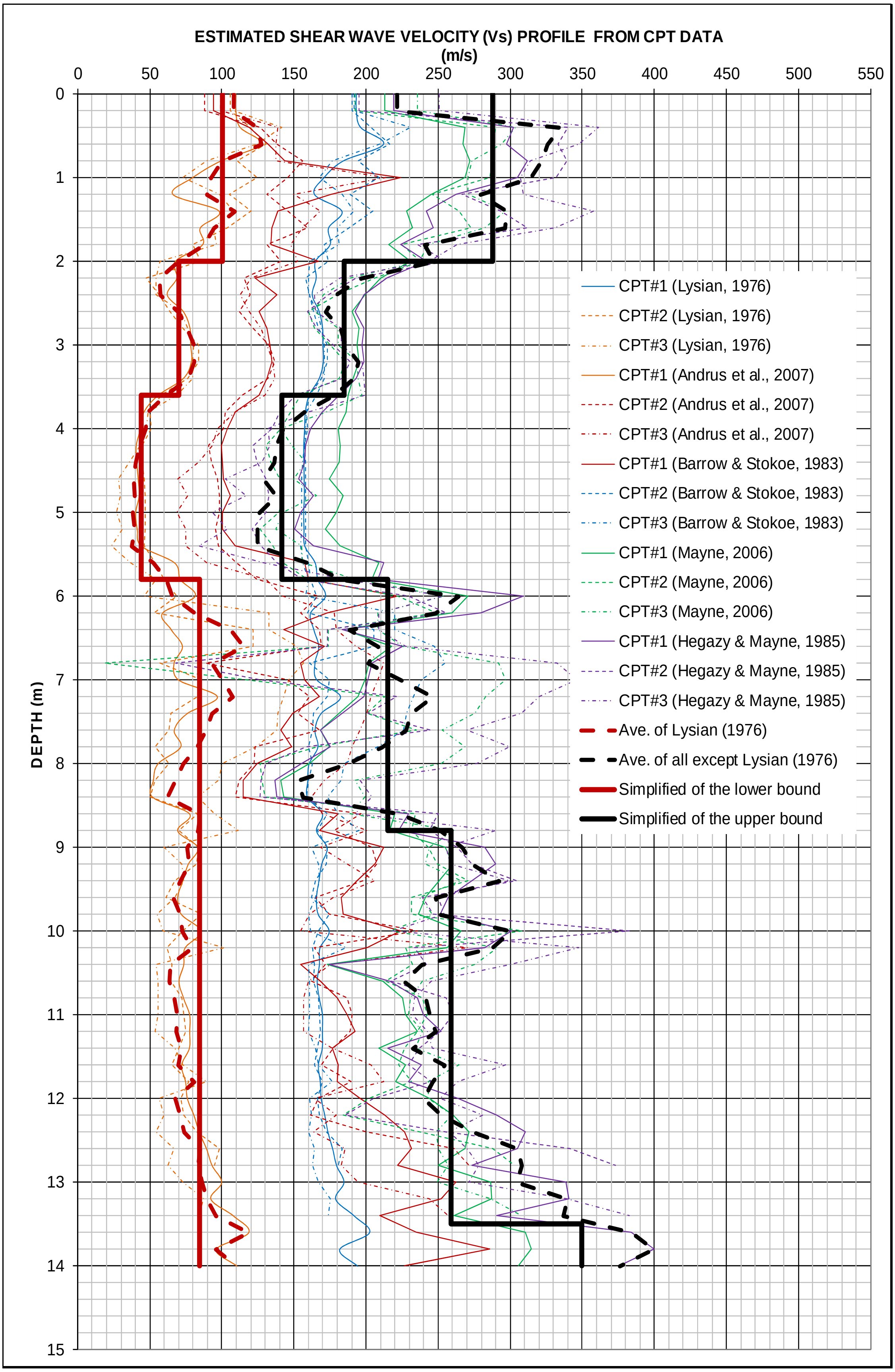


Figure 4.9 Empirical shear wave velocity profiles from all *CPT* data at Gillman, SA

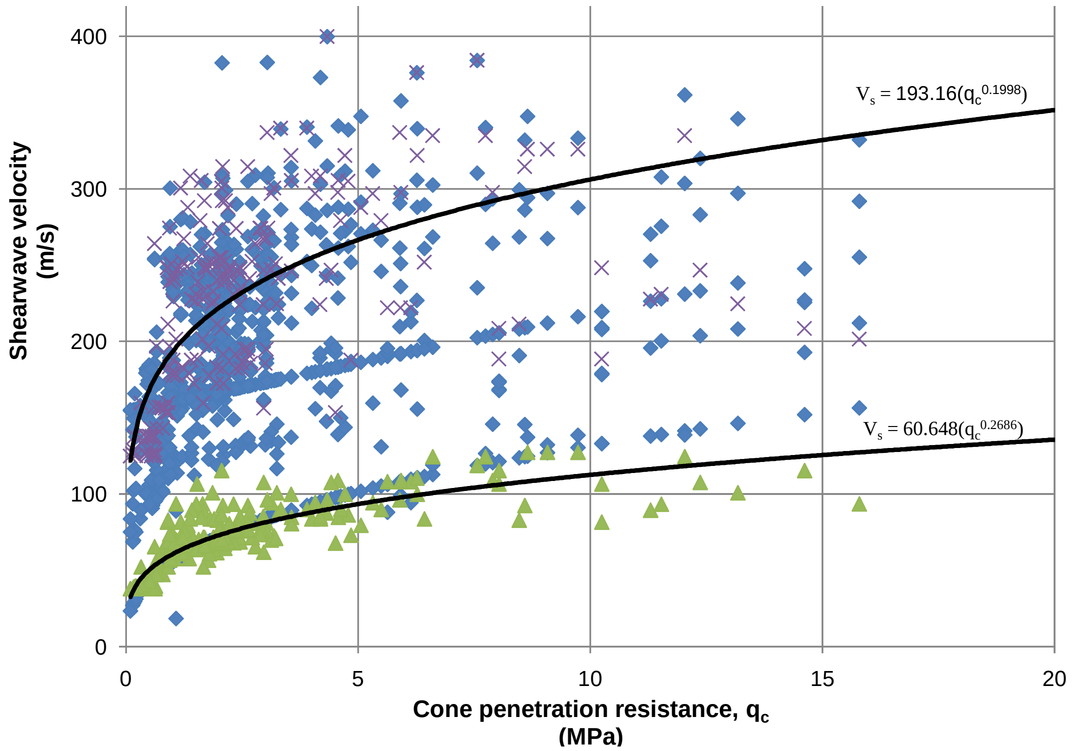


Figure 4.10 Plotting cone penetration resistances, q_c, and its estimated shear wave velocity, V_s

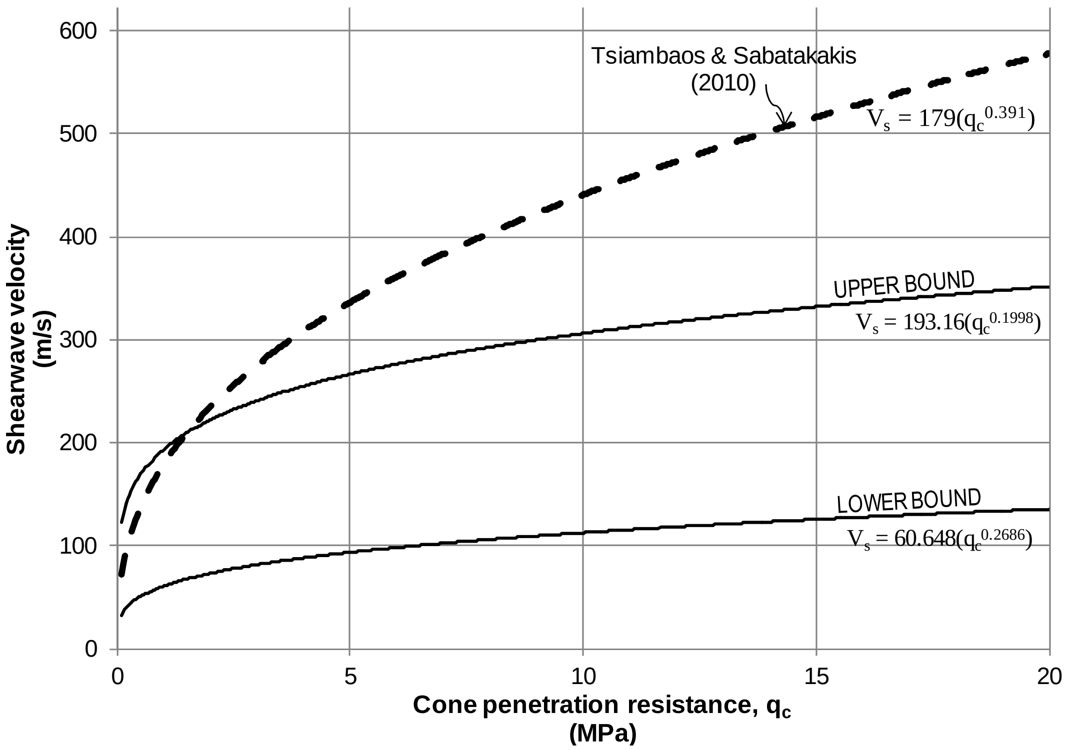


Figure 4.11 Comparison empirical shear wave velocity profiles with Tsiambaos & Sabatakakis (2010)'s model

Table 4.2 *CPT*'s simplified shear wave velocity for site-specific ground response analysis

Depth (m)	Shear wave velocity (m/s)	Remarks
0.0 – 2.0	288	Top soil
2.0 – 3.6	184	
3.6 – 5.8	141	
5.8 – 8.8	214	
8.8 – 13.5	259	
>13.5	350	Hindmarsh CLAY

Shear wave velocity from DMT data

Currently, there is no direct method for using *DMT* data to enable estimation of shear wave velocity in soil. However, Schneider et al. (1999) advised that the small strain soil modulus can be used to successfully estimate the shear wave velocity, V_s, of the soil. The relation is shown in Equation 4.3, as follows:

$$V_s = \sqrt{\frac{G_0}{\rho}} \quad \text{……..………………………………………..……..} \ (4.3)$$

where ρ is soil mass density.

The small strain modulus, G_0, of soils can be estimated using empirical relationships proposed by Monaco et al. (2009) derived from the vertically drained, constrained modulus, M_{DMT}, and the horizontal stress index, K_D. The estimation of the small strain modulus using *DMT* indices is soil type dependent. Thus, three different suggested correlations are proposed. These are as follows:

a) for CLAY or $I_D < 0.6$

$$G_0 = \left(26.177 \times K_D^{-1.0066}\right) \times M_{DMT} \quad \text{………..……………………………...} \ (4.4a)$$

b) for SILT or $0.6 < I_D < 1.8$

$$G_0 = \left(15.686 \times K_D^{-0.921}\right) \times M_{DMT} \quad \text{…..…………………………………....} \ (4.4b)$$

c) for SAND or $I_D > 1.8$

$$G_0 = \left(4.5613 \times K_D^{-0.7967}\right) \times M_{DMT} \quad \text{(4.4c)}$$

A detailed estimation of how the total weight of the soil was estimated using *DMT* data is provided in the following sections. The results of the estimation of the shear wave velocity vary, as shown in Figure 4.12. The estimated shear wave velocity of the simplified *DMT* is presented in Table 4.3.

Table 4.3 *DMT*'s simplified shear wave velocity for site-specific ground response analysis

Depth (m)	Shear wave velocity (m/s)	Remarks
0.0 – 4.0	134	Top soil
4.0 – 6.0	95	
6.0 – 9.0	150	
>9.0	219	Hindmarsh CLAY

4.2.1.3 Soil unit weight

The determination of the unit weight of soil at depth is extremely difficult to measure accurately due to sample disturbance. Hence, indirect methods, based on in-situ measurements are often used.

Soil unit weight from CPT data

The estimated soil unit weight from *CPT* data was calculated using an approximation by Mayne et al. (2010). The suggested approximation is as follows:

$$\gamma_{soil} = \left(8.32 \times \log(V_s)\right) - \left(1.61 \times \log(z)\right) \quad \text{(4.5)}$$

where γ_{soil} = soil mass density, kN/m^3,
V_s = shear wave velocity, in m/s and
z = depth, in metres.

The results are shown in Figure 4.13. Similar to the shear wave estimation discussed above, the simplified unit weight of the soil is separated into two different categories: a lower and upper bound. And for the ground response analysis using *CPT* data, the simplified soil unit weight derived from the upper bound approximation is used. The results are presented in Table 4.4.

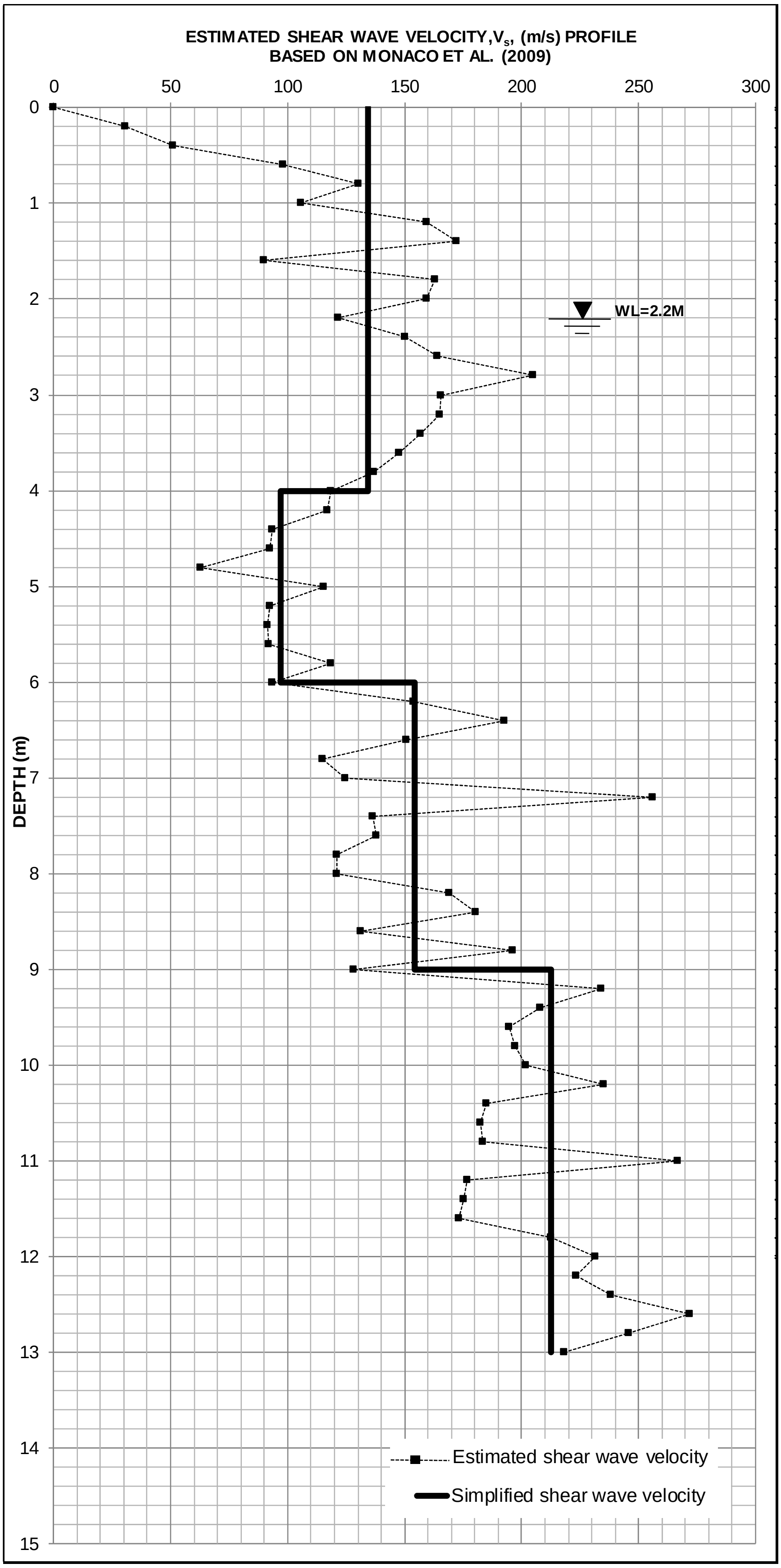


Figure 4.12 Estimated shear wave velocity profile from *DMT* data at Gillman, SA

Table 4.4 Simplified soil unit weight for site-specific ground response analysis based on *CPT* data

Depth (m)	Unit weight (kN/m^3)	Remarks
0.0 – 2.0	20.5	Top soil
2.0 – 3.6	18.1	
3.6 – 5.8	16.7	
5.8 – 8.8	17.8	
8.8 – 12.6	18.4	
>12.6	19.1	Hindmarsh CLAY

Soil unit weight from DMT data

For the current study, soil unit weight from *DMT* data was determined by plotting the material index, I_D, and dilatometer modulus, E_D, of *DMT* parameters into a chart developed by Marchetti & Crapps, (1981). The chart empirically correlates the I_D and E_D of a soil with a normalized soil unit weight to the water unit weight. A plot of the I_D and E_D parameters onto the chart is shown in Figure 4.14. As seen from the chart, most of the soil of the site is distributed between 1.6 and 1.8 normalised unit weights to the unit weight of water. These normalised unit weights need to be converted into the soil unit weight and the results are plotted as shown in Figure 4.15.

This unit weight profile was simplified and the simplified estimated unit weight from the *DMT*s is presented in Table 4.5.

Table 4.5 Simplified soil unit weight for site-specific ground response analysis based on *DMT* data

Depth (m)	Unit weight (kN/m^3)	Remarks
0.0 – 4.0	17.6	Top soil
4.0 – 6.0	15.6	
6.0 – 7.6	17.2	
7.6 – 9.0	14.9	
>9.0	17.6	Hindmarsh CLAY

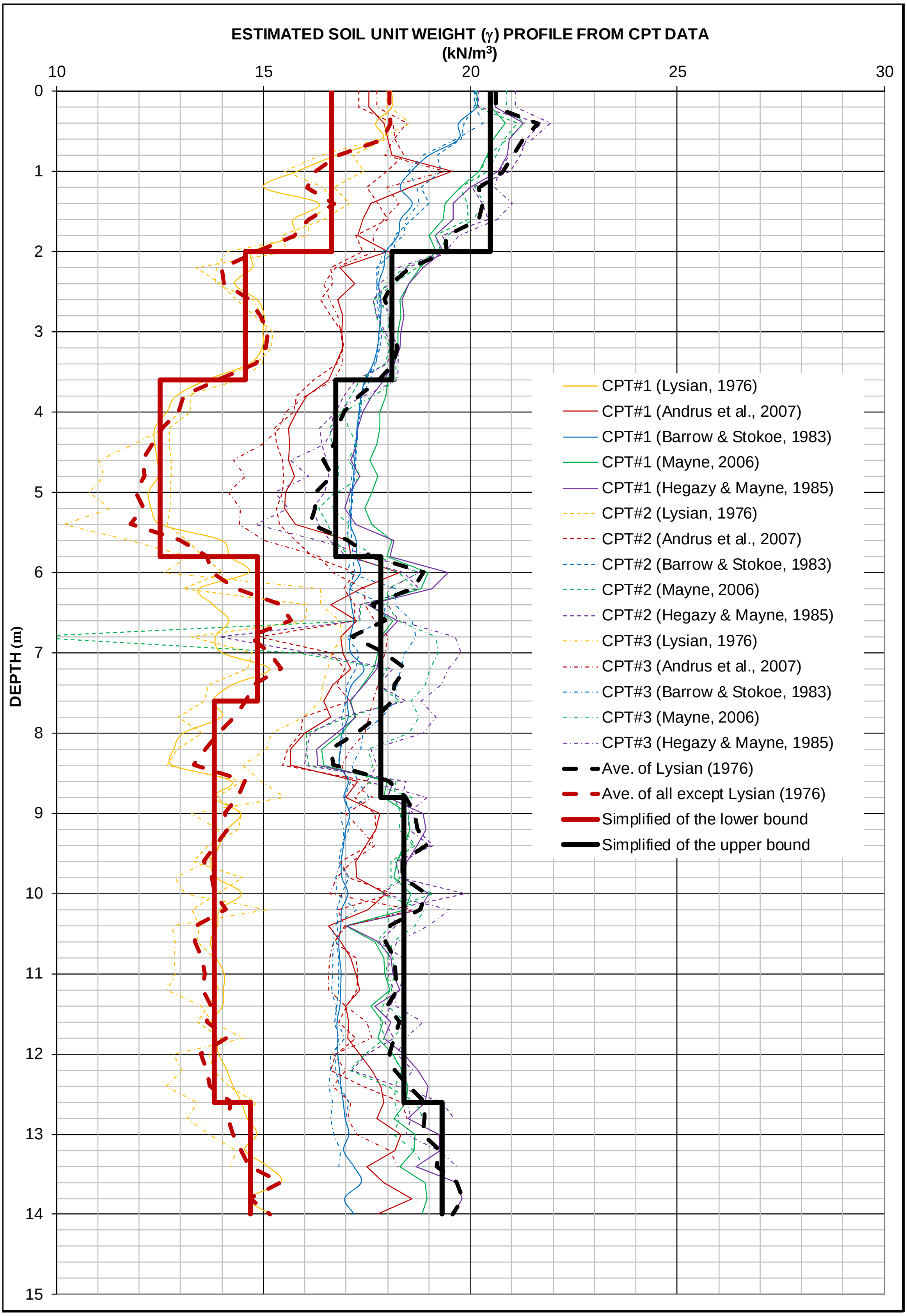


Figure 4.13 Empirical soil unit weight profiles from all *CPT* data at Gillman, SA

I_D	E_D (Bars)	Estimated γ_{Soil} (kN/m^3)
0.67	136.63	**14.72**
1.24	224.08	**19.13**
2.16	129.34	**17.66**
0.70	114.77	**17.66**
0.49	34.61	**17.66**
0.73	187.64	**19.13**
0.96	187.64	**19.13**
0.20	27.33	**17.66**
0.87	107.48	**17.66**
0.77	100.20	**17.66**
0.35	34.61	**17.66**
0.74	71.05	**17.66**
0.88	78.34	**17.66**
1.40	92.91	**17.66**
0.79	85.62	**17.66**
0.89	71.05	**17.66**
0.80	63.76	**17.66**
0.71	56.47	**17.66**
0.72	41.90	**17.66**
0.44	20.04	**15.70**
0.34	20.04	**15.70**
0.22	12.75	**15.70**
0.20	12.75	**15.70**
0.09	5.47	**14.72**
0.29	20.04	**15.70**
0.18	12.75	**15.70**
0.17	12.75	**15.70**
0.17	12.75	**15.70**
0.44	20.04	**15.70**
0.19	12.75	**15.70**
0.32	56.47	**17.66**
0.41	136.63	**18.64**
0.55	34.61	**16.68**
0.44	12.75	**17.66**
0.87	12.75	**17.66**
11.34	362.53	**17.66**
0.96	12.75	**16.68**
0.91	5.47	**14.72**
-3.41	5.47	**14.72**
-2.41	5.47	**14.72**
1.37	5.47	**14.72**
1.64	5.47	**14.72**
2.05	5.47	**14.72**
1.22	34.61	**15.70**
4.11	5.47	**14.72**
2.90	20.04	**16.68**
1.24	49.19	**17.66**
0.61	114.77	**17.66**
0.53	71.05	**17.66**
0.51	78.34	**17.66**
1.11	100.20	**17.66**
0.70	78.34	**17.66**
0.67	78.34	**17.66**
0.74	71.05	**17.66**
1.39	92.91	**17.66**
0.72	63.76	**17.66**
0.62	71.05	**17.66**
0.45	49.19	**17.66**
0.64	129.34	**17.66**
0.53	107.48	**17.66**
0.90	100.20	**17.66**
2.62	41.90	**17.66**
1.38	85.62	**17.66**
1.06	107.48	**17.66**
0.82	100.20	**17.66**

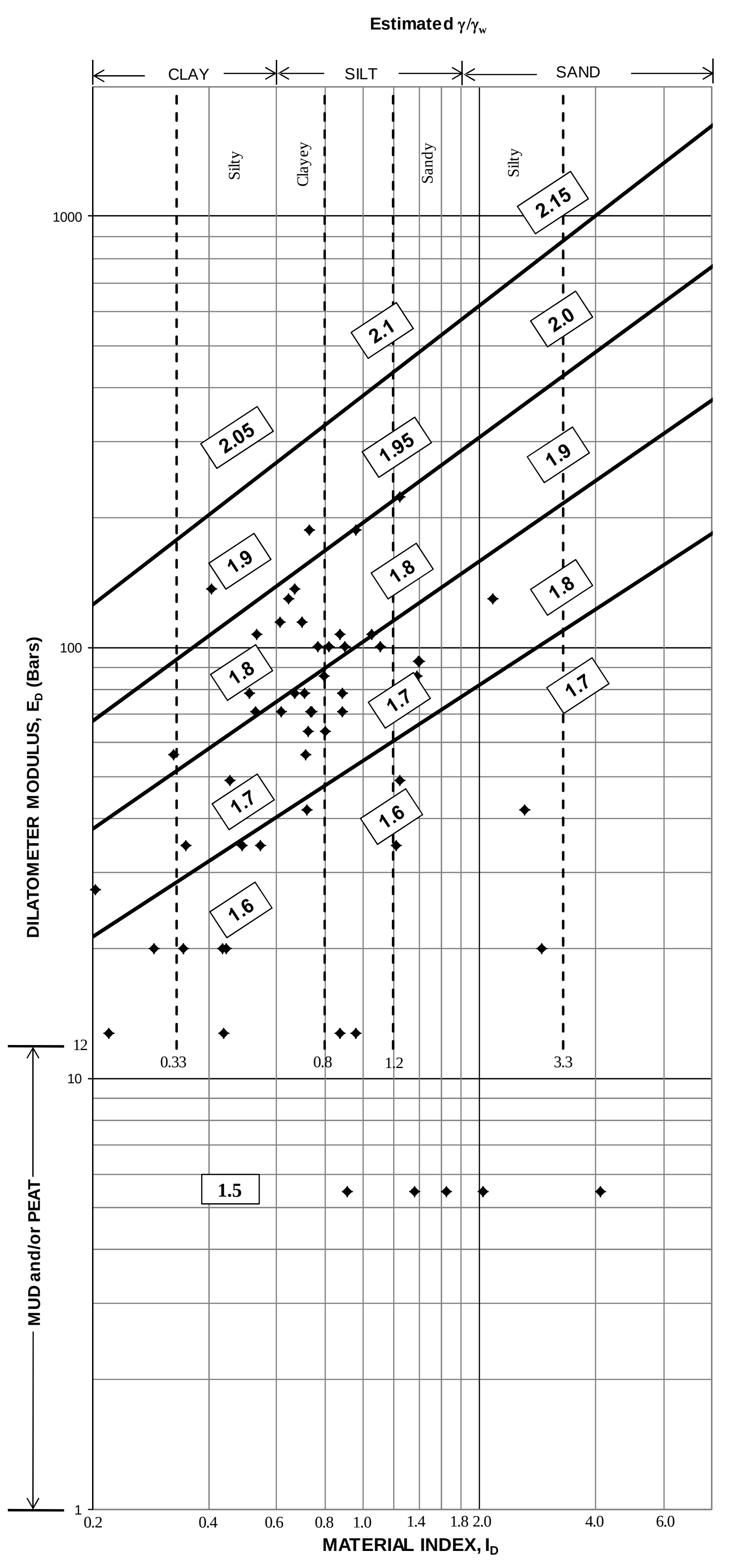


Figure 4.14 Estimated soil unit weight using a chart developed by Marchetti & Crapps, 1981 from *DMT* data at Gillman, SA

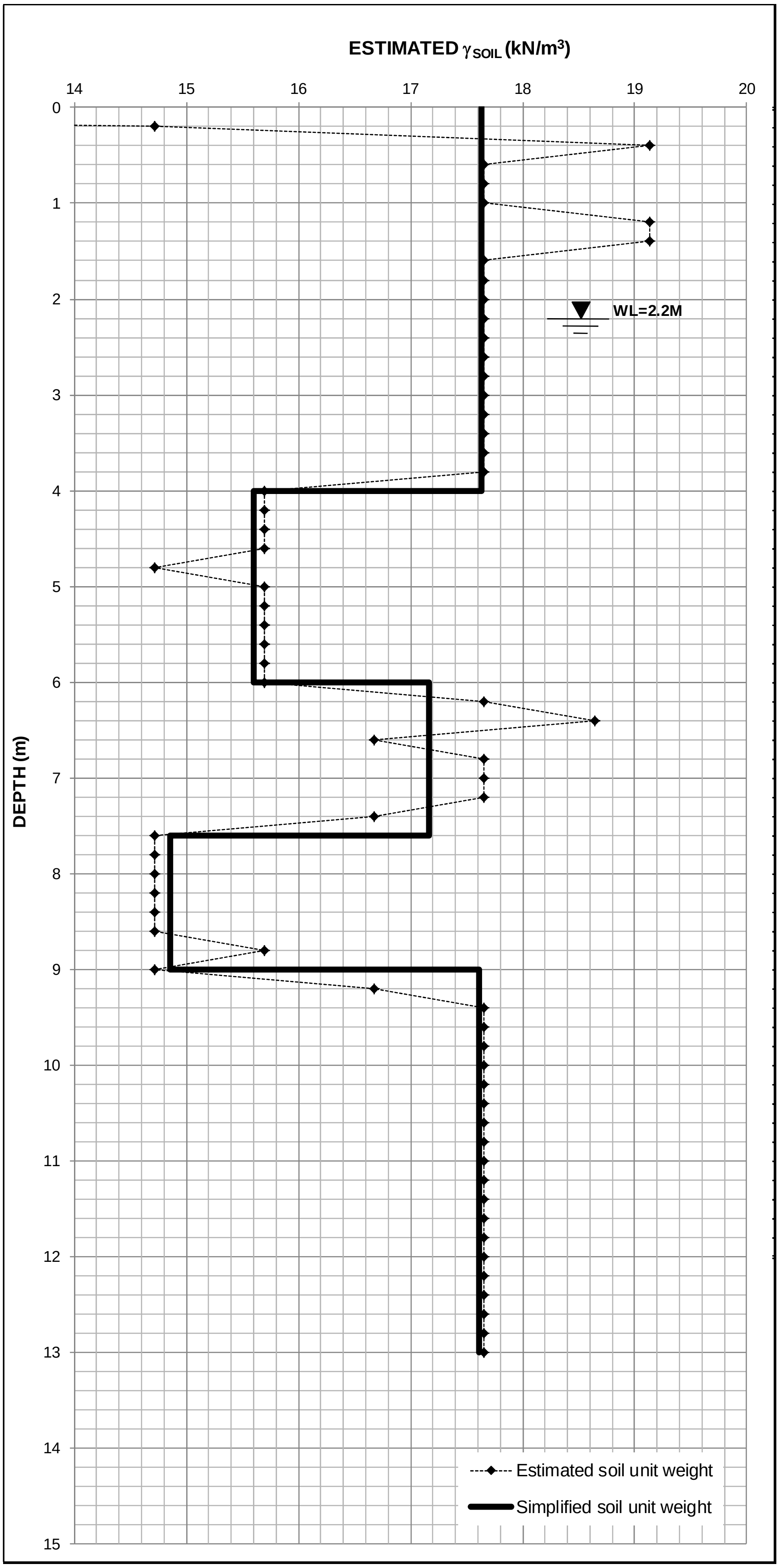


Figure 4.15 Estimated soil unit weight profile from *DMT* data at Gillman, SA

4.2.1.4 Extended the soil profiles up to the bedrock

Site-specific ground response analysis requires an extended soil profile up to the bedrock level of the site of interest (Schnabel et al., 1972; Idriss & Sun, 1992; Sykora & Davis, 1993; Bardet et al., 2000). Therefore, an extended soil profile up to the bedrock at the study site was developed. It was carried out by combining the results of the soil investigation from this research with the soil profiles used by Mitchell & Moore (2007) and Mitchell (2009) for their assessment at Port Adelaide, as shown in Figure 4.16.

Figure 4.16 Soil profiles at Port Adelaide from Mitchell (2009)

In addition, this extended soil profile also incorporated direct shear wave velocity measurements obtained using the *SASW* method at Government House (*GHS*), Adelaide, by Collins et al. (2006). The results are presented in Figures 4.17 and 4.18. Generally, there is a similar profile from the ground surface to approximately 60 m depth. The figures also indicate that the bedrock level is deeper at the study site than at the Government House.

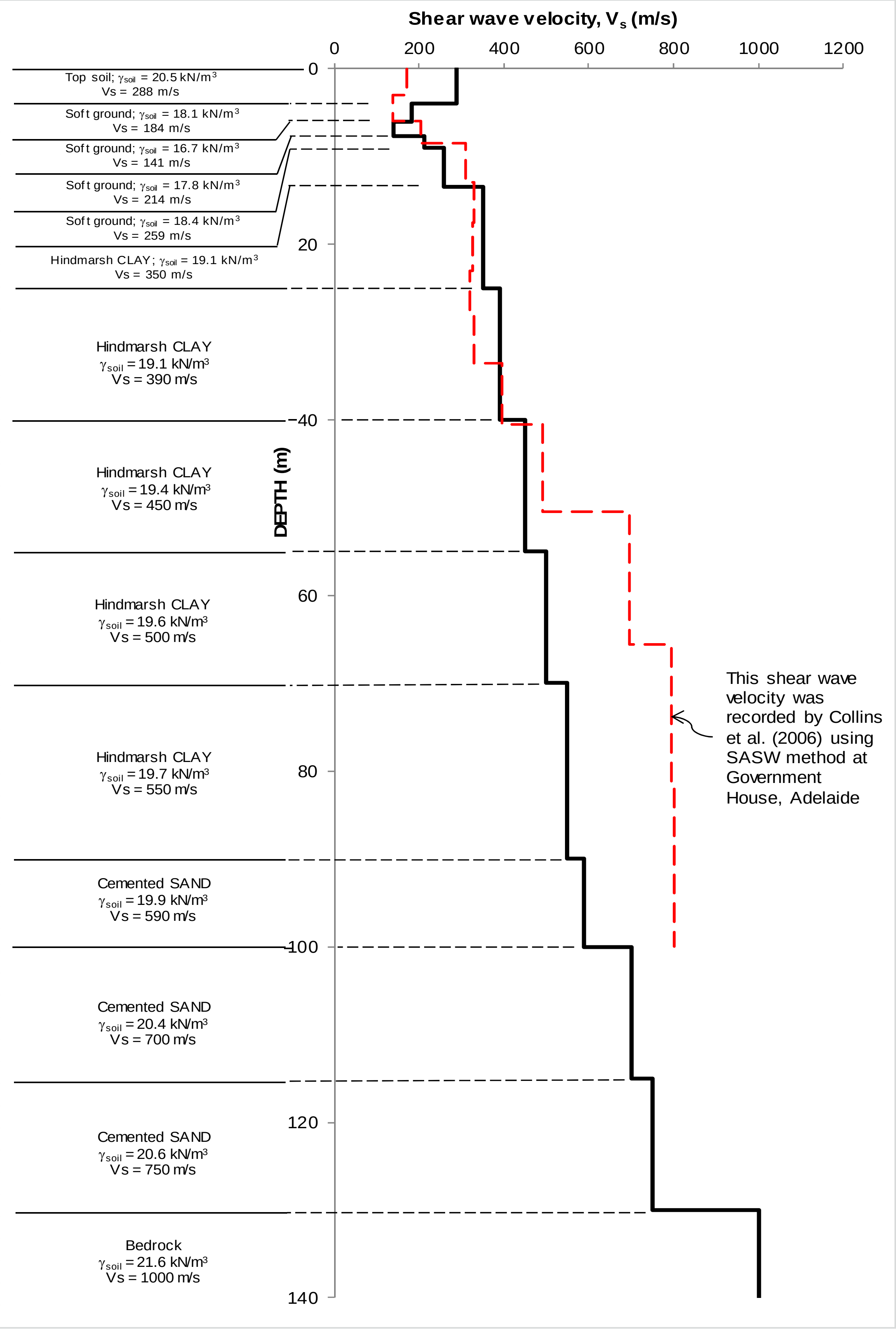


Figure 4.17 Extended soil profiles for site-specific ground response analysis from *CPT* data at Gillman, SA

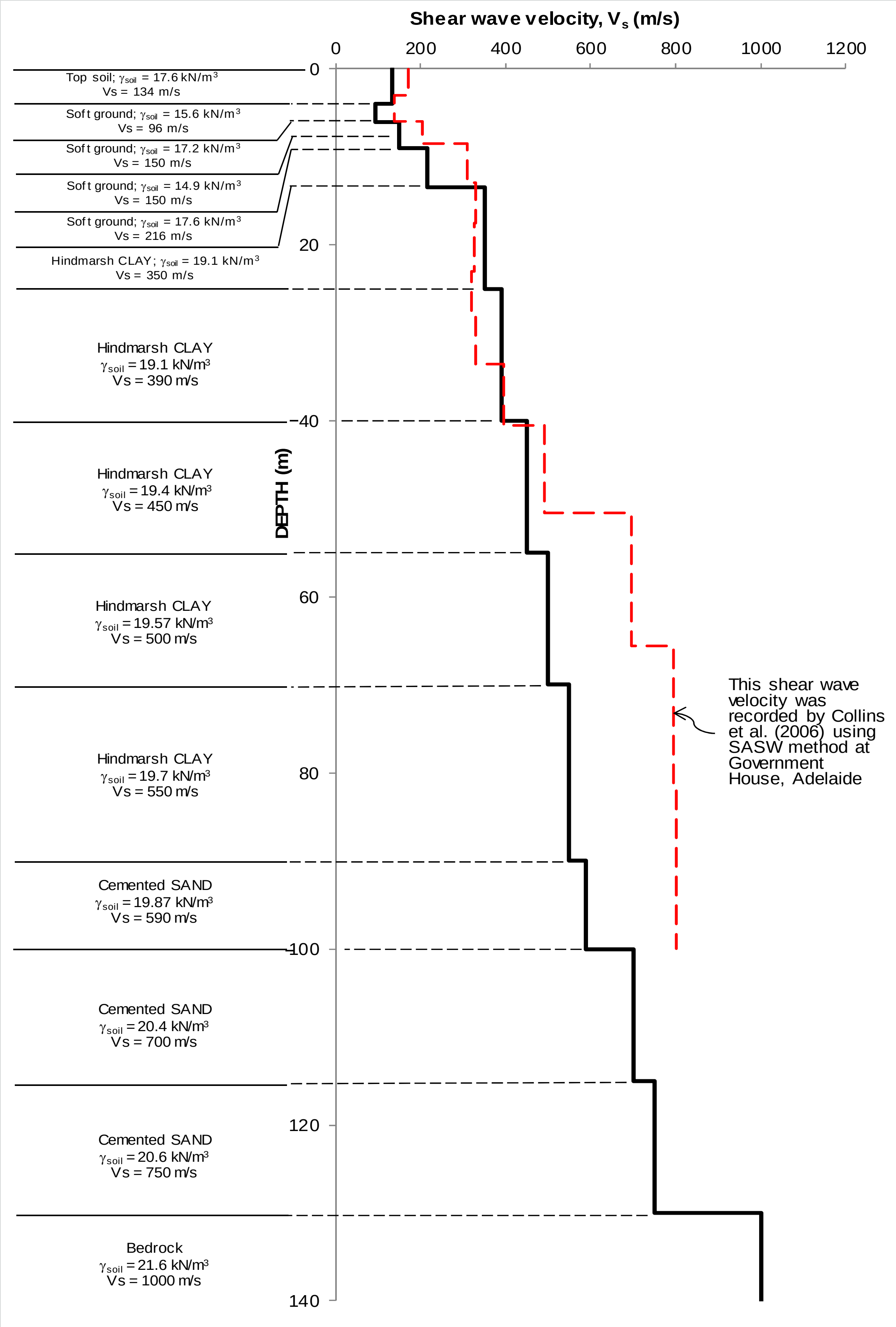


Figure 4.18 Extended soil profiles for site-specific ground response analysis from *DMT* data at Gillman, SA

4.2.2 Modulus reduction and damping curves

Ideally for a site-specific ground response analysis, the modulus reduction and damping curves are obtained according to the soil profile. As there was no access to a controlled cyclic triaxial apparatus for this research, the default shear modulus-strain and damping ratio-strain curves in *SHAKE91* and *EERA* were used. These default curves have proven to work well in most applications for site-specific ground response analysis (Sykora & Davis, 1993; Uthayakumar & Naesgaard, 2004). Each curve represents a unique behaviour of the shear modulus and damping ratio during strain, as shown in Figures 4.19 to 4.21. The shear modulus reduction and damping ratio curves are the upper bound shear modulus curve for clay proposed by Seed and Sun (1989) (Figure 4.19), the upper bound shear modulus curve for sand developed by Seed and Idriss (1970) (Figure 4.20), the damping curves for clay and sand proposed by Idriss (1990) (Figures 4.19 and 4.20), and for rocks, curves developed by Schnabel (1973) (Figure 4.21). Thus, the soil column profile for the ground analysis was grouped into three different soil types: clay, sand and rock.

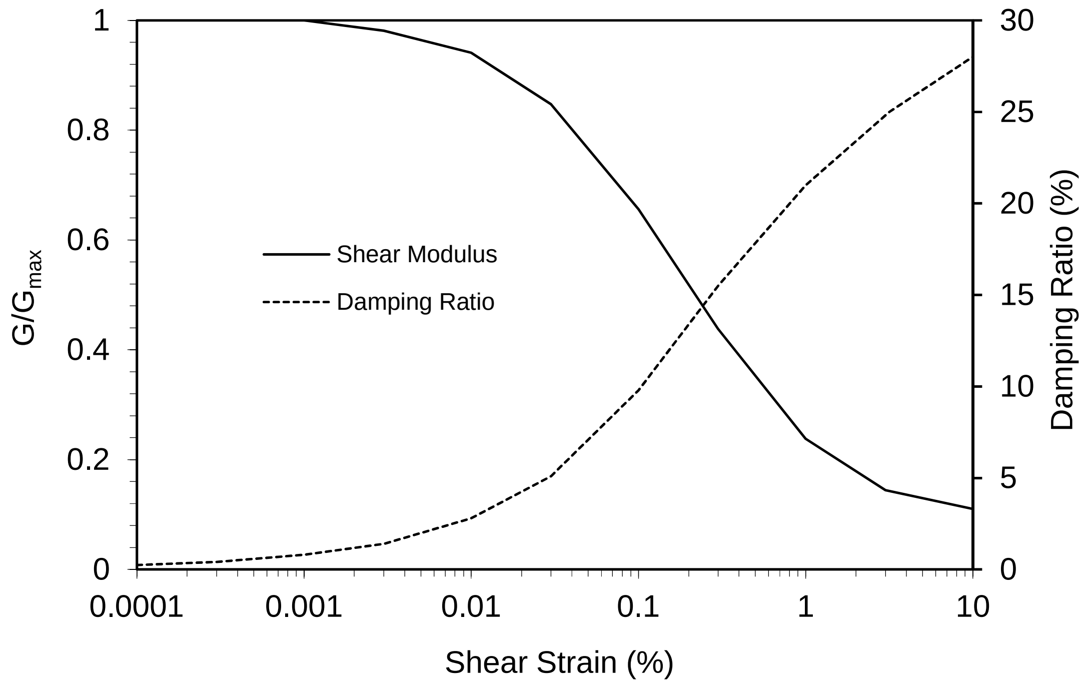


Figure 4.19 Modulus for clay by Seed and Sun (1989) upper range and damping for clay by Idriss (1990) cited in Bardet et al. (2000)

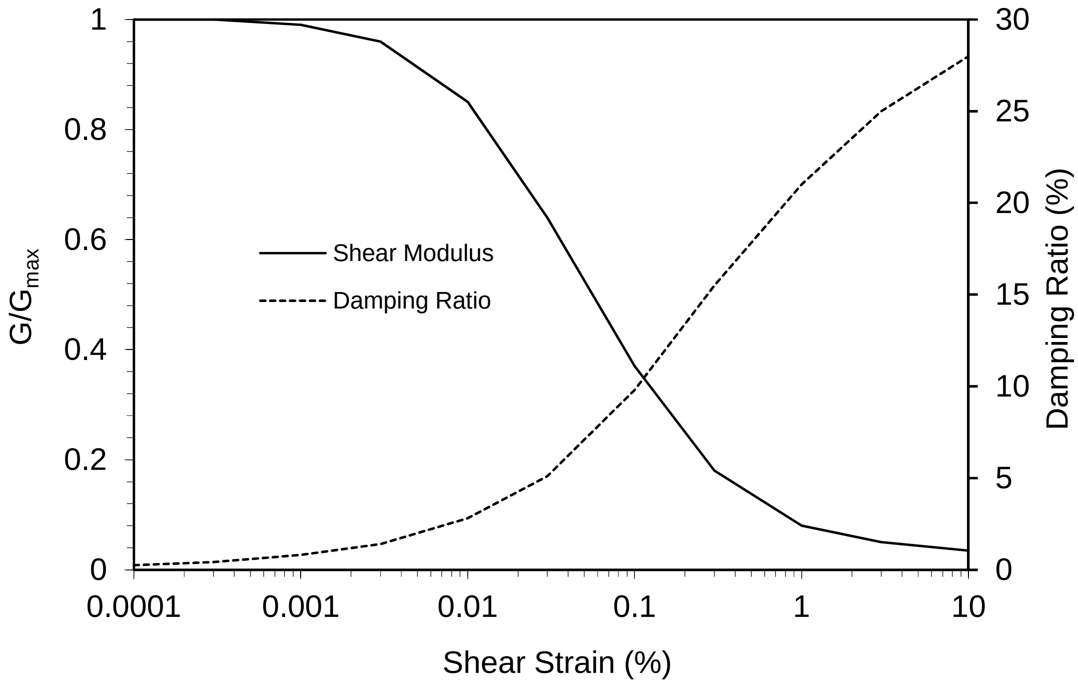


Figure 4.20 Modulus for sand by Seed & Idriss (1970) - Upper Range and damping for sand by Idriss (1990) cited in Bardet et al. (2000)

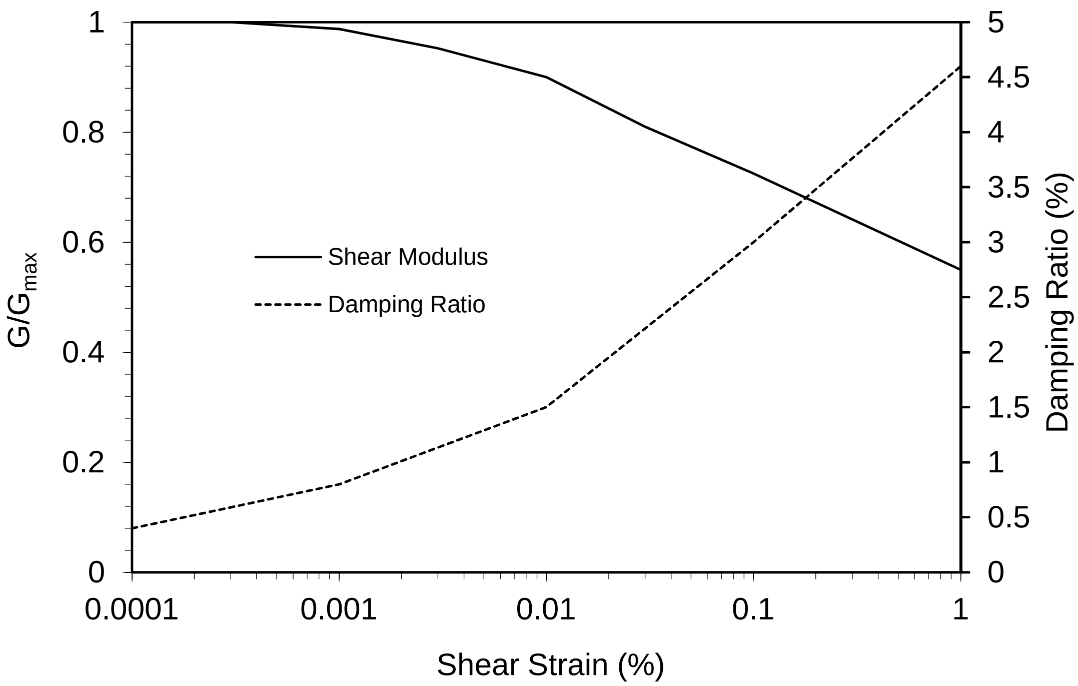


Figure 4.21 Attenuation of rock average and damping in rock by Schnabel (1973) cited in Bardet et al. (2000)

4.2.3 Earthquake motion input

When assessing liquefaction potential, it is advantageous to use acceleration time-histories that have been recorded at the study site or use recorded motions that are somewhat similar in overall ground motion level and spectral shape to those at the designated site. However, compromises were required in this study because of the numerous attributes of the seismic environment and the scarce data bank of recorded acceleration time-histories in low seismic regions such as Adelaide. Therefore, the most recent strongest record and nearest to the study site was chosen to represent the natural acceleration time histories of the Adelaide region, which was a 5.1 magnitude earthquake that occurred on 5 March 1997 South of Burra, South Australia, with a duration of around 46 seconds.

This earthquake was recorded by digital accelerographs at Government House (*GHS*) which is founded on soil in the *CBD* of Adelaide. It was also recorded by other digital accelerographs at Mt Osmond (*TUK*), which is founded on rock at the outskirts of Adelaide. Three components of the ground motion, consisting of two horizontal waves and one vertical wave, were documented by both stations. Hence, in total, six natural acceleration-time histories from local sources were used to generate the free-field motions, as shown in Figures 4.22 and 4.23 (Love, 2010).

Judging by the accelerograms produced by the accelerographs at each location, the 5 March 1997 earthquake was felt much more strongly at the *GHS* than at the *TUK*. The *PGA* of the three components at the *GHS* station range from 0.0023 to 0.0045 *g*, whereas at the *TUK* station the *PGA* varies from only 0.000986 to 0.0014 *g*. The discrepancy of this recording is most likely because the *GHS* accelerograph is erected on soil but the *TUK* accelerograph is constructed on rock.

Additional facts found in the acceleration time histories of the 5 March 1997 earthquake showed that the highest *PGA* and its time had been recorded. The highest *PGA* was 0.0045 *g*, recorded on the Government House Accelerograph Station for the east-west horizontal wave. The *PGA* of all components of both stations occurred between 22.38 and 27.65 seconds from the beginning of the tremor felt by the accelerographs. The *PGA* and its recorded time are summarised in the Table 4.6.

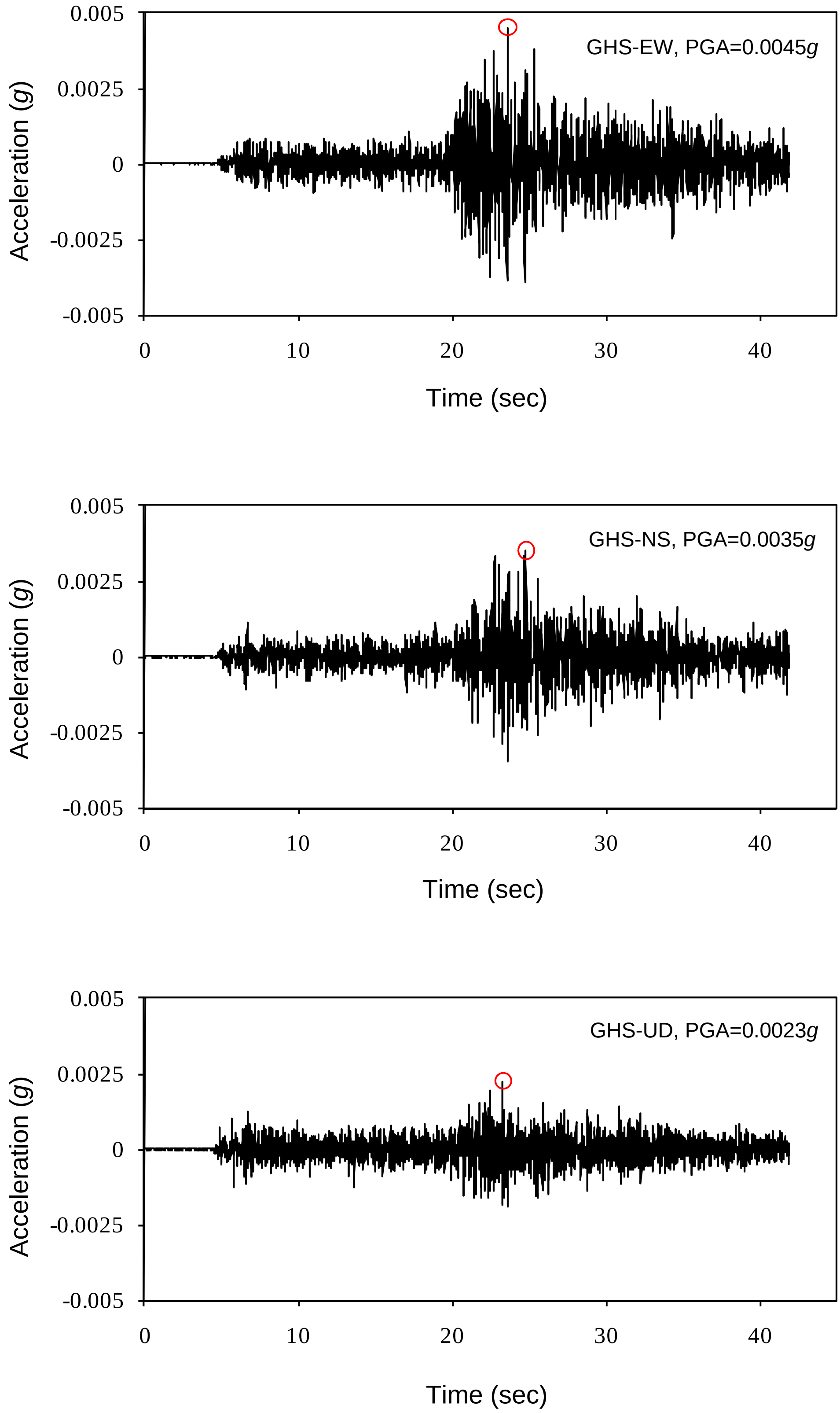


Figure 4.22 Input motion accelerograms recorded at Government House (*GHS*), Adelaide, from an earthquake on 5 March 1997 (Love, 2010)

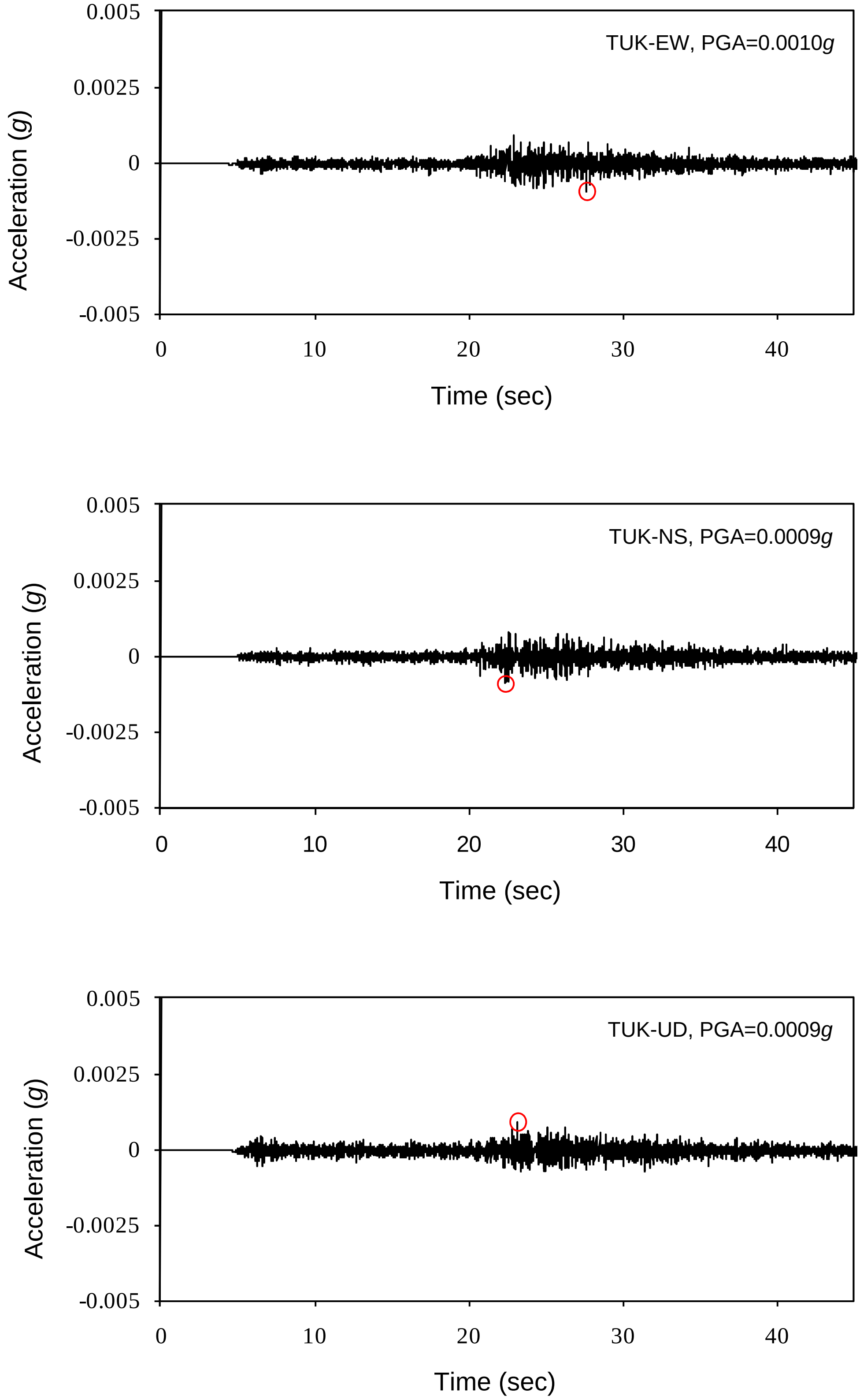


Figure 4.23 Input motion accelerograms recorded at Mt. Osmond (*TUK*) near Adelaide from an earthquake on 5 March 1997 (Love, 2010)

Table 4.6 Summary of acceleration time histories of 5 March 1997 earthquake

Accelerograms Station	Motions Direction	Notation	*PGA* Value (*g*)	Time of the *PGA* occurred (seconds)
Government House (*GHS*) The accelerograph station is founded on soil.	East-West	GHS-EW	0.0045	23.6
	North-South	GHS-NS	0.003	23.6
	Up-Down	GHS-UD	0.0023	23.272
Mt Osmond (*TUK*) The accelerograph station is founded on rock.	East-West	TUK-EW	0.0014	22.38
	North-South	TUK-NS	0.000895	23.156
	Up-Down	TUK-UD	0.000986	27.65

4.2.4 Methods of the site-specific ground response analysis

4.2.4.1 Overview of the analytical tools

One dimensional equivalent linear analysis was undertaken using *SHAKE* and *ERRA* to compute the free-field response. The software computes the ground response of horizontally layered soil deposits subjected to transient and vertically propagating shear waves through a one dimensional soil column, as shown in Figure 4.24. Each soil layer is assumed to be homogeneous, visco-elastic and infinite in the horizontal extent. The equivalent linear estimation of soil properties is taken to express the nonlinearity of the soil's shear modulus and damping values. These values are assumed to be a function of shear strain amplitude and determined by an iterative process that must be consistent with the level of the effective strain induced in each sublayer (Idriss & Sun, 1992; Bardet et al., 2000).

Starting with the highest shear modulus and a low damping value, the shear modulus and the damping ratio of each sublayer are modified. The modification is based on the applicable relationship between both properties and the shear strain. The calculation is repeated until strain-compatible modulus and damping values converge within a tolerance of 1%.

Figure 4.24 One dimensional idealisation of a horizontally layered soil deposit over a uniform half-space (Idriss & Sun, 1992)

4.2.4.2 Input parameters

Both the *SHAKE91* and *EERA* programs share the same basic input parameters, which are: (i) earthquake acceleration time histories or ground motions; (ii) soil profile; and (iii) dynamic soil characteristics such as strain dependent modulus reduction and damping behaviour. Each of the inputs has been discussed and presented above. However, the data need to be re-adjusted in such a way as to suit the input structure of each program, as discussed below.

Input data for SHAKE91

Input of the earthquake acceleration time histories in *SHAKE91* followed the format shown in Figures 4.25 and 4.26.

```
"1997/03/05","ADELAIDE","GHS-EW","init. vel:"," .307 c/s","disp: -0.016 cm"
"Total No. of Points :",5236,"@ DT =",.02
"Peak Acceleration (g) =",.1128945,"@ Time (sec) :",38.104
  0.000004  0.000007  0.000037  0.000036  0.000031  0.000031  0.000011  0.000035
  0.000000  0.000000  0.000014  0.000010  0.000003  0.000009  0.000034  0.000038
  0.000034  0.000034  0.000008  0.000004  0.000003  0.000010  0.000031  0.000008
  0.000014  0.000004  0.000007  0.000014  0.000004  0.000031  0.000011  0.000030
  0.000040  0.000041  0.000032  0.000034  0.000003  0.000011  0.000008  0.000002
  0.000010  0.000035  0.000039  0.000031  0.000036  0.000008  0.000006  0.000007
  0.000010  0.000004  0.000009  0.000011  0.000013  0.000001  0.000005  0.000014
  0.000035  0.000036  0.000000  0.000014  0.000030  0.000013  0.000031  0.000007
  0.000013  0.000011  0.000003  0.000036  0.000013  0.000040  0.000037  0.000014
  0.000012  0.000003  0.000006  0.000014  0.000001  0.000014  0.000034  0.000040
  0.000034  0.000033  0.000036  0.000006  0.000005  0.000011  0.000010  0.000008
  0.000003  0.000035  0.000036  0.000030  0.000008  0.000009  0.000003  0.000001
  0.000003  0.000030  0.000013  0.000032  0.000035  0.000032  0.000014  0.000003
  0.000006  0.000011  0.000033  0.000042  0.000033  0.000037  0.000006  0.000006
  0.000003  0.000006  0.000014  0.000012  0.000009  0.000032  0.000032  0.000041
  0.000013  0.000009  0.000003  0.000004  0.000011  0.000014  0.000013  0.000031
  0.000002  0.000003  0.000011  0.000005  0.000035  0.000031  0.000042  0.000039
  0.000037  0.000036  0.000006  0.000007  0.000005 -0.000016  0.000011  0.000013
  0.000035  0.000030  0.000034  0.000043  0.000036  0.000037  0.000007  0.000009
  0.000009  0.000011  0.000005  0.000003  0.000013  0.000038  0.000031  0.000030
  0.000032  0.000008  0.000011  0.000001  0.000003  0.000000  0.000002  0.000008
  0.000005  0.000012  0.000002  0.000000  0.000008  0.000011  0.000039  0.000032
  0.000040  0.000040  0.000039  0.000040  0.000010  0.000004  0.000006  0.000010
  0.000007  0.000006  0.000014  0.000031  0.000037  0.000036  0.000035  0.000007
  0.000008  0.000013  0.000001  0.000009  0.000011  0.000010  0.000006  0.000033
  0.000035  0.000034  0.000014  0.000011  0.000036  0.000032  0.000037  0.000034
  0.000005  0.000031  0.000014  0.000007  0.000013  0.000009  0.000010  0.000009
  0.000005  0.000013  0.000032  0.000042  0.000034  0.000030  0.000011  0.000003
  0.000011  0.000005  0.000011  0.000012  0.000012  0.000037  0.000034  0.000031
  0.000030  0.000004  0.000004  0.000012  0.000000  0.000008  0.000012  0.000038
  0.000011  0.000002  0.000007  0.000003  0.000011  0.000007  0.000005  0.000034
  0.000005  0.000013  0.000031  0.000013  0.000014  0.000008  0.000014  0.000014
  0.000033  0.000014  0.000005  0.000009  0.000001  0.000006  0.000012  0.000012
  0.000038  0.000039  0.000030  0.000030  0.000004  0.000001  0.000007  0.000002
  0.000013  0.000004  0.000010  0.000038  0.000030  0.000032  0.000030  0.000011
  0.000003  0.000004  0.000031  0.000005  0.000006  0.000005  0.000009  0.000032
  0.000037  0.000032  0.000011  0.000008  0.000033  0.000011  0.000034  0.000005
  0.000002  0.000014  0.000011  0.000006  0.000002  0.000008  0.000032  0.000036
  0.000032  0.000043  0.000036  0.000011  0.000004  0.000012  0.000009  0.000004
  0.000007  0.000014  0.000030  0.000040  0.000041  0.000037  0.000009  0.000035
  0.000010  0.000003  0.000002  0.000009  0.000009  0.000006  0.000010  0.000011
  0.000007  0.000031  0.000030  0.000014  0.000013  0.000003  0.000030  0.000013
  0.000034  0.000036  0.000011  0.000014  0.000005  0.000008  0.000012  0.000006
  0.000039  0.000031  0.000011  0.000013  0.000009  0.000034  0.000008  0.000011
  0.000005  0.000009  0.000006  0.000010  0.000030  0.000014  0.000009  0.000031
  0.000037  0.000032  0.000011  0.000008  0.000000  0.000005  0.000011  0.000000
  0.000011  0.000040  0.000032  0.000036  0.000037  0.000034  0.000036  0.000014
  0.000007  0.000002  0.000007  0.000013  0.000005  0.000012  0.000039  0.000013
  0.000013  0.000007  0.000012  0.000032  0.000012  0.000008  0.000012  0.000011
  0.000003  0.000012  0.000012  0.000010  0.000010  0.000040  0.000037  0.000035
  0.000043  0.000013  0.000011  0.000001  0.000008  0.000006  0.000000  0.000001
 -0.000015  0.000010  0.000002  0.000034  0.000030  0.000035  0.000039  0.000032
  0.000013  0.000011  0.000001  0.000010  0.000011  0.000032  0.000040  0.000033
  0.000006  0.000002  0.000004  0.000005  0.000001  0.000012  0.000034  0.000036
  0.000031  0.000041  0.000040  0.000014  0.000011  0.000007 -0.000015  0.000010
  0.000002  0.000030  0.000042  0.000037  0.000038  0.000013  0.000001  0.000006
  0.000010  0.000003  0.000013  0.000034  0.000040  0.000035  0.000032  0.000005
  0.000012  0.000000  0.000014  0.000014  0.000030  0.000030  0.000035  0.000035
  0.000031  0.000037  0.000012  0.000014  0.000005  0.000001  0.000004  0.000007
  0.000005  0.000004  0.000030  0.000031  0.000037  0.000034  0.000013  0.000032
  0.000013  0.000007  0.000000  0.000009  0.000004  0.000013  0.000013  0.000038
  0.000030  0.000035  0.000030  0.000032  0.000011  0.000014  0.000003  0.000014
  0.000014  0.000039  0.000013  0.000031  0.000006  0.000007  0.000008  0.000003
  0.000030  0.000029  0.000008  0.000004  0.000011  0.000014  0.000032  0.000010
  0.000014  0.000014  0.000035  0.000007  0.000005  0.000005  0.000003  0.000031
  0.000008  0.000005  0.000008  0.000009  0.000014  0.000033  0.000032  0.000037
  0.000011  0.000014  0.000011  0.000034  0.000032  0.000002  0.000013  0.000009
  0.000005  0.000034  0.000036  0.000033  0.000010  0.000009  0.000013  0.000013
  0.000002 -0.000024 -0.000019  0.000010  0.000009  0.000032  0.000030  0.000031
  0.000042  0.000033  0.000013  0.000002  0.000004  0.000006  0.000002  0.000003
  0.000001 -0.000016  0.000001  0.000005  0.000005  0.000012  0.000005  0.000011
```

Figure 4.25 Sample parts of the earthquake motions input data for the *SHAKE 91* ground response analysis (Idriss & Sun, 1992)

```
                                        GHSEWCPTExt.DAT
option 1 - dynamic soil properties - (max is thirteen):
    1
    3
   11      #1 modulus for clay (seed & sun 1989) upper range
0.0001     0.0003    0.001     0.003     0.01      0.03      0.1       0.3
1.         3.        10.
1.000      1.000     1.000     0.981     0.941     0.847     0.656     0.438
0.238      0.144     0.110
   11        damping for clay (Idriss 1990) -
0.0001     0.0003    0.001     0.003     0.01      0.03      0.1       0.3
1.         3.16      10.
0.24       0.42      0.8       1.4       2.8        5.1       9.8      15.5
21.        25.       28.
   11      #2 modulus for sand (seed & idriss 1970) - upper Range
0.0001     0.0003    0.001     0.003     0.01      0.03      0.1       0.3
1.         3.        10.
1.000      1.000     0.990     0.960     0.850     0.640     0.370     0.180
0.080      0.050     0.035
   11        damping for sand (Idriss 1990) - (about LRng from SI 1970)
0.0001     0.0003    0.001     0.003     0.01      0.03      0.1       0.3
1.         3.        10.
0.24       0.42      0.8       1.4       2.8        5.1       9.8      15.5
21.        25.       28.
    8       #3 ATTENUATION OF  ROCK  AVERAGE
 .0001      0.0003    0.001      0.003     0.01      0.03       0.1      1.0
 1.000      1.000     0.9875    0.9525    0.900     0.810      0.725     0.550
    5       DAMPING IN ROCK
 .0001      0.001     0.01        0.1       1.
  0.4       0.8       1.5         3.0       4.6
    3    1    2    3
Option 2 -- Soil Profile
    2
    1   14      SUMMARY OF CPT TESTS EXTENT -- -ft layer; input:GHSEW @ .1g
    1    1            6.6                  0.01     0.130      945.
    2    2            5.2                  0.01     0.115      604.
    3    1            7.2                  0.01     0.107      463.
    4    2            9.8                  0.01     0.114      702.
    5    1           15.4                  0.01     0.117      850.
    6    1           37.7                  0.01     0.122     1148.
    7    1           49.2                  0.01     0.122     1280.
    8    1           49.2                  0.01     0.123     1476.
    9    1           49.2                  0.01     0.125     1640.
   10    1           65.6                  0.01     0.126     1804.
   11    2           32.8                  0.01     0.127     1936.
   12    2           49.2                  0.01     0.130     2297.
   13    2           49.2                  0.01     0.131     2461.
   14    3                                 0.01     0.137     3281.
Option 3 -- input motion:
    3
 4000 4096      .008 ghsew.acc                          (8f10.6)
                  .10       25.    3    8
Option 4 -- sublayer for input motion {within (1) or outcropping (0):
    4
   14    0
Option 5 -- number of iterations & ratio of avg strain to max strain
    5
    1   15    0.20
Option 6 -- sublayers for which accn time histories are computed & saved:
    6
    1    2    3    4    5    6    7    8    9   10   11   12   13   14   14
    0    1    1    1    1    1    1    1    1    1    1    1    1    1    0
    1    0    0    0    0    0    0    0    0    0    0    0    0    1    0
option 7 -- sublayer for which shear stress or strain are computed & saved:
    7
    1    1    1    0 4000           -- stress in level 1
    1    0    1    0 4000           -- strain in level 1
option 7 -- sublayer for which shear stress or strain are computed & saved:
    7
   14    1    1    0 4000           -- stress in level 14
   14    0    1    0 4000           -- strain in level 14
option 9 -- compute & save response spectrum:
    9
    1    0
    1    0     981.0
   0.05
option 10 -- compute & save amplification spectrum:
   10
   14    0    1    0     0.130      - surface/rock outcrop
option 11 -- compute & save Fourier spectrum:
   11
    1    0    1    1 1000
    1    0    1    3 1000
execution will stop when program encounters 0
    0
```

Figure 4.26 Sample input data for the *SHAKE 91* ground response analysis (Idriss & Sun, 1992)

Input data for EERA

As mentioned earlier, *EERA* is add-on software for Windows and Microsoft Excel. In this research, *EERA* was embedded into Microsoft Excel 2003, as it was incompatible with Microsoft Excel 2007.

The earthquake motion data in *EERA* is entered directly into the designated cells or is imported from a text file. A sample of parts of the earthquake motion input in *EERA* is shown in Figure 4.27.

1997 Adelaide Earthquake GHS-EW

Time step ∆T (sec) =	0.008
Desired maximum acceleration (g) =	0.1
Maximum frequency cut-off (Hz) =	25
Use frequency cut-off in calculation ?	Yes
Number of points for FFT =	8192
Import input motion from external file ?	No
Name of input file =	DIAM.ACC
Total number of values read =	5236
Peak Acceleration in input file (g) =	0.0045
Time of peak acceleration (sec) =	23.600
Mean Square Frequency (Hz) =	8.875
Peak acceleration after filtering (g) =	0.098

Time (sec)	Input Acceleration (g)	Scaled Acceleration (g)	Filtered Acceleration (g)
0.000	0.000004	0.00	0.00
0.008	0.000007	0.00	0.00
0.016	0.000037	0.00	0.00
0.024	0.000036	0.00	0.00
0.032	0.000031	0.00	0.00
0.040	0.000031	0.00	0.00
0.048	0.000011	0.00	0.00
0.056	0.000035	0.00	0.00

Figure 4.27 Sample of parts of earthquake motions input data for *EERA* ground response analysis (Bardet, et al., 2000)

Subsequently, soil profile data such as soil type, layer thickness, unit weight, shear wave velocity, location and type of earthquake motion input and groundwater level are entered, as shown in Figure 4.28.

Finally, data defining the modulus reduction and damping curves of each soil type are specified. As previously mentioned, since there was no laboratory testing to determine these curves, the default values were used, as described in Section 4.2.2.

CPT DATA -- 14M layer; input:Diam @ .1g

Fundamental period (s) = 1.03
Average shear wave velocity (m/sec) = 506.27
Total number of sublayers = 14

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		2.0	173.24		20.49	*288*		*W*	1.0	10.68
Soft Ground	2	2		1.6	62.50		18.11	*184*			2.8	28.00
Soft Ground	3	1		2.2	33.93		16.74	*141*			4.7	42.26
Soft Ground	4	2		3.0	83.28		17.84	*214*			7.3	61.93
Soft Ground	5	1		4.7	125.75		18.39	*259*			11.1	94.14
Hindmarsh CLAY	6	1		11.5	238.38		19.09	*350*			19.3	167.66
	7	1		15.0	296.67		19.13	*390*			32.5	290.95
	8	1		15.0	400.10		19.38	*450*			47.5	432.68
	9	1		15.0	498.72		19.57	*500*			62.5	577.67
	10	1		20.0	608.71		19.74	*550*			80.0	750.17
Cemented SAND	11	2		10.0	705.18		19.87	*590*			95.0	899.79
	12	2		15.0	1019.16		20.40	*700*			107.5	1029.56
	13	2		15.0	1178.98		20.56	*750*			122.5	1189.65
Bedrock	14	3			2197.68		21.56	*1000*	Outcrop		130.0	1270.28

Figure 4.28 Sample of soil profile input for *EERA* ground response analysis (Bardet, et al., 2000)

4.2.5 Results of the site-specific ground response analysis

The site-specific ground response analysis yielded the following: peak ground acceleration; stress and strain at each layer; amplification at the ground surface or the surface of each layer; Fourier amplitude; and the response spectrum.

Sample outputs from the *EERA* ground response analysis are shown in Figures 4.29 to 4.34. Similar results were obtained from *SHAKE91*, as shown in Tables 4.7 and 4.8.

In this study, there are three recorded components from two accelerograms: east-west, north-south and up-down. Each component was used independently in the analysis. These six input motions were entered separately into *SHAKE91* and *EERA*. Site-specific ground response analyses were carried out for the soil profiles which were developed using the two in-situ testing methods (*CPT* and *DMT*).

A summary of the site-response analysis outputs using the *CPT* and *DMT* data are presented in Tables 4.7 and 4.8, respectively. The results are presented separately, as the analysis was performed individually for each component of the input motions recorded by the accelerographs at Government House (*GHS*) and Mt. Osmond (*TUK*).

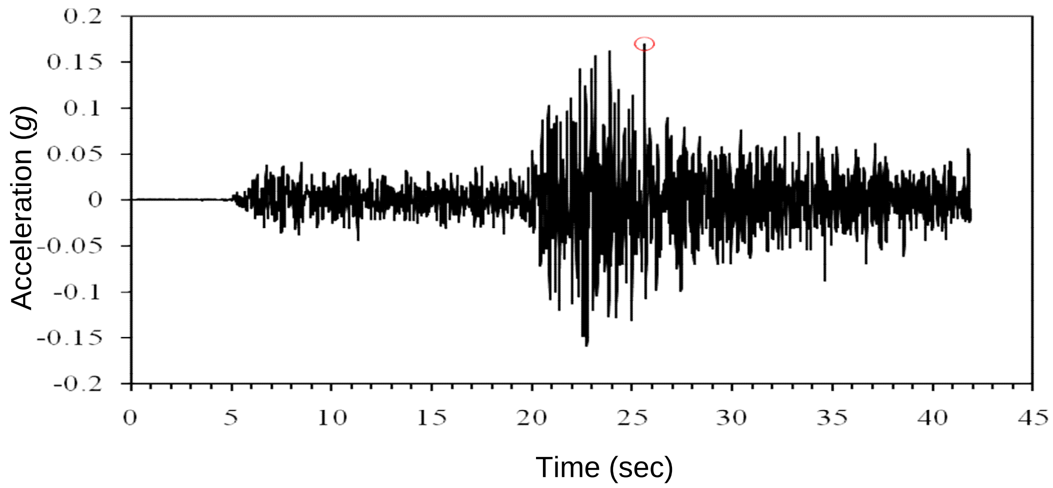


Figure 4.29 Sample peak ground acceleration output from the *EERA* ground response analysis

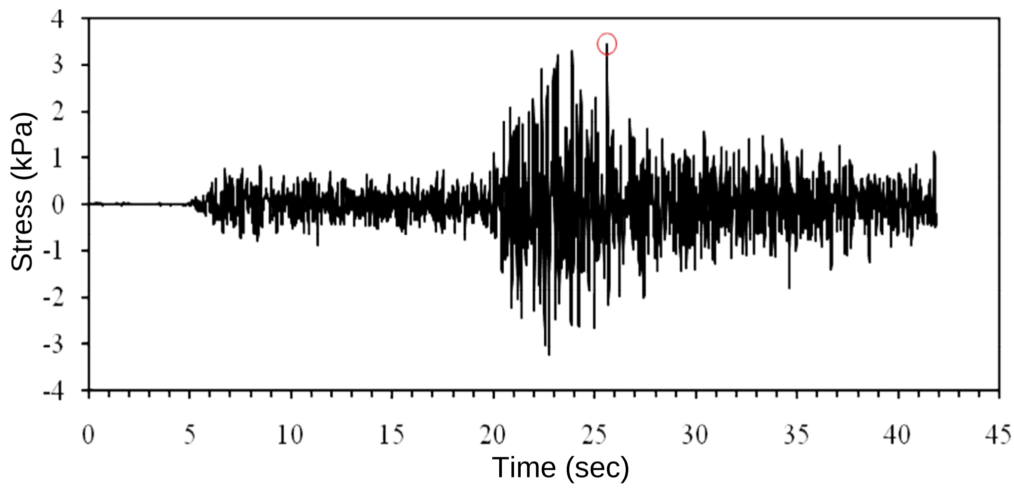


Figure 4.30 Sample stress output from the *EERA* ground response analysis

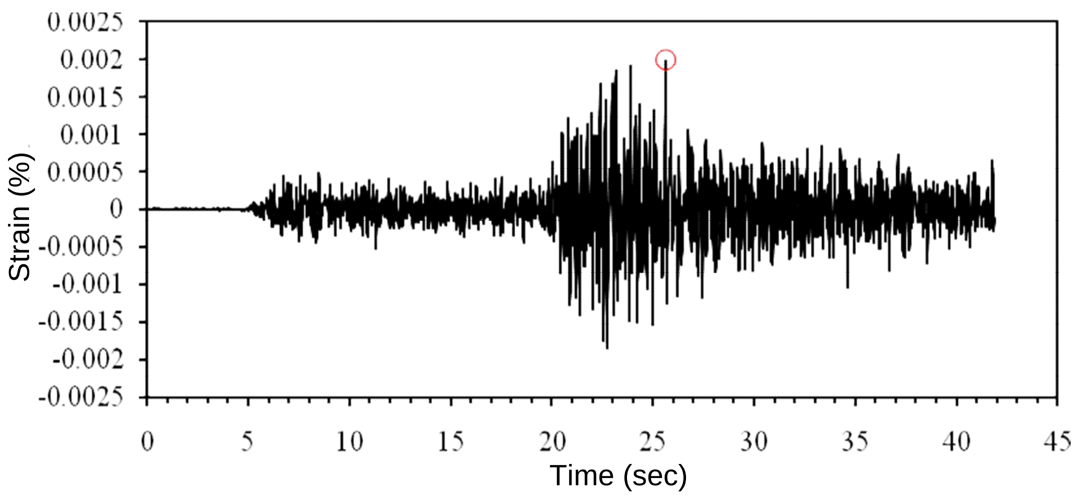


Figure 4.31 Sample strain output from the *EERA* ground response analysis

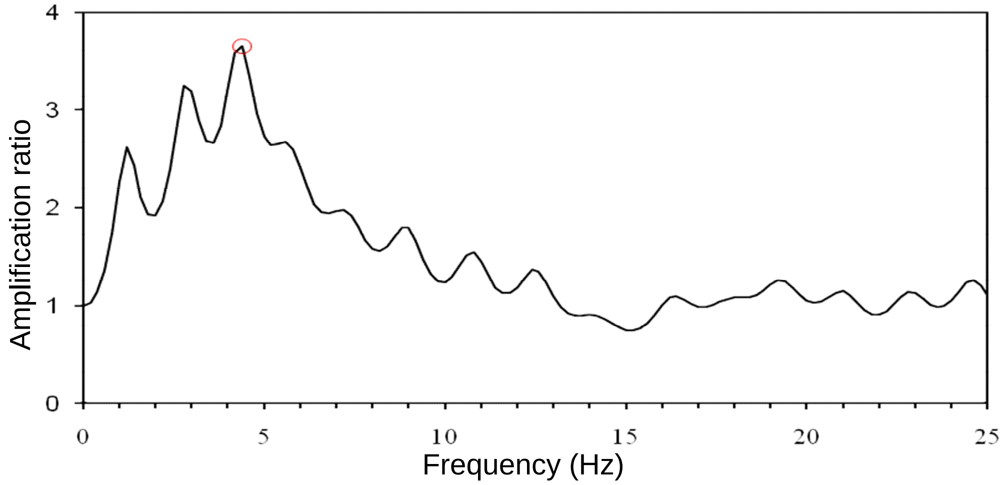


Figure 4.32 Sample amplification ratio output from the *EERA* ground response analysis

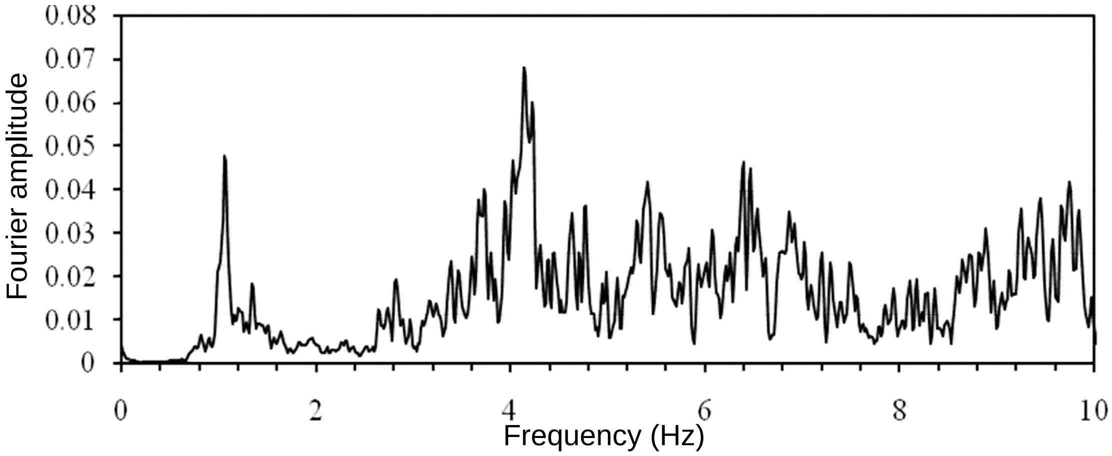


Figure 4.33 Sample Fourier spectrum output from the *EERA* ground response analysis

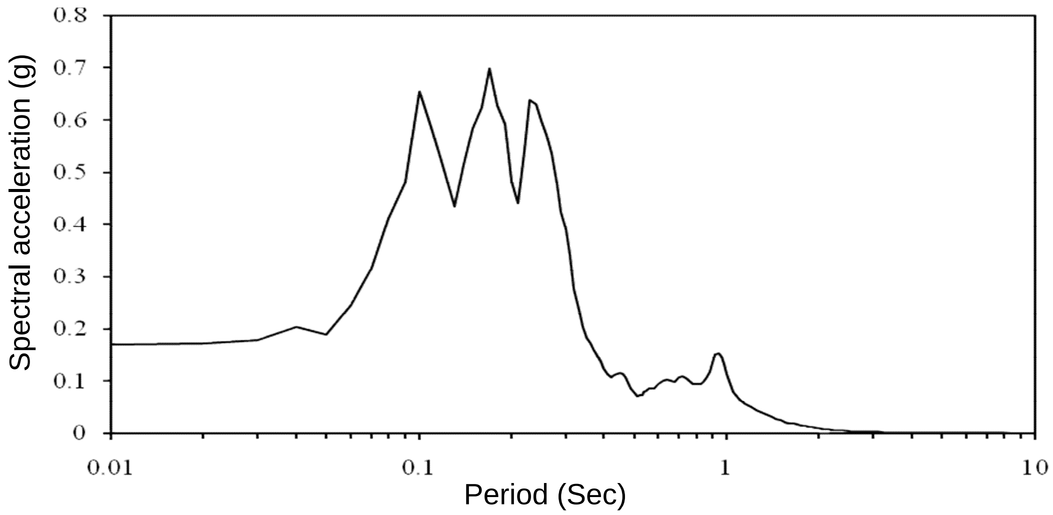


Figure 4.34 Sample response spectral acceleration output from the *EERA* ground response analysis

Table 4.7 Summary of the results of site-specific ground response analysis using *CPT* data

No.	Parameters	Cone Penetration Test											
		GHS-EW		GHS-NS		GHS-UD		TUK-EW		TUK-NS		TUK-UD	
		EERA	SHAKE91	EERA	SHAKE91	EERA	SHAKE91	EERA	SHAKE91	EERA	SHAKE91	EERA	SHAKE91
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	**Compute Motion in New Sublayers**												
A.1	Maximum acceleration @ surface level (g)	0.170	0.170	0.201	0.202	0.173	0.168	0.164	0.175	0.199	0.199	0.131	0.133
A.2	Time of maximum acceleration (sec)	25.62	25.62	23.04	23.04	23.57	23.57	23.22	23.22	22.68	22.68	24.23	24.23
A.3	Mean Square frequency (Hz)	6.69	6.60	6.81	6.82	8.26	8.17	7.60	7.4	7.92	7.31	9.79	9.83
A.4	Maximum acceleration @ bedrock level (g)	0.069	0.069	0.071	0.071	0.054	0.052	0.070	0.075	0.058	0.058	0.059	0.055
A.5	PGA amplification factor	2.46	2.46	2.85	2.83	3.21	3.20	2.33	2.34	3.43	3.44	2.23	2.43
B	**Stress/Strain Values in Times Domain**												
B.1	Maximum strain (%)	0.0020	0.0020	0.0024	0.0024	0.0020	0.0020	0.0020	0.0021	0.0023	0.0023	0.0015	0.0015
B.2	Maximum stress (kPa)	3.46	3.46	4.10	4.123	3.51	3.415	3.43	3.697	3.98	3.999	2.56	2.60
B.3	Time of maximum strain and stress (sec)	25.62	25.62	23.04	23.04	23.57	23.57	23.22	23.22	22.68	22.68	24.23	24.23
C	**Compute Amplification Function in Frequency Domain**												
C.1	Maximum amplification	21.56	38.17	21.66	38.38	20.42	38.15	20.39	38.10	21.45	37.34	22.20	37.13
C.2	Frequency of maximum amplification (Hz)	4.20	2.73	4.20	2.73	4.20	2.73	4.20	2.73	4.20	2.73	2.80	2.73
D	**Fourier Spectrum**												
D.1	Fundamental frequency (Hz)	4.14	4.15	3.98	3.94	6.06	4.18	6.15*	6.61	5.49*	5.51	5.04*	6.17*
E	**Response Spectrum (Ratio of Critical Damping 5%)**												
E.1	Maximum Spectral Acceleration (g)	0.70	0.70	0.67	0.68	0.68	0.62	0.66	0.70	0.56	0.55	0.56	0.47
E.2	Maximum Spectral Velocity (cm/s)	24.89	24.86	19.62	19.66	16.75	16.62	17.67	18.87	21.08	21.10	11.83	11.86

)* This is the interpretation highest fundamental frequency.

Table 4.8 Summary of the results of site-specific ground response analysis using *DMT* data

No.	Parameters	Flat Dilatometer Test											
		GHS-EW		GHS-NS		GHS-UD		TUK-EW		TUK-NS		TUK-UD	
		EERA	SHAKE91	EERA	SHAKE91	EERA	SHAKE91	EERA	SHAKE91	EERA	SHAKE91	EERA	SHAKE91
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	**Compute Motion in New Sublayers**												
A.1	Maximum acceleration @ surface level (g)	0.216	0.214	0.185	0.184	0.199	0.189	0.204	0.217	0.208	0.211	0.185	0.182
A.2	Time of maximum acceleration (sec)	23.01	23.02	22.99	23.00	22.75	22.76	23.24	23.24	22.93	22.94	25.41	24.93
A.3	Mean Square frequency (Hz)	7.91	7.77	7.60	7.69	9.66	9.60	9.89	9.50	9.97	9.08	12.38	12.20
A.4	Maximum acceleration @ bedrock level (g)	0.058	0.056	0.073	0.066	0.061	0.066	0.064	0.070	0.062	0.060	0.066	0.060
A.5	PGA amplification factor	3.72	3.84	2.53	2.78	3.24	2.88	3.20	3.11	3.35	3.50	2.82	3.04
B	**Stress/Strain Values in Times Domain**												
B.1	Maximum strain (%)	0.0224	0.0223	0.0197	0.0197	0.0191	0.0184	0.0205	0.0216	0.0204	0.0208	0.0161	0.0156
B.2	Maximum stress (kPa)	6.98	6.95	6.13	6.16	5.95	5.78	6.42	6.75	6.40	6.51	5.12	4.94
B.3	Time of maximum strain and stress (sec)	23.01	23.02	22.99	23.00	22.75	23.59	23.24	23.24	22.94	22.94	25.40	23.72
C	**Compute Amplification Function in Frequency Domain**												
C.1	Maximum amplification	21.48	80.68	22.59	90.90	20.64	99.65	20.39	92.79	21.75	71.19	25.73	111.13
C.2	Frequency of maximum amplification (Hz)	3.60	1.12	3.60	1.12	3.60	1.12	3.60	1.12	3.60	1.12	2.60	1.12
D	**Fourier Spectrum**												
D.1	Fundamental frequency (Hz)	1.05**	3.69	3.98	3.94	2.50	2.50	2.46*	2.19	2.62*	2.93	2.54*	2.58
E	**Response Spectrum (Ratio of Critical Damping 5%)**												
E.1	Maximum Spectral Acceleration (g)	0.71	0.69	0.66	0.66	0.67	0.58	0.68	0.56	0.88	0.67	1.02	0.53
E.2	Maximum Spectral Velocity (cm/s)	26.21	26.83	22.52	22.75	31.73	31.50	25.96	28.02	25.15	24.90	17.88	17.76

)* This is the interpretation highest fundamental frequency.

)** The second highest fundamental frequency is 3.68Hz.

4.3 RESULTS OF THE SITE-SPECIFIC GROUND RESPONSE ANALYSIS USING *CPT* DATA

The results of site-specific ground response analysis using *CPT* data are as follows. The maximum ground surface acceleration was found to be in the range of 0.131 to 0.202 *g*. The maximum accelerations at the ground surface were compared with the acceleration at the site's bedrock level. The results imply site amplification factors of 2.23 to 3.44. The average site amplification factor of 2.77 is shown in Figure 4.35.

The maximum strain in the uppermost layer was found to vary between 0.0015 and 0.0024%, with a maximum stress from 2.56 to 4.12 kPa. The amplification ratio between the top layer and bedrock was between 20.39 and 38.38 which occurred in the frequency range of 2.73to 4.20 Hz. Fourier spectrum analysis indicates a fundamental frequency from 3.94 to 6.17 Hz. Response spectrum analysis with a critical damping ratio of 5% shows a maximum spectral acceleration of 0.47 to 0.70 *g*, and a maximum spectral velocity that varies from 11.86 to 24.89 cm/s.

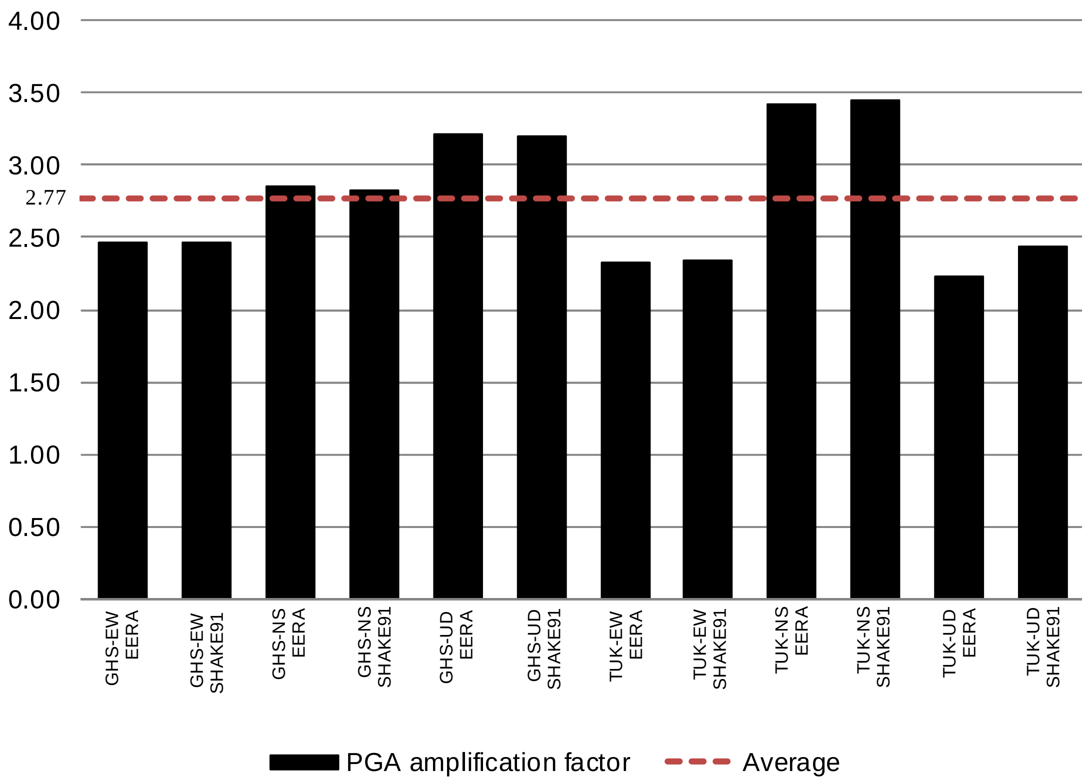


Figure 4.35 PGA amplification factor from site-specific ground response analysis using *CPT* data

4.4 RESULTS OF THE SITE-SPECIFIC GROUND RESPONSE ANALYSIS USING *DMT* DATA

The results of ground response analysis using *DMT* data are as follows. The maximum ground surface acceleration was predicted to be in the range of 0.182 to 0.217 *g*. The site amplification factor was estimated to vary between 2.53 and 3.84, with an average factor of 3.17, as shown in Figure 4.36.

The maximum strain in the top layer was found to be in between 0.0156 and 0.0224%, with a maximum stress varying from 4.94 to 6.98 kPa. The value of the output of the amplification ratio between the top layer and the bedrock varied considerably between *EERA* and *SHAKE91*. The amplification ratio produced by *EERA* ranged from 20.39 to 25.73 which occurred at a frequency between 2.6 and 3.6 Hz. On the other hand, *SHAKE91* produced a ratio between 71.19 and 111.13 at a frequency of about 1.12 Hz. The Fourier response spectrum varies between 2.19 and 3.98 Hz. The response spectrum analysis with a critical damping ratio of 5% shows a maximum spectral acceleration ranging from 0.53 to 1.02 *g*, while the maximum spectral velocity varies from 17.76 to 31.73 cm/s.

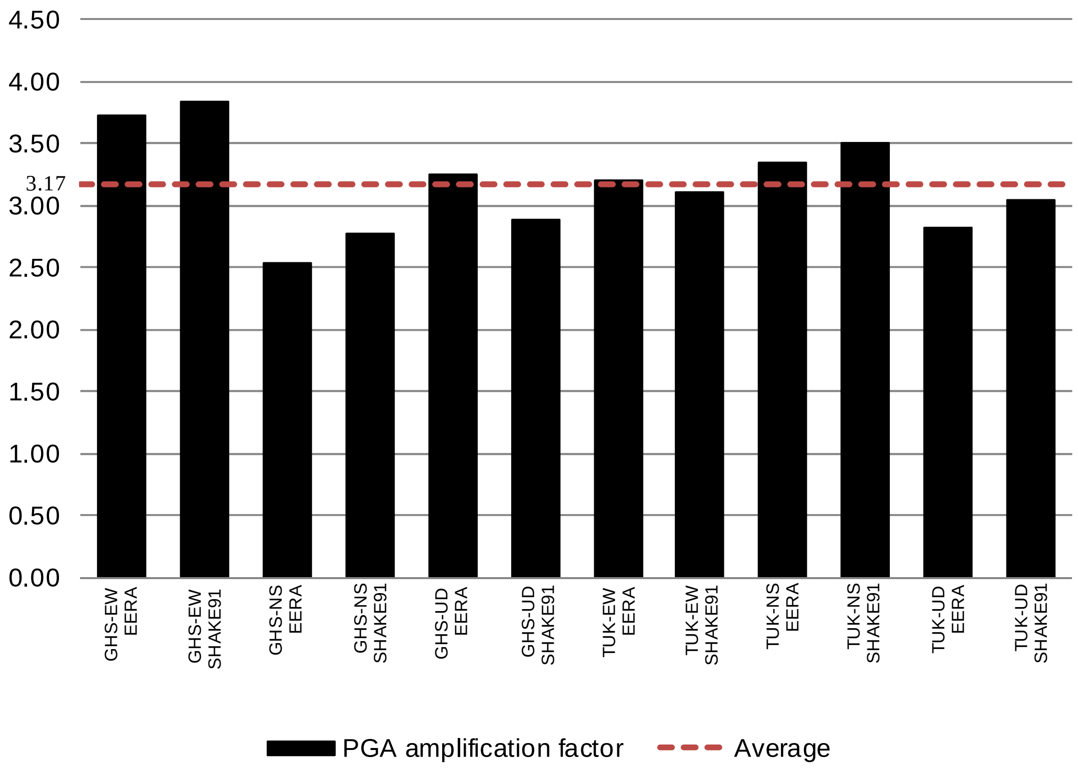


Figure 4.36 *PGA* amplification factor from site-specific ground response analysis using *DMT* data

4.5 COMPARISON THE SITE-SPECIFIC GROUND RESPONSE ANALYSIS RESULTS WITH OTHERS

The ground response analysis outputs were compared with the results from a study by Love (1996). Of particular interest were the results from Profile 14 of the Gillman Site, SA. In terms of site-specific peak ground acceleration as shown in Figures 4.37 and 4.38, the average calculated *PGA* was 0.17 *g* in the analysis using *CPT* data and 0.20 *g* in the analysis using *DMT* data. This is slightly lower than the average *PGA* predicted by Love (1996). He expected a *PGA* average of 0.25 *g*.

The averages of site-specific ground acceleration in this study (0.17 g and 0.20 *g*) are higher than the value used by Mitchell and Moore (2007) and Mitchell (2009), which was only 0.15 *g*. The difference is between 0.024 and 0.049 *g*. On the other hand, the average found in this study is lower than the PGA (0.23 *g*) estimated by Poulos et al. (1996) for approximately similar soil profiles in the St. Kilda Formation. The discrepancy varies from 0.051 to 0.076 *g*. This may be due to differences in the method or the input data used in the analysis. In addition, the differences may reflect the complexity of the ground motion induced by earthquakes, which involves frequency, content, travel path, duration and other characteristics. A summary of the comparison is presented in Table 4.9.

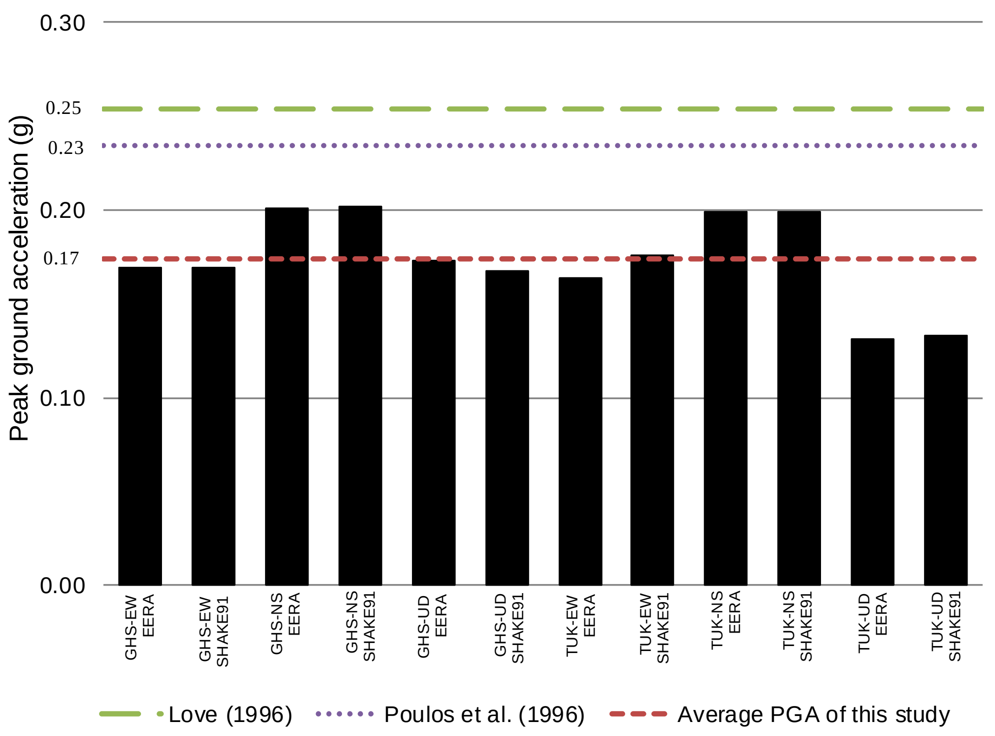


Figure 4.37 Predicted maximum acceleration at ground level using *CPT* data

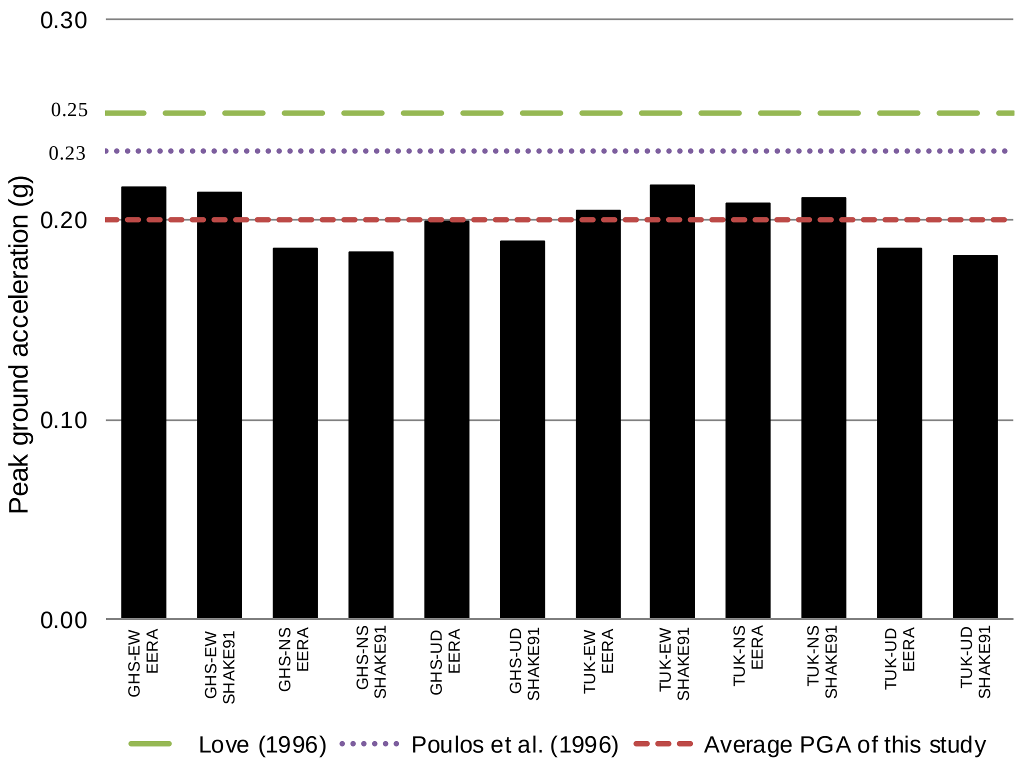


Figure 4.38 Predicted maximum acceleration at ground level using *DMT* data

Table 4.9 Summary of comparison of site-specific peak ground acceleration (*PGA*)

Description	*PGA* (*g*)	Notes
Site-specific ground response analysis of this study	0.202 (MAX) 0.174 (AVERAGE) 0.131 (MIN)	Site-specific ground response analysis was carried out using *SHAKE91* and *EERA*. Soil profiles were estimated using *CPT* data.
	0.217 (MAX) 0.199 (AVERAGE) 0.182 (MIN)	Site-specific ground response analysis was carried out using *SHAKE91* and *EERA*. Soil profiles were estimated using *DMT* data.
Poulos et al. (1996)	0.234	Site-specific ground response analysis was carried out using *ERLS* (Earthquake Response of Layered Soils). Soil profiles were estimated using geological map of Adelaide. The *PGA* is the median value.
Mitchell & Moore (2007) and Mitchell (2009)	0.15	Site-specific ground response analysis was carried out using *SHAKE91*.
Love (1996)	0.253	Site-specific ground response analysis was carried out using *ERLS* (Earthquake Response of Layered Soils).

A comparison of these analyses of the spectral acceleration values with 5% damping ratio with the Love (1996) findings shows a reasonably good agreement. The averages of the spectral accelerations of these analyses are 0.63 *g* and 0.69 *g*. Love (1996) estimated an average spectral acceleration of 0.76 *g* at Gillman, SA. The comparisons are shown in Figures 4.39 and 4.40.

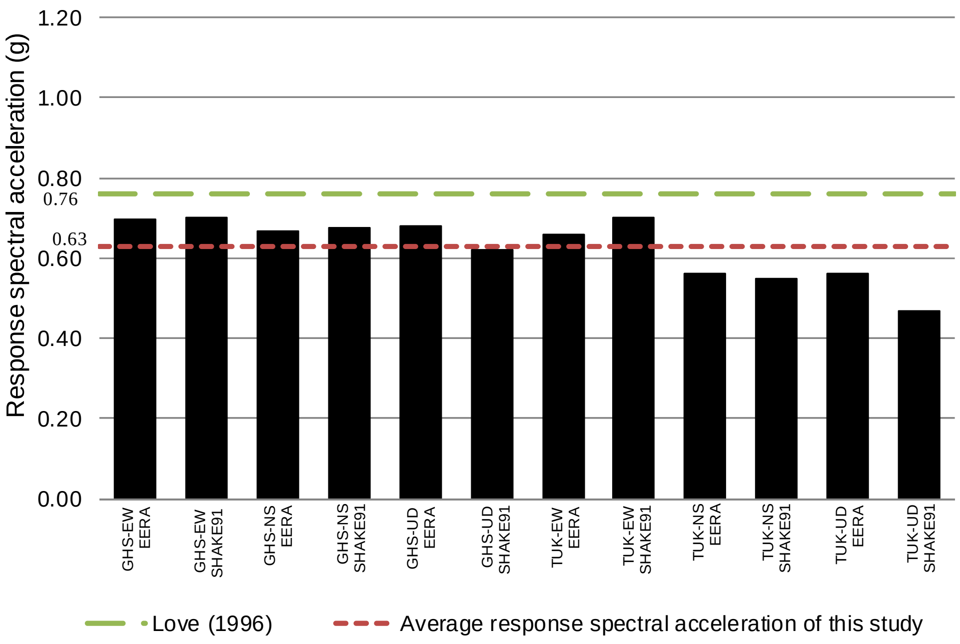


Figure 4.39 Acceleration response spectra of calculated motions at ground surface from *CPT* data

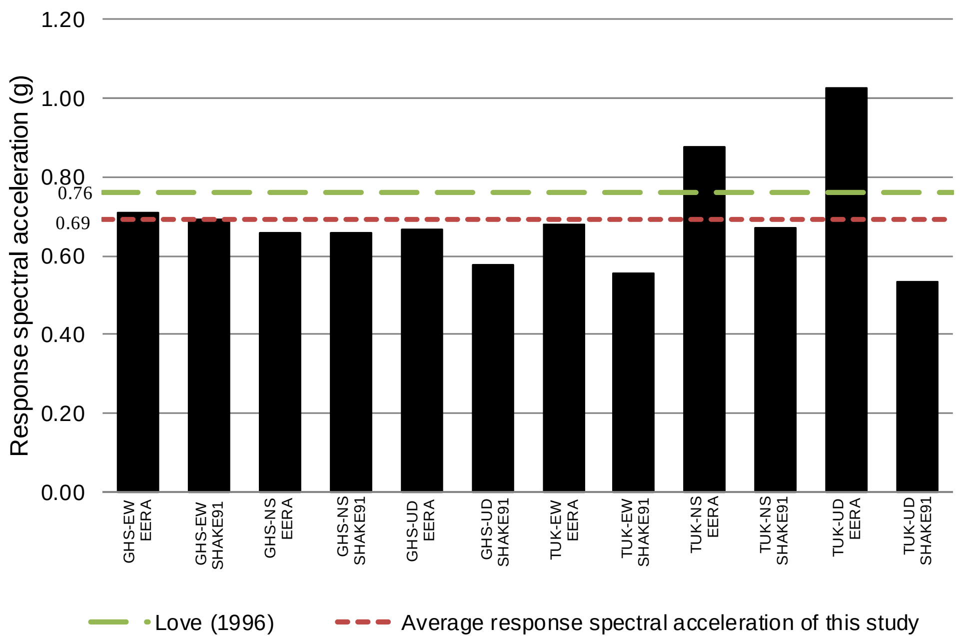


Figure 4.40 Acceleration response spectra of calculated motions at ground surface from *DMT* data

The outputs of spectral acceleration from Profile 14 (Gillman Site, SA) were also compared with those of Love (1996) in the time domain. It was found that the averages of the spectral acceleration appear to have two resonant peaks, as shown in Figures 4.41 to 4.44. The first of the peaks is at 0.2 seconds and the second peak is in the range of 0.4 to 0.6 seconds. These analyses show that all the peaks of spectral acceleration occur at a period of less than 2 seconds, as shown in Figures 4.41 to 4.44.

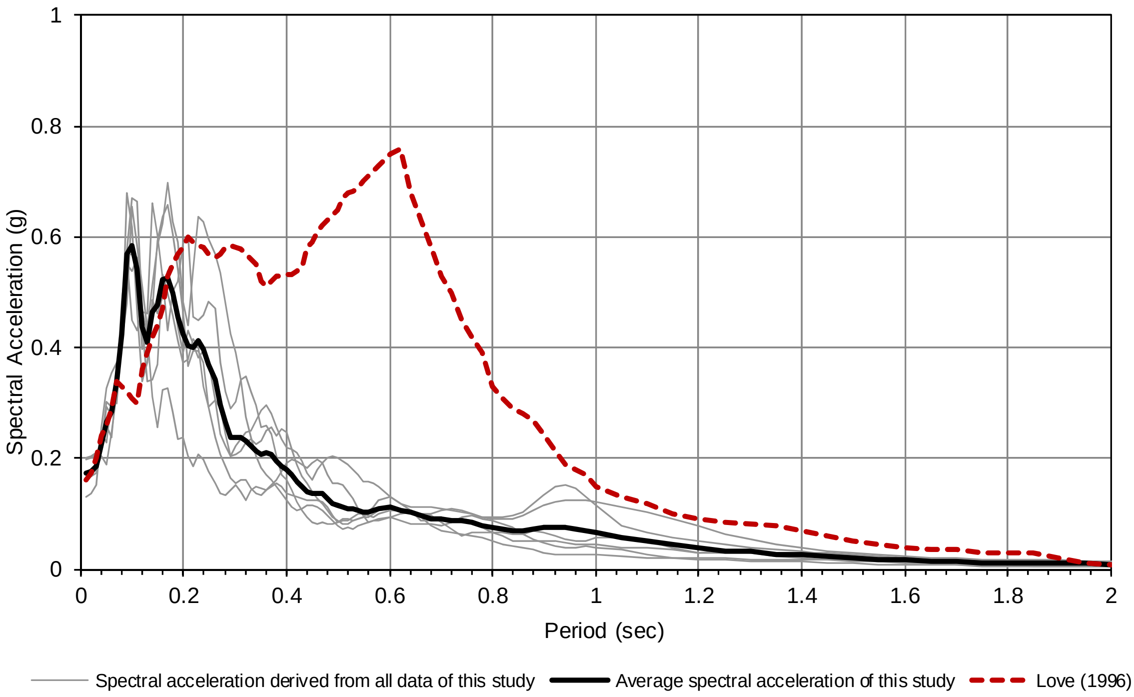


Figure 4.41 Spectral acceleration in time domain from *EERA* using *CPT* data

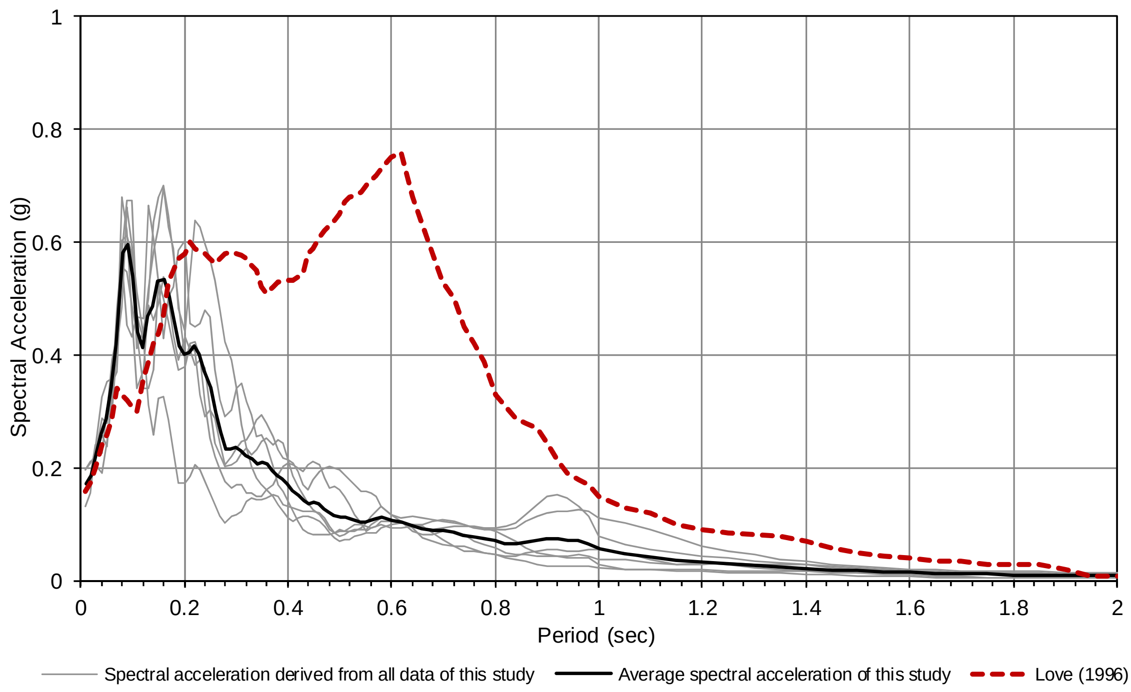


Figure 4.42 Spectral aceleration in time domain from *SHAKE91* using *CPT* data

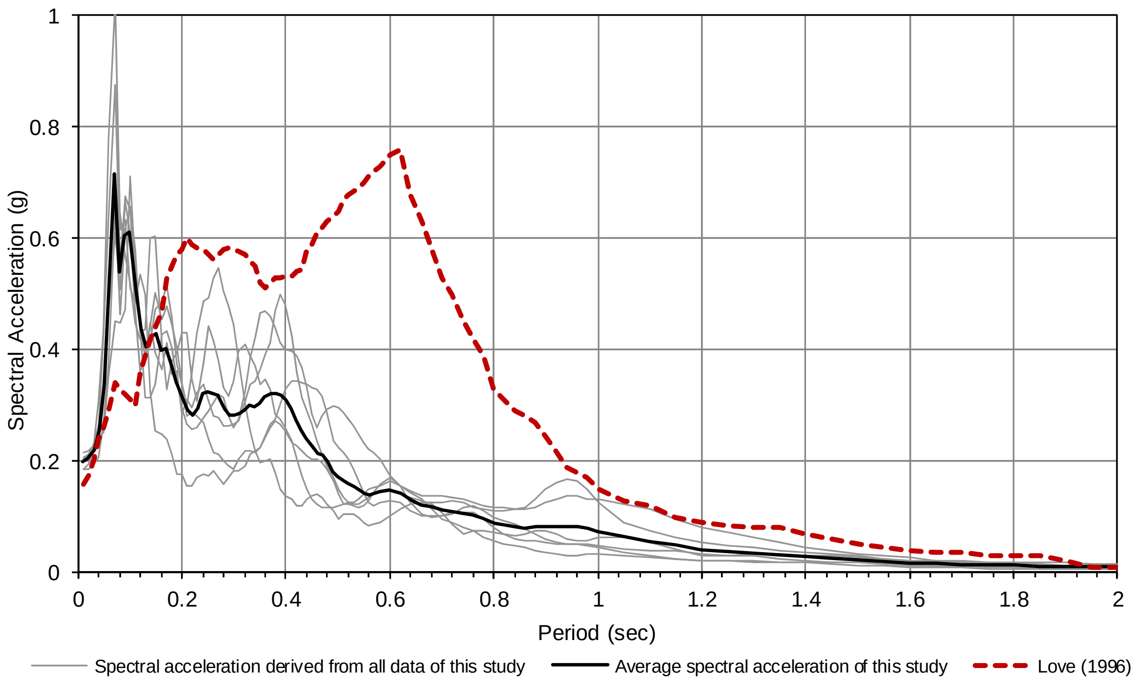


Figure 4.43 Spectral acceleration in time domain from *EERA* using *DMT* data

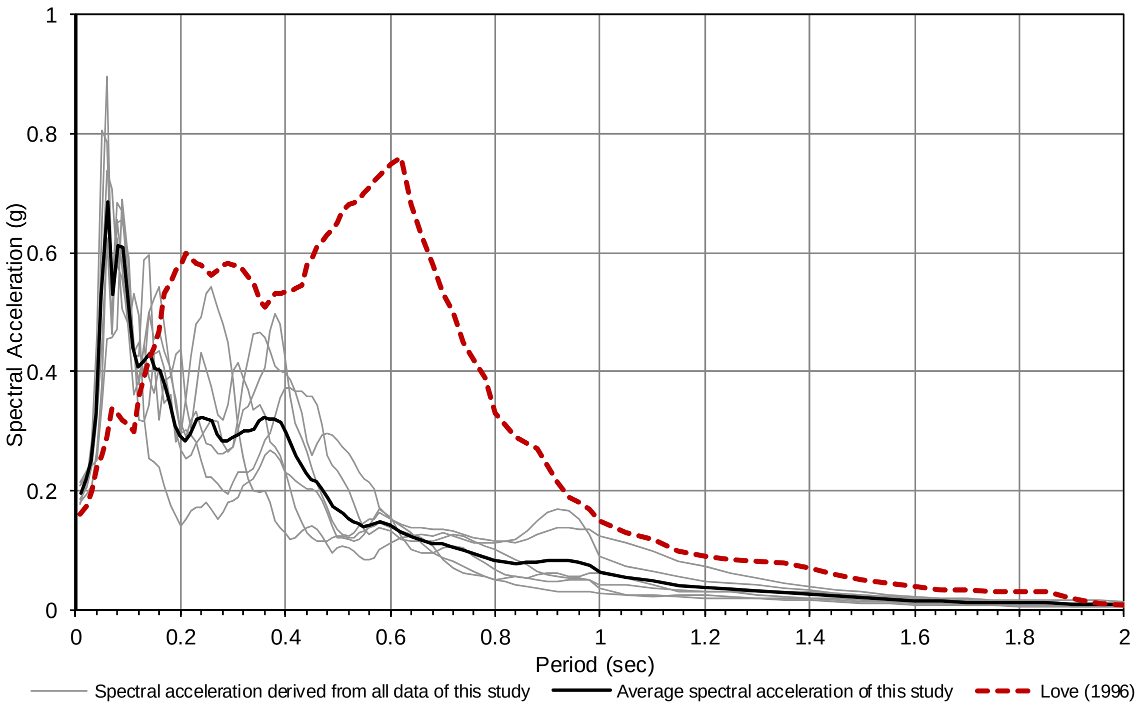


Figure 4.44 Spectral acceleration in time domain from *SHAKE91* using *DMT* data

4.6 CONCLUSION

Various aspects related to site-specific ground response analysis involved in conducting a complete ground response study have been reviewed, along with the justification for the widely used one-dimensional ground response analysis. A case study involving ground response analysis was presented. This involved the input from six earthquake motions, two estimated soil profiles and three types of modulus and damping curves. The results of these ground response analyses clearly indicate that the input parameters are modified considerably at the area of the study site due to local site effects.

In the ground response analyses using soil profiles from the *CPT* show that the *PGA* varies from 0.131 to 0.202 *g*. The *PGA* amplification factor ranges from 2.23 to 3.44. Spectral acceleration with a 5% ratio of critical damping ranges from 0.47 and 0.70 *g*.

In the analyses using the *DMT* data, soil profiles reveal that the maximum acceleration at the surface level varies from 0.182 to 0.217 *g*. The acceleration at bedrock level is amplified in a range between 2.53 to 3.84 *g*. A response spectrum using a 5% ratio of critical damping indicates that spectral acceleration is between 0.53 and 1.02 *g*.

A comparison with other studies shows that the results of site-specific ground response analysis depend on the earthquake input motions used, the characteristic soil profiles, and the shear modulus and damping behaviour of the soil material when it is strained. However, the general results exhibit reasonably good agreement with the results of others. Finally, the spectral acceleration values of the ground motion plotted in the time domain indicate higher values of spectral acceleration for periods less than approximately 0.2 seconds.

The following chapter details a simple critical state parameter test. The results of the test are used for liquefaction assessment using a critical state approach.

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Chapter Five

CRITICAL STATE PARAMETER OF THE ST. KILDA FORMATION

5.1 INTRODUCTION

Generally, the behaviour of granular soil is influenced by various factors, such as void ratio, mean effective stress, soil fabric or cementation, and the stress or strain history. However, due to the difficulty in measuring some of these parameters, emphasis has been given to relative density, D_r. The density of coarse-grained soil can, alternatively, be captured by the relationship between the void ratio and the mean stress. This relationship is known as the soil state parameter, ψ, which is defined as the difference between the existing void ratio of the soil and its reference critical void ratio at the same mean effective stress (Been & Jefferies, 1985). The critical state was defined by Schofield and Wroth (1968) as the state at which the soil continues to deform at constant stress.

The state parameter concept is an important concept in the characterization of the behaviour of coarse-grained soils, combining as it does the effects of both relative density and stress level in a rational way. The state parameter governs the tendency of sand to increase or decrease in volume when sheared, and is, therefore, strongly related to liquefaction resistance (e.g. Boulanger, 2003 and Boulanger & Idriss, 2004).

In this study, a method to determine the critical state line proposed by Santamarina & Cho (2001) was used. This chapter primarily describes the steps related to this method, as shown in Figure 5.1, which consist of selecting the soil samples for testing, the experimental apparatus, the testing procedure, calibrating the procedure and membrane stiffness, calculating the data and finally presenting and discussing the results.

5.2 SELECTING AND PREPARING THE TEST SAMPLES

Methods of selecting and preparing the samples for the critical state parameter (*CS*) test are not mentioned in the proposal by Santamarina & Cho (2001). Therefore, an interpretation with respect to selecting and preparing the samples for this laboratory testing was made. These processes are explained in the following sections.

5.2.1 Selecting sample for the simple *CS* test

A selection process is necessary prior to critical state parameter testing as the test is applicable only for sandy soils. Therefore, there are a number of basic soil tests that need to be carried out to facilitate soil classification. These basic soil tests include: specific gravity, natural moisture content, sieve analysis, and Atterberg's liquid and plastic limits tests. The details and summaries of the basic soil laboratory testing are shown in Appendix D and Chapter 3.

Of interest was the granular soils which made up the three samples at *BH* #1 and three samples at *BH* #2. All of these samples are classified as SM – Silty SAND in the *USCS* and are expected to liquefy during cyclic loading. Therefore, the behaviour of these samples is of interest whether it is dilative or contractive.

The laboratory results indicated that there were three coarse-grained layers at the study site. The first one ranged from 1.2 to 2.7m depth. The in-situ moisture content of this layer varied from 36.0 to 39.2%. Specific gravity was between 2.62 to 2.63. The plasticity index was between 3.8 and 4.2%, and the fines content varied from 26.9 to 28.5%.

The second coarse-grained layer was between 2.2 and 4.7 m deep. The in-situ moisture content ranged from 50.4 to 67.3%. The specific gravity ranged from 2.68 to 2.69. The plasticity index was between 2.9 and 4.2. The fines content of this layer varied from 22.1 to 24.4%.

The last layer was located 6.0 to 9.0 m below ground level. This layer had a moisture content of 26.6 to 33.1%. The specific gravity varied between 2.67 to 2.68. The plasticity index of this last layer was between 3.1 and 3.6, and the fines content ranged from 17.8 and 18.9%. The detailed characteristics of each sample are summarised in Tables 5.1 and 5.2.

The SM – Silty SAND layer from 0.0 to 0.7 m depth in *BH* #2 was excluded from critical state parameter testing because it was localised to *BH* #2 and the natural moisture content of this sample was very low (8.6 %). Liquefaction, therefore, was unlikely to occur in this layer and further investigation was not necessary.

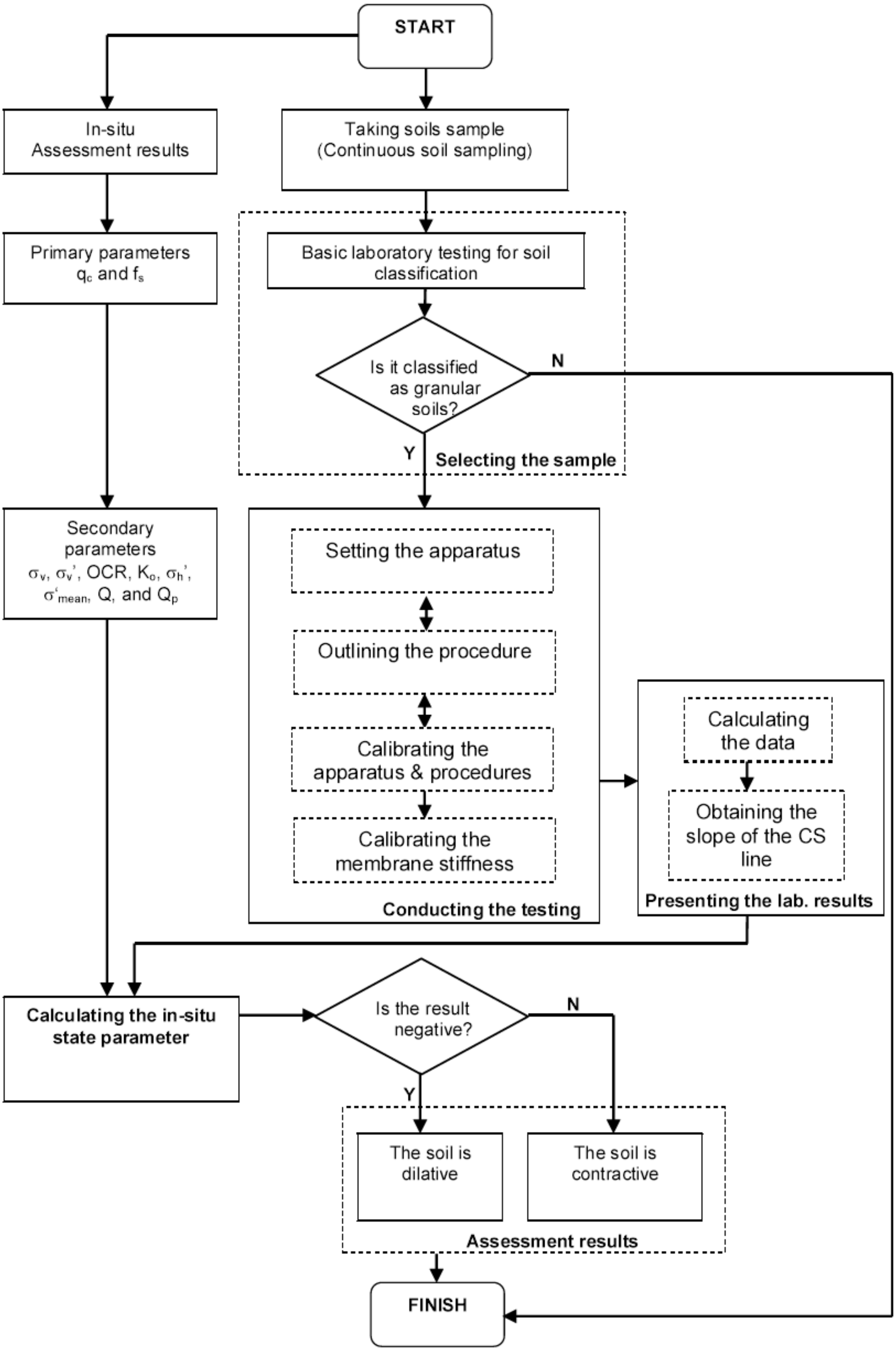


Figure 5.1 Sequence of steps to determine the in-situ critical state parameter, ψ

Table 5.1 Characteristics of the samples for the critical state parameter testing at *BH* #1

Depth (m)	USCS Classification	Characteristics of the samples				Sample Notation Number
		Moisture Content (%)	Specific Gravity	Plasticity Index (%)	Fines Content (%)	
1.35 – 2.70	SM – Silty SAND	39.2	2.63	3.8	28.5	Sample #1.2
2.70 – 4.70	SM – Silty SAND	50.4	2.68	2.9	24.4	Sample #1.3
6.00 – 9.00	SM – Silty SAND	33.1	2.68	3.6	17.8	Sample #1.5

Table 5.2 Characteristics of the samples for the critical state parameter testing at *BH* #2

Depth (m)	USCS Classification	Characteristics of the samples				Sample Notation Number
		Moisture Content (%)	Specific Gravity	Plasticity Index (%)	Fines Content (%)	
1.20 – 2.20	SM – Silty SAND	36.0	2.62	4.2	26.9	Sample #2.3
2.20 – 4.30	SM – Silty SAND	67.3	2.69	4.2	22.1	Sample #2.4
6.30 – 8.50	SM – Silty SAND	26.6	2.67	3.1	18.9	Sample #2.6

5.2.2 Preparing the sample for the simple *CS* test

Sample preparation for the simple *CS* test is another issue that was not mentioned in the method proposed by Santamarina & Cho (2001). Therefore, the samples for the test were prepared in accordance with AS 1289.1.1-2001. According to this standard, the following apparatus is required: (a) balances with sufficient capacity and limit of performance; (b) mortar and rubber pestle; (c) 2.36 mm opening sieve; (d) controlled drying oven; and (e) drying trays.

The procedures in preparing the sample for the test were:

(1) Collect approximately a 1.5 kg sample from the core box and put in the drying tray.

(2) Place it into an oven operating at a temperature of 50° C for 24 hours.

(3) Reduce the size of soil clods by chopping, grating and crumbling until the individual soil particle is separated (if necessary use mortar and rubber pestle).

(4) Remove all the organic matter.

(5) Put the soil through a sieve with a 2.36 mm opening.

(6) Recombine all soil particles and mix thoroughly by quartering.

(7) Divide the sample into three different groups as follow:

   a. approximately 800 g for the simple CS test

   b. approximately 300 g for the critical friction angle test

   c. approximately 100 g for the specific gravity test.

5.3 METHOD OF LABORATORY TESTING

Only two laboratory tests are explained detail, including the set up of the experimental apparatus and the procedures. These are the *simple critical state parameter test* and the *critical friction angle test*. The remaining laboratory tests, such as specific gravity, moisture content, sieve analysis and Atterberg limits are relatively routine and are described by numerous standards and books, such as Australian Standards, *ASTM* or Bowles (1986).

5.3.1 Setting up the experimental apparatus for the *CS* test

Santamarina & Cho (2001) explained that the apparatus for use in their simplified test included: a vacuum system, a thin latex membrane, two plexiglass caps, two o-rings, a graduated cylinder, a porous stone, and a semi-rigid transparent hose. The general set up of the apparatus is shown in Figure 5.2.

5.3.2 Procedure of the simple *CS* test

The general test procedure for the determination of critical state parameters of sandy soils follows that outlined by Santamarina and Cho (2001). However, a slight modification was made in this study. The simplified *CS* experimental procedures were as follows:

Step 1 Measure all the fixed parameters, such as the internal cross-sectional area of the transparent tube (A_t) and the volume of the device components without soil (V_d). A_t was measured using a caliper. V_d was measured by placing the whole set of device components (two plexiglass caps, a rubber filter, a porous stone, a membrane, a rubber mock-up sample, two O-rings, and an adapter between device and the transparent hose) into a graduated cylinder with a pre-determined volume of water. The graduated cylinder and transparent tube were marked to indicate the point at which the total volume of soil was reached and could be measured. By using a pre-determined volume of water in a graduated cylinder, the volume of the rubber mock-up sample could be measured:

Step 2 Collect approximately 800 g sample from the preparation dish, mix with about 0.5 litre distilled water and de-air the mixture by boiling for about 10 minutes.

Step 3 Place dish in a safe place at room temperature to cool overnight (or the equivalent number of hours).

Step 4 Fill a bucket with about 2 litres of distilled water. Place porous stone in it and leave overnight.

Step 5 Take the sample and slowly place it into the bucket the next day. Be careful not to expose any of the soil to open air.

Step 6 Connect the bottom plexiglass cap with a latex rubber membrane and tighten it using an O-ring.

Step 7 Place the plexiglass set at the bottom of the bucket and carefully fill the membrane with soil and water to a depth of approximately 75 mm or more. Be careful not to compress the sample. Leave it in a loose state.

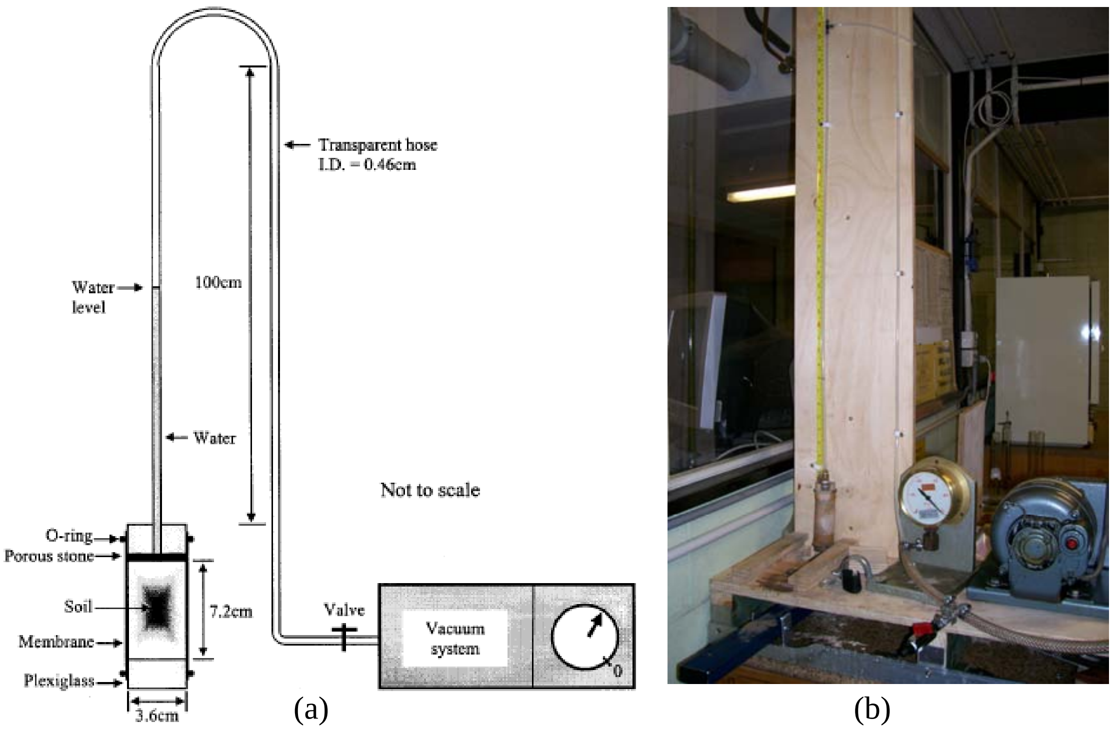


Figure 5.2 (a) Simplified *CS* test experimental set up proposed by Santamarina & Cho (2001) and (b) experimental set up apparatus adopted in this study

Step 8 Put the soaked porous stone and the top plexiglass cap on top of the soil sample and secure it with an O-ring. Maintain the water inside the sample full at all times.

Step 9 Connect the whole set sample with a transparent hose. Secure it tightly and measure the length of the sample.

Step 10 Apply vacuum pressure in three stages (10 kPa, 60 kPa and 100 kPa) and occasionally press the specimen to remove any trapped air. The first two stages were run over about 5 minutes and the last one was run over 10 minutes.

Step 11 Release the vacuum, reform the specimen to its cylindrical shape. When a loose state has been achieved, fasten the sample onto the back wall using a clamp.

Step 12 Apply a vacuum pressure of 10 kPa and apply a vertical loading until the axial strain reached about 40%. Leave it for three 3 minutes. Then, record the elevation of the water h_1 and the distance of the vertical strain. Set the axial vertical strain distance to be constant throughout the trial.

Step 13 Release the vacuum and let the membrane swell, loosen the soil and reform the specimen to its original cylindrical shape by hand.

Step 14 Repeat these steps 12 and 13 at different pressures: 15 kPa, 20 kPa, 25 kPa, 30 kPa, 35 kPa, 40 kPa and 50 kPa while recording σ'_{ci} and h_i.

Step 15 Open the clamp, release the whole set sample, apply vacuum pressure of 50 kPa and put the whole set sample into a graduated cylinder with a pre-determined volume of water to measure the total volume (V_t) of soil as well as the device components at any intermediate pressure and mark the water level (h_o).

Step 16 Release the vacuum, reform the specimen to its cylindrical shape until a loose state is achieved, then fasten the sample onto the back wall again using a clamp.

Step 17 Apply a vacuum pressure of 60 kPa and a vertical loading until an axial strain similar to that achieved at the previous distance is reached. Leave this configuration for about three minutes. Then, record the elevation of the water h_i.

Step 18 Release the vacuum and let the membrane swell, loosen the soil and reform the specimen to its original cylindrical shape by hand.

Step 19 Repeat steps 17 and 18 at pressures of 80 kPa and 100 kPa while recording σ'_{ci} and h_i.

Step 20 Disassemble the device, place the soil sample into a dish and then into an oven at 105°C for a minimum of 16 hours to determine the dry weight of the soil (W_s).

Step 21 Measure the water temperature inside the laboratory to obtain the unit weight of water at a similar temperature (γ_w).

The entire procedure was repeated at least two more times.

5.3.3 Establishing the experimental apparatus for the critical friction angle test

Generally, the apparatus for the critical friction angle test consists of a base, a pedestal and a wall. The base is to keep the apparatus stable during testing. The pedestal is to secure the graduated cylinder. This pedestal must be able to be rotated by an angle of at least 60°. The wall is to secure the pedestal, as well as to mark the degree of its rotation. Between the wall and the pedestal, there is a pin lock. The pin is to ensure that the pedestal returns to a level horizontal to the base. The general layout of the experimental apparatus for the critical angle test used in this study is shown in Figure 5.3.

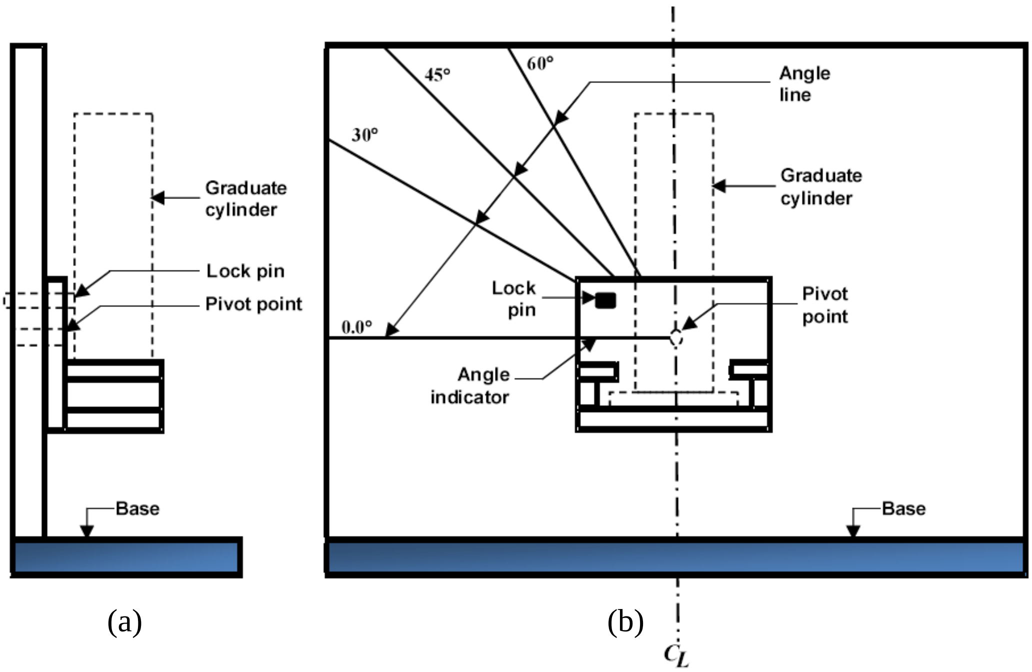


Figure 5.3 Critical friction angle test experimental design apparatus used in this study (a) the side elevation of the apparatus, (b) the front elevation of the apparatus

5.3.4 Procedure of the critical friction angle test

The general experimental procedures for the critical friction angle test are as follows:

Step 1 Almost fill a 500 ml graduated cylinder with water.

Step 2 Collect approximately a 300 g sample from the preparation dish and pour it into the graduated cylinder.

Step 3 Mix thoroughly the sample and the water using a rubber stopper cap or the palm of the hand to cover the graduated cylinder, and carefully agitate it for about one minute.

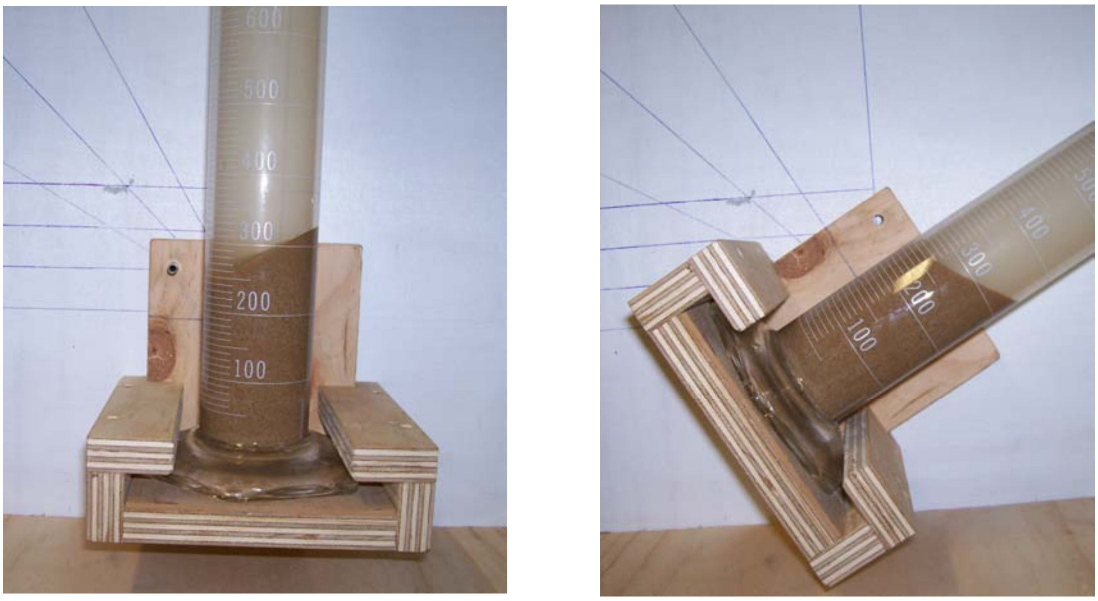
Step 4 Place the graduated cylinder into the pedestal of the apparatus and leave it for about five minutes.

Step 5 Unlock the pin and rotate the pedestal up to 60° and back slowly to avoid unnecessary agitation. Restore the the lock pin to the original position.

Step 6 Measure the critical state friction angle (ϕ_{cs}).

Step 7 Repeat steps 3 to 6 at least two more times.

A representative critical state friction angle is selected by averaging all three trials. Figure 5.4 illustrates of how the critical state friction angle was determined.



(a) (b)

Figure 5.4 Determination of the critical state friction angle in this study (a) the pedestal was rotated for at least 60° (b) the pedestal was returned to it original position prior to measuring the angle

5.4 CALIBRATION TESTS

Two main calibration tests were carried out. These were for calibrating the *CS* and critical state angle test procedures and calibrating the membrane stiffness. Detailed reasons and methods are presented in the following sections.

5.4.1 Calibrating the *CS* and critical state friction angle test procedures

Calibration of the *CS* and the critical state friction angle test are normally carried out to check the overall testing procedure. Calibration includes the sample preparation steps, the *CS* test procedure and the critical state friction angle test procedure. Furthermore, the calibration is also designed to identify the most influential parameter of the testing.

In this study, the calibration was carried out by applying all the procedures as described in detail above for clean sand. The characteristics of the clean sand used in the study were as follows:

- The specific gravity of the sand was 2.66. Gravel content was 0.04%. Sand content was 99.90%. The fines content was 0.06%.

- The grain size distribution is shown in Figure 5.5. The grain diameter (in mm) corresponding to 60%, 30% and 10% passing by weight were 0.461, 0.329 and 0.225 mm, respectively.

- The coefficient of uniformity of the sample is 2.05 and the coefficient of curvature were 1.05. The low value of the coefficient of uniformity at 1.05 indicates that the calibration sample was formed by a single range of grain size.

- Generally, this type of sand is most likely liquefiable because the D_{10} ranges between 0.01 and 0.25 mm, and C_u between 2 and 10, provided the relative density ranges from very loose to medium dense (Guyer, 2010).

Similar to the preparation process for the natural soil sample, the mixing and quartering process was applied to an approximate 1.5 kg calibration sample. Three samples for the specific gravity, *CS* test and critical state friction angle test were selected. A slight difference was made to the *CS* test for the calibration sample. The *CS* test for the natural sample was run only once, but it was run three times for the calibration sample. Detailed characteristics and simple *CS* test results of the calibration samples are presented in Appendix E.

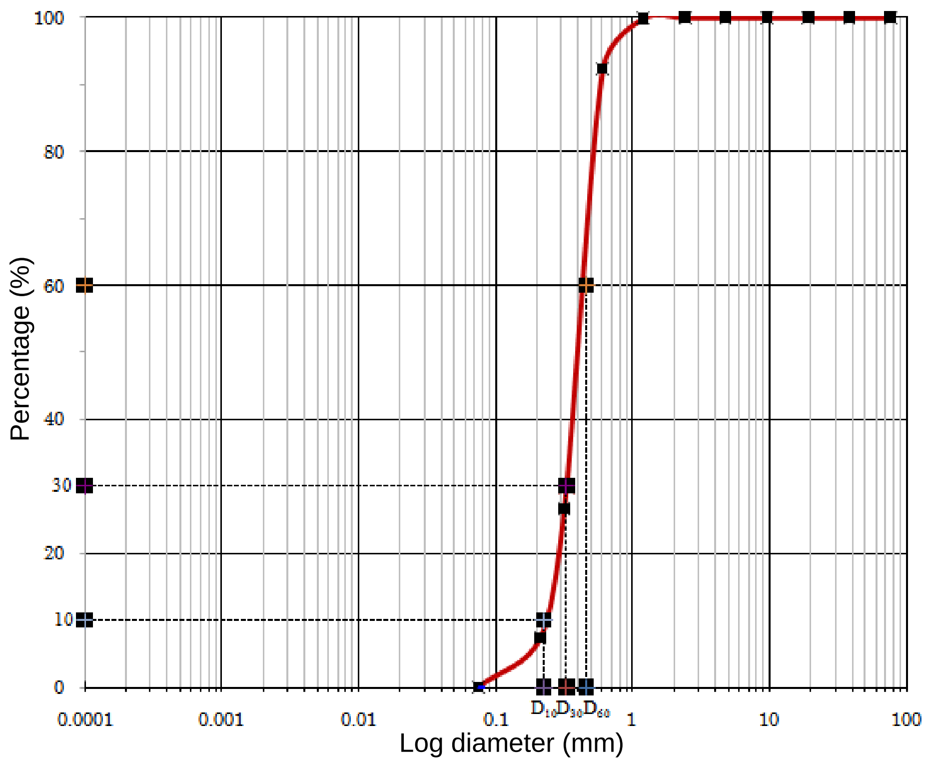


Figure 5.5 Grain sieve analysis results of the calibration sample

5.4.2 Calibrating the membrane stiffness

In order to carry out a *CS* test, a membrane is used. The membranes are latex rubber and are usually employed in standard triaxial testing. The membranes have a diameter of 38 mm and a length of 150 mm. The thickness of the membrane is 0.44 mm.

Enclosing a *CS* specimen with a membrane contributes to the pressure that is applied during testing. This restraining effect needs to be measured to account for this pressure. Measuring the restraining effect is not an easy task, however, because it depends very much on the behaviour of the specimen under strain. In this study, the specimen was assumed to be a plastic material. Therefore, a correction for the membrane stiffness when strained to about 40% was investigated. To determine the magnitude of the membrane correction an equation developed by Henkel & Gilbert (1952) cited by Head (1994) was adopted:

$$c_M = \frac{0.4M\varepsilon(100-\varepsilon)}{D} \quad \text{..} (5.1a)$$

$$c_M \approx \sigma'_m \quad \text{(5.1b)}$$

where

c_M = membrane correction (kN/m^2),

σ'_m = additional radial stress (kN/m^2),

ε = axial strain in the specimen (%),

M = compression modulus of the membrane material (N/mm width), and

D = the initial diameter of the specimen (mm).

The compression modulus of the membrane material, *M*, is expected to be approximately similar with its extension modulus. Therefore, testing to determine the membrane extension modulus was conducted.

Apparatus establishment for membrane extension modulus testing

The establishment of apparatus to measure the membrane extension modulus was originally developed by Bishop & Henkel (1962) (Figure 5.6). Bishop & Henkel's apparatus was adopted for this study and is shown in Figure 5.7.

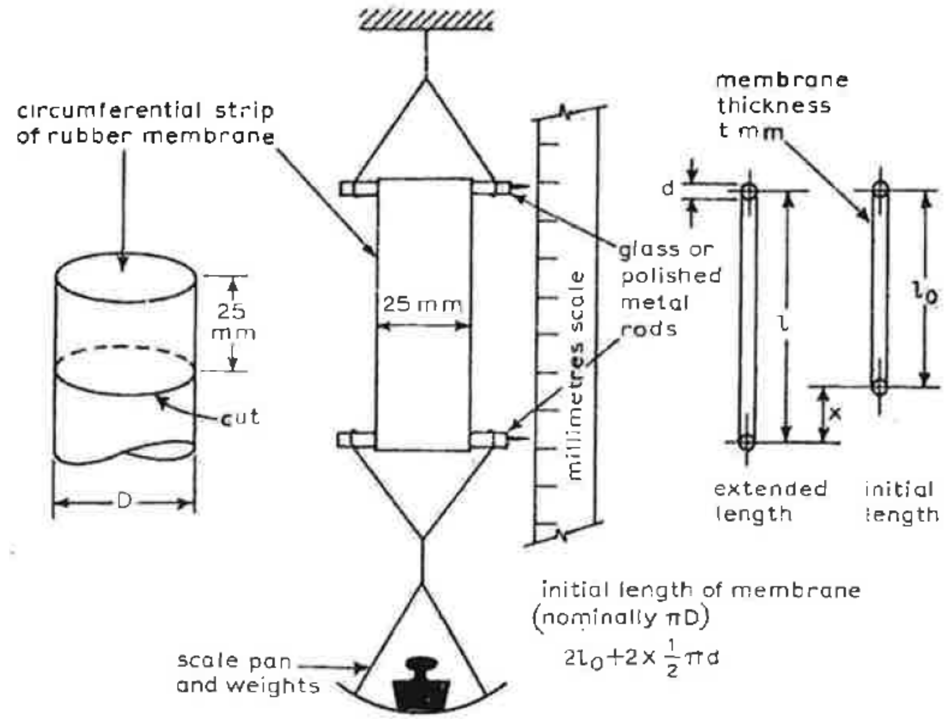
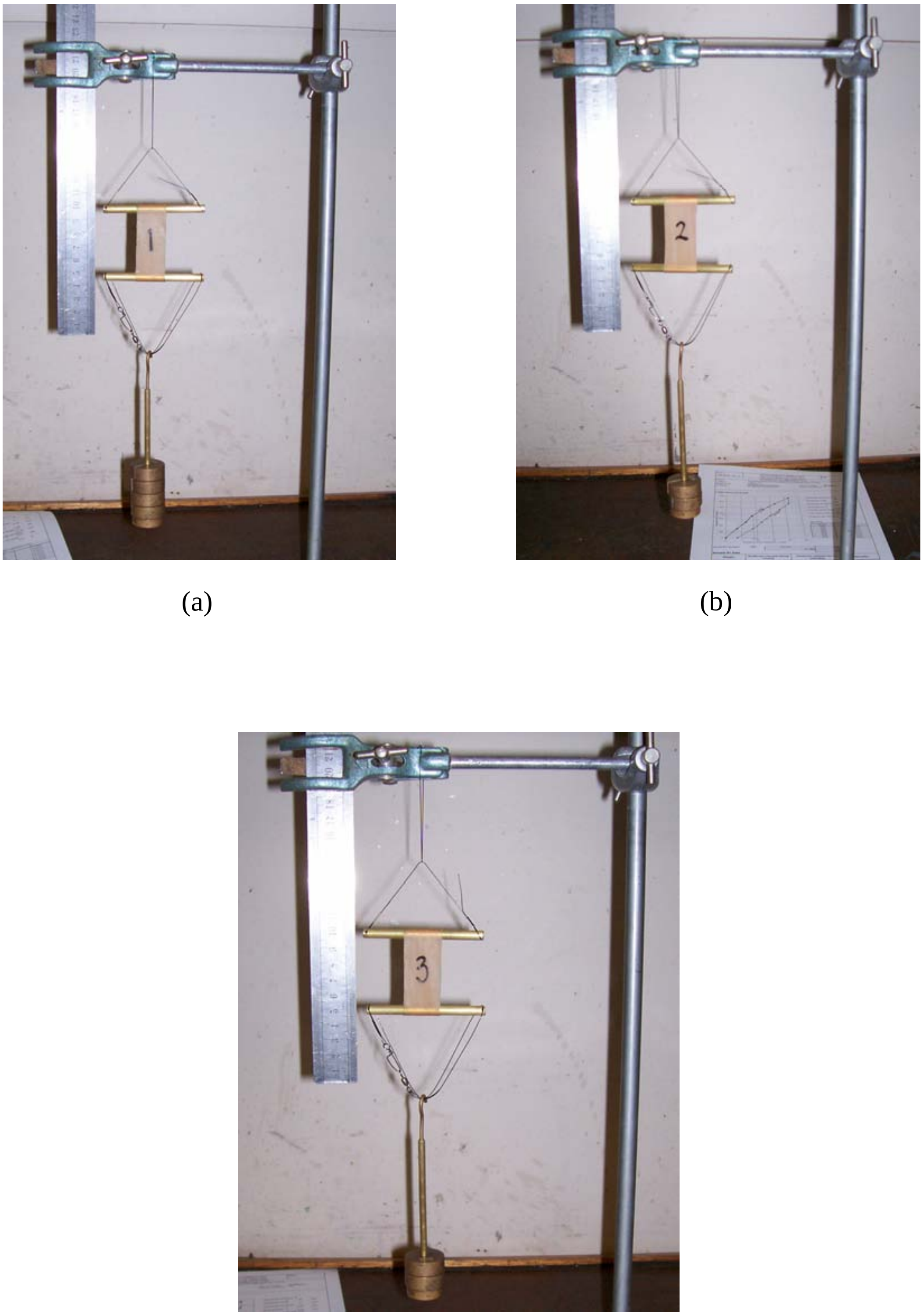


Figure 5.6 Diagram of membrane extension modulus testing
(after Bishop & Henkel, 1962 cited by Head, 1994)



(a) (b)

(c)

Figure 5.7 Membrane extension modulus testing of this study (a) membrane extension modulus testing on specimen #1; (b) membrane extension modulus testing on specimen #2; and (c) membrane extension modulus testing on specimen #3

Procedures for membrane extension modulus testing

Bishop & Henkel (1962, cited by Head (1994) developed a procedure to conduct the membrane extension modulus testing, but a slight modification was made in this study. The routine was as follows:

Step 1 Cut a 25 mm length of a rubber membrane to be used for the testing.

Step 2 Measure and record the diameter of the steel rods to be used (6.38 mm is the diameter of the steel rods in this study).

Step 3 Set up the whole apparatus as shown diagrammatically in Figures 5.6 or 5.7 but without any additional weight hung at the bottom of the steel rods.

Step 4 Measure and record the total lengths of the membrane which is from the upper and lower edges of the steel rods at both sides. The results of this measurement will be used to obtain the initial length. Two different methods of measurement were carried out in this study. The first method used a caliper and another used the attached steel ruler.

Step 5 Add 150 g weights by hanging them onto the thin light wire which is attached to the bottom of the steel rod.

Step 6 Measure and record the distance from the upper and lower edges of the steel rods at both sides by using both a caliper and reading the attached steel ruler.

Step 7 Repeat steps 5 to 6 for attached weights in order of 250 g, 350 g, 454.3 g, 559 g and 665.1 g.

Step 8 Remove the last weight from the suspended pan so the total weight is 559 g.

Step 9 Repeat step 6.

Step 10 Repeat steps 8 to 9 for weights in the order of 454.3 g, 350 g, 250 g, 150 g, without any additional weight.

The average of the total length in the first measurement is used as the initial length. Each average of each total length in the subsequent measurements is subtracted by the initial length to obtain the extension of the membrane, x. A graph of suspended mass against the extension of the membrane during loading and unloading is then plotted, as in Figures 5.8, 5.9 and 5.10, from which the load, W, at 40% strain can be obtained. This W is used to calculate the extension modulus of the rubber membrane.

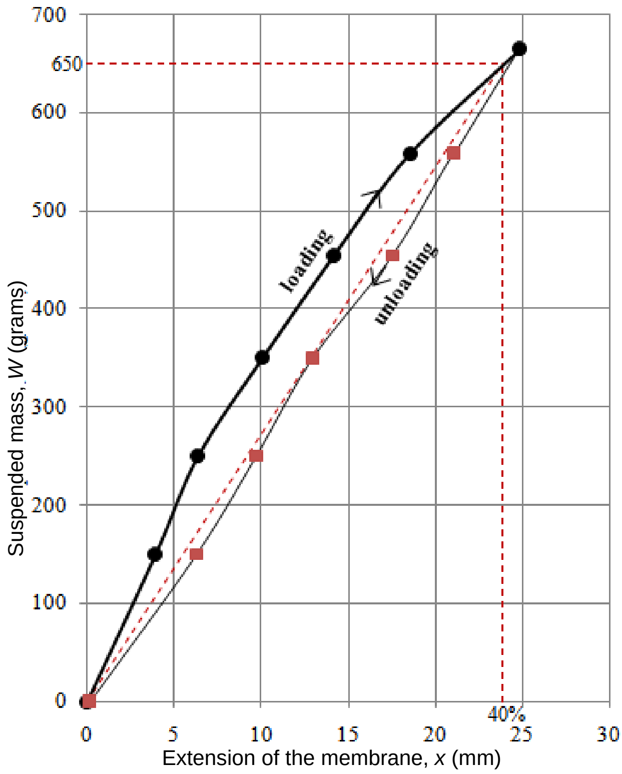


Figure 5.8 Extension modulus test on rubber membrane of sample #1

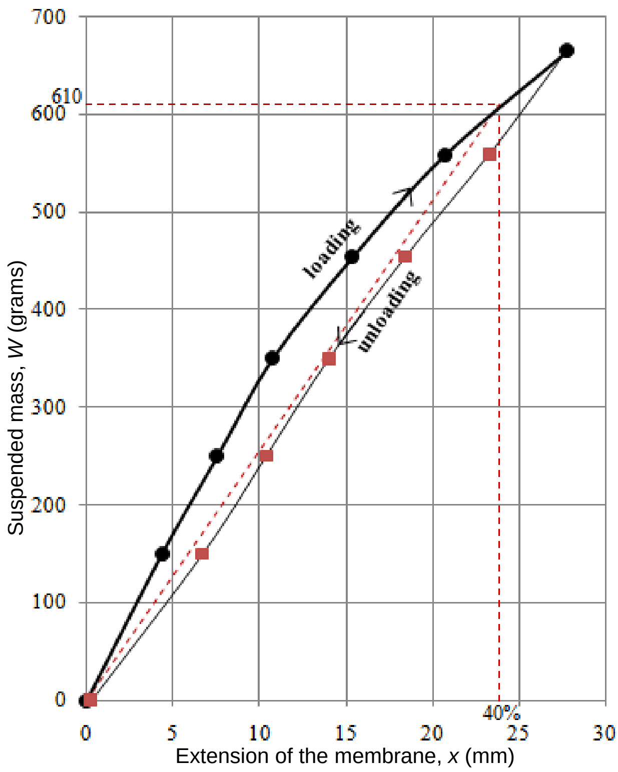


Figure 5.9 Extension modulus test on rubber membrane of sample #2

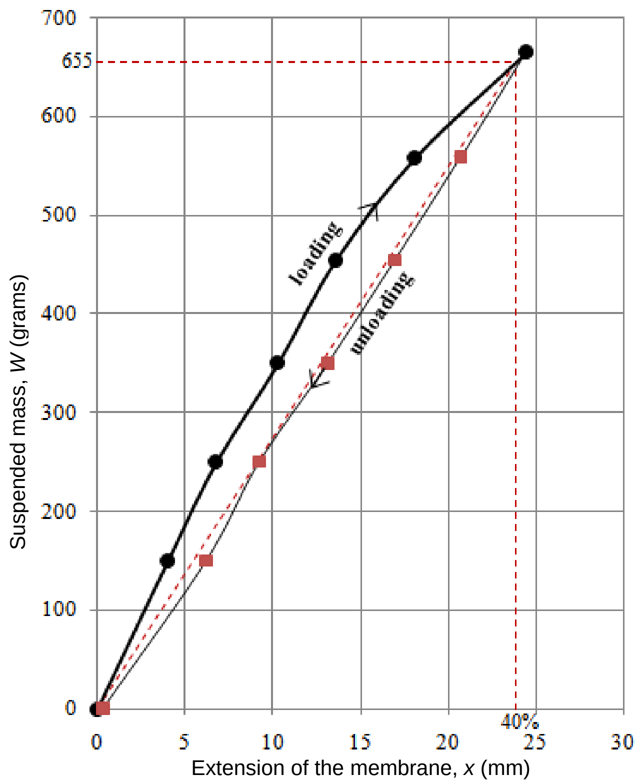


Figure 5.10 Extension modulus test on rubber membrane of sample #3

5.5 RESULTS AND ANALYSIS OF THE CRITICAL STATE TESTING

5.5.1 Data reduction of the testing results

The data reductions to obtain the critical state line can be broken down into three different groups. Some of the data reductions for the critical state parameter test were achieved by direct measurement from the apparatus or sample, such as applied pressure (σ'_{ci}), soil weight (W_s), total volume (V_t), a reference of water level (h_0) and a water level when the a pre-determined pressure is applied and the sample sheared about 40% (h_i).

Two measurements were obtained by averaging two parameters several times. These measurements were the volume of the device (V_d) and the area inside the transparent tube (A_t). Other data were obtained by conducting other tests or finding measurements through specific gravity testing, critical state friction angle tests, membrane stiffness tests and room temperature measurements. Information about specific gravity is necessary to obtain the soil volume (V_s). The critical state friction angle test and membrane stiffness tests allow the mean principal stress (p'_i) to be calculated. Finally, the measurement of room temperature is carried out to estimate the unit weight of the water during the *CS* test

(γ_w) from which the soil volume is obtained. A summary of the entire data reduction for the *CS* test is given in Table 5.3.

Table 5.3 Data calculation formula and its correlations of the *CS* test on this study

SYMBOL	DESCRIPTION	REDUCTION FORMULAE	REMARKS
σ'_{ci}	Applied pressure	None	All the data are obtained by direct measurement from the apparatus or sample during the test See Section 5.3.2 for details
W_s	Soil unit weight	None	
h_0	Reference water level	None	
h_i	Measured water level	None	
V_t	Volume of the device with soil	None	
V_d	Volume of the device without soil	Obtained by averaging the measurement results	At least three trials to obtain the volume of the device were carried out.
A_t	Area inside the transparent tube	Obtained by averaging the measurement results	Three samples were obtained from the tube. Two measurements were performed on each sample.
G_s	Specific gravity of the soil	Obtained from the specific gravity test	Refer to the relevance standard
γ_w	Unit weight of water	Estimated from the water current temperature during the CS test	Assumed that the water inside the specimen has a similar temperature to the water in the lab.
ϕ_{cs}	Critical state friction angle	Obtained from the critical state friction angle test	See Section 5.3.4 for details
V_s	Volume of the soil	$V_s = \dfrac{W_s}{(G_s \times \gamma_w)}$	None
σ'_m	Additional radial stress	Obtained from the membrane stiffness test	See Section 5.4.2 for details
σ'_{3i}	Correction applied pressure	$\sigma'_{3i} = \sigma'_{ci} + \sigma'_m$	None
p'_i	Mean principal stress in each measurement	$p'_i = \sigma'_{3i} \times \left(\dfrac{3 - \sin\phi_{cs}}{3 \times (1 - \sin\phi_{cs})} \right)$	None
d_i	Distance	$d_i = h_0 - h_i$	None
ΔV_i	Volume change	$\Delta V_i = d_i \times A_t$	None
V_{sp}	Volume of the specimen	$V_{sp} = V_t - V_d$	None
V_{w0}	Reference water volume	$V_{w0} = V_{sp} - V_s$	None
V_{wi}	Water volume	$V_{wi} = V_{w0} + \Delta V_i$	None
e_i	Void ratio	$e_i = \dfrac{(V_{wi} \times G_s \times \gamma_w)}{W_s}$	The void ratio, e_i, at a given mean pressure, p'_i

The next step is to plot the calculated void ratio, e_i, versus its mean principal stress, p'_i, on a logarithmic scale. A line is projected to represent the best-fit of the critical state line (*CSL*) on the *e-logp'*. Finally, the slope of the *CSL*, λ, and the intersection of the *CSL* at 1 kPa mean stress pressure, Γ, are obtained.

5.5.2 Membrane correction testing results

A membrane correction factor is necessary to obtain the correct applied pressure as the actual pressure is affected by the specimen's membrane stiffness. This additional radial stress, σ'_m, was estimated by deriving Equation 5.1 after obtaining the extension modulus of the rubber membrane, *M*, from the membrane stiffness testing. Detailed membrane stiffness testing results are shown in Appendix E. The final results of the additional radial stress estimation for each *CS* test are summarized at Table 5.4. As shown in the table, the additional radial stress adopted in this study is in the range between 7.73 and 7.86 kN/m^2. It is slightly higher than the value obtained by Santamarina & Cho (2001) which is 7 kN/m^2.

Table 5.4 Membrane correction factor for the *CS* test of this study

Sample/Specimen no.	Trial/Run no.	Ave. strain of the trial (%)	Approximate modulus elasticity of the membrane (kN/m)	Additional radial stress, σ'_m (kN/m^2)
Sample #1.2	Trial#1	38.6%	0.31	7.73
	Trial#2	39.8%	0.31	7.82
	Trial#3	40.0%	0.31	7.83
Sample #1.3	Trial#1	39.0%	0.31	7.76
	Trial#2	39.7%	0.31	7.81
	Trial#3	40.0%	0.31	7.83
Sample #1.5	Trial#1	39.1%	0.31	7.77
	Trial#2	39.8%	0.31	7.82
	Trial#3	40.0%	0.31	7.83
Sample #2.3	Trial#1	39.1%	0.31	7.77
	Trial#2	39.8%	0.31	7.82
	Trial#3	40.0%	0.31	7.83
Sample #2.4	Trial#1	38.8%	0.31	7.75
	Trial#2	39.8%	0.31	7.82
	Trial#3	40.0%	0.31	7.83
Sample #2.6	Trial#1	39.5%	0.31	7.80
	Trial#2	39.0%	0.31	7.76
	Trial#3	39.7%	0.31	7.81
Calibration Specimen #1	Run#1	40.0%	0.31	7.83
	Run#2	39.0%	0.31	7.76
	Run#3	39.7%	0.31	7.81
Calibration Specimen #2	Run#1	40.5%	0.31	7.86
	Run#2	39.2%	0.31	7.78
	Run#3	39.7%	0.31	7.81
Calibration Specimen #3	Run#1	40.0%	0.31	7.83
	Run#2	39.5%	0.31	7.80
	Run#3	40.0%	0.31	7.83

5.5.3 Calibration sample *CS* testing results

In the calibration testing, three runs on each specimen of the clean SAND were necessary to assess the repeatability of the test. The results are consistent with a coefficient determination that varies between 0.76 and 0.89. This means that the repeatability of the simple *CS* test for the specimens in this study is very good as shown in Figures 5.11, 5.12 and 5.13.

The overall results were superimposed to obtain the *CSL* of the calibration sample as shown in Figure 5.14. The results show a reasonably good coefficient determination of 0.56. Additional details are included as Appendix F. Further examination consisted of comparing the results of the *CS* test on the calibration sample with four different samples obtained by Santamarina & Cho (2001). The examples were *ASTM* graded sand, glass beads, OTTAWA 20-30 sand and SANDBOIL sand. Among those samples, the properties of the material, such as the D_{10}, coefficient of uniformity, coefficient of curvature and the specific gravity of the calibration sample of this study proved to be very close to the *ASTM* graded Sand, as shown in Table 5.5. However, the typical grainsize distribution chart of the GLASS beads is almost parallel to the results of the sieve analysis of the calibration sample as shown in Figure 5.15.

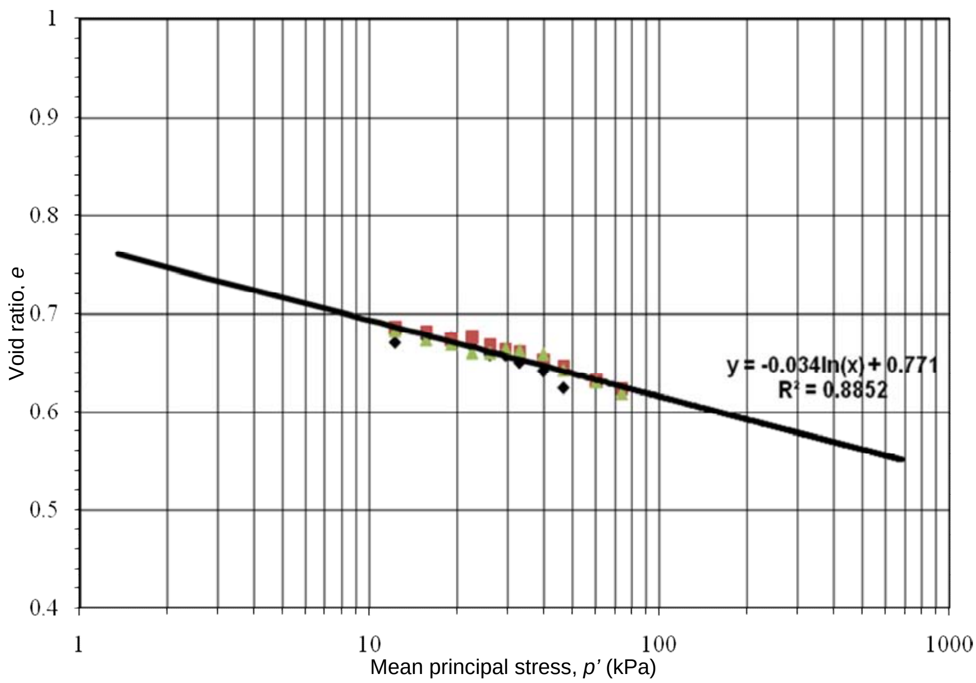


Figure 5.11 Results of the *CS* test on calibration specimen #1

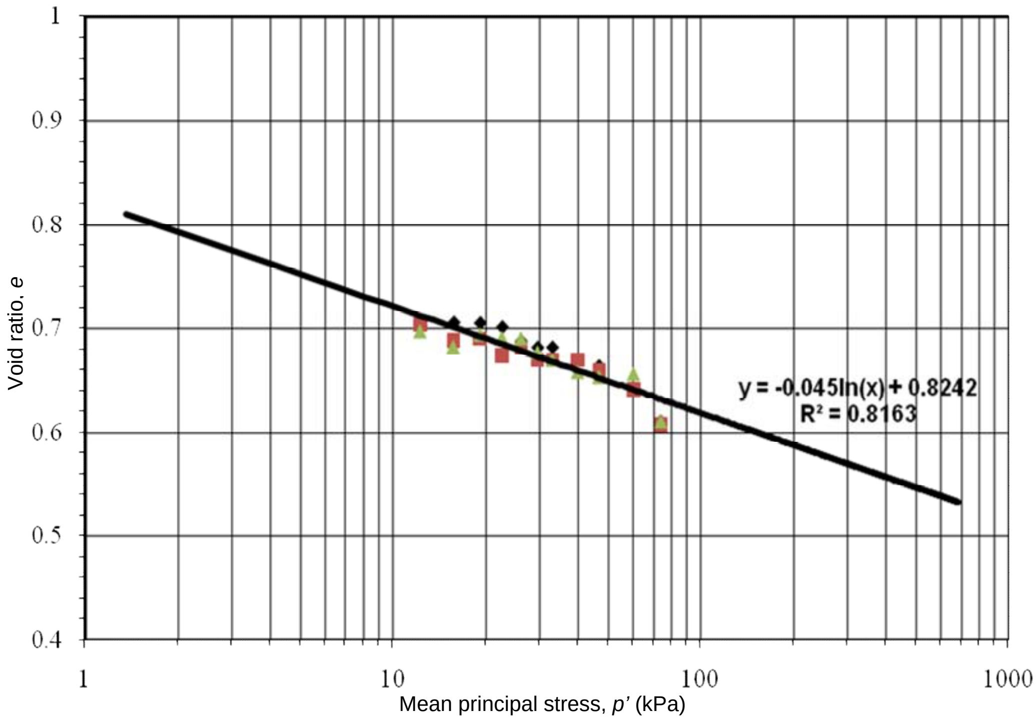


Figure 5.12 Results of the *CS* test on calibration specimen #2

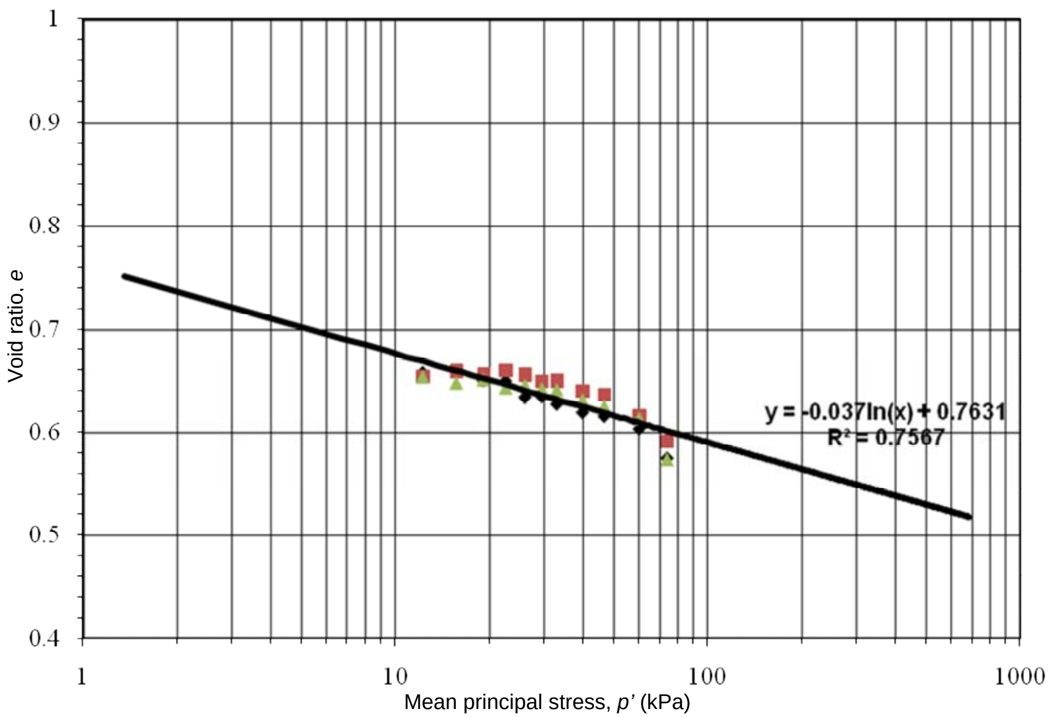


Figure 5.13 Results of the *CS* test on calibration specimen #3

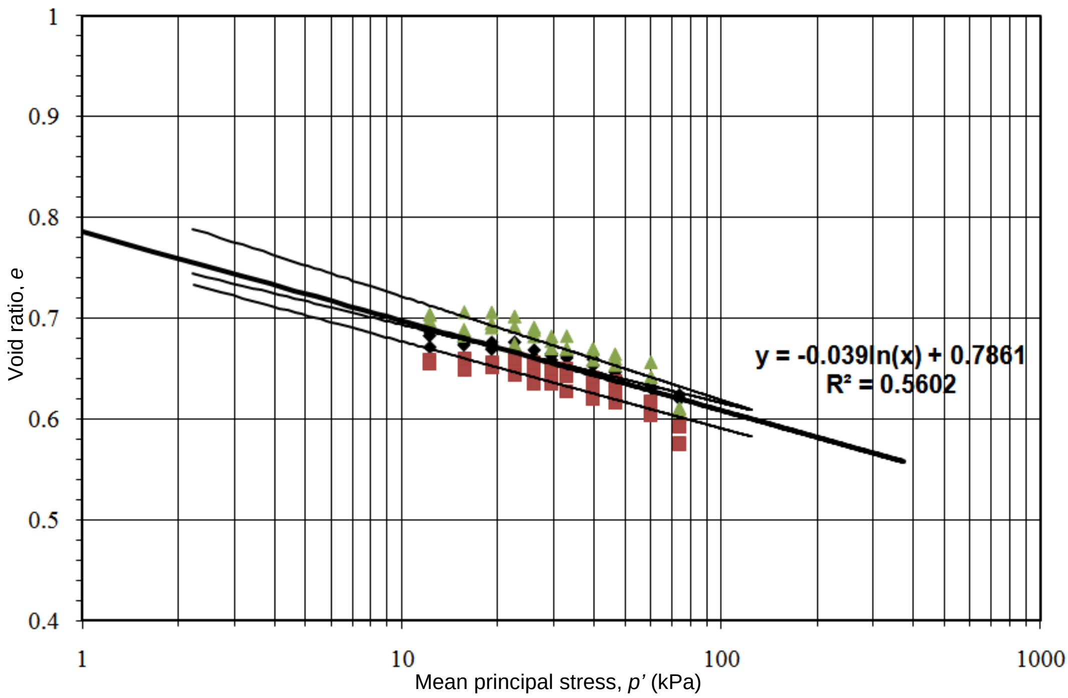


Figure 5.14 Results of the *CS* test on all calibration specimens

Table 5.5 Properties of the calibration sample of this study and several materials from Santamarina & Cho (2001)

Material name	D_{10} (mm)	**Coefficient of uniformity** (C_u)	**Coefficient of curvature** (C_c)	**Specific gravity** (G_s)
ASTM Graded Sand	0.23	1.65	1.06	2.65
Glass Beads	0.24	1.37	0.99	2.46
Ottawa 20-30 Sand	0.65	1.15	1.02	2.65
Sandboil Sand	0.17	2.41	1.29	2.62
Calibration sample of this study	0.225	2.05	1.05	2.66

The *CS* test results of the calibration sample used in this study indicated that the *CSL* of the glass beads is the closest one to the sample, as shown in Figure 5.16. The intercept of the *CSL* at 1 kPa means that the pressure for the calibration samples is 0.786, whereas for the glass beads, it is 0.807. The slope of the *CSL* for both the calibration samples and the glass beads is -0.039. It seems that the proportion of the soil particle sizes has a significant influence on their critical state parameters.

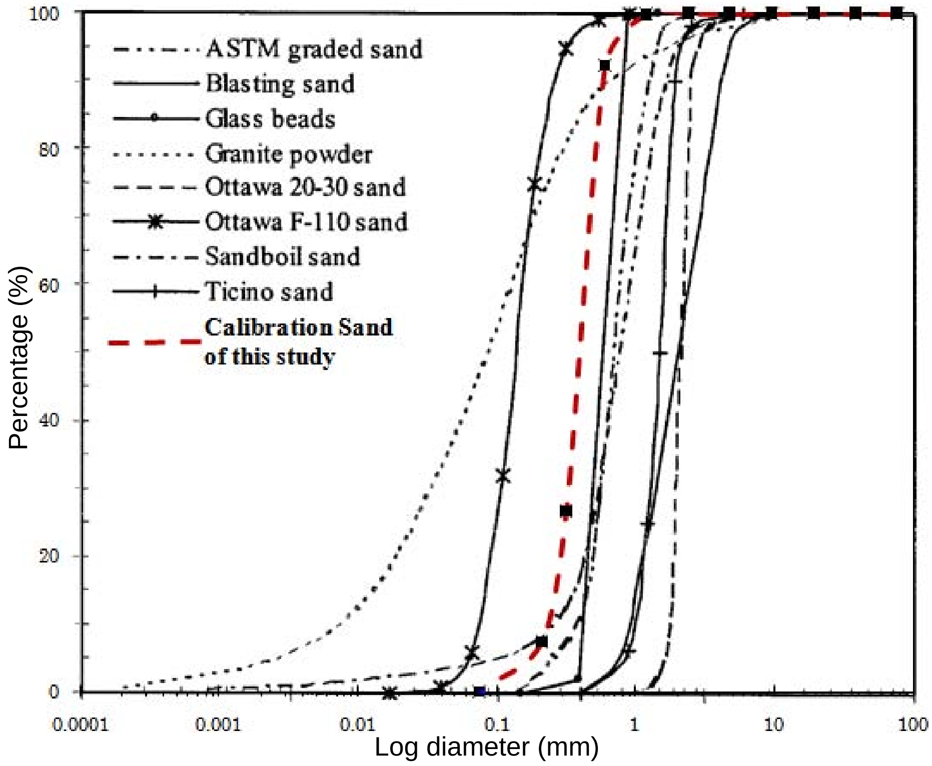


Figure 5.15 Comparison of the results of the grainsize distribution of the calibration sample with samples provided by Santamarina & Cho (2001)

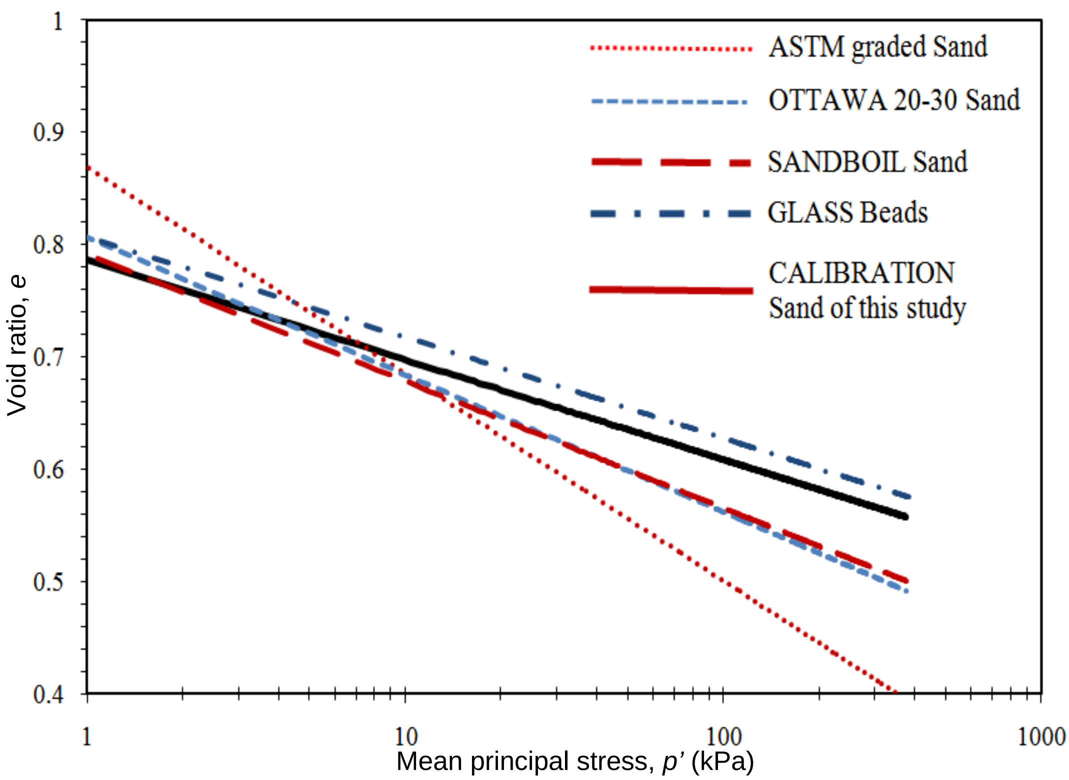


Figure 5.16 Comparison of the results of the *CS* test for the calibration sample with other several samples provided by Santamarina & Cho (2001)

In addition, the comparison of results also demonstrates that the overall simple *CS* test conducted in this study from the preparation of the sample to data reduction processes is in accordance with Santamarina & Cho (2001). A detailed summary of the *CS* test compared with the samples from Santamarina & Cho (2001) is provided in Table 5.6.

Table 5.6 Simple *CS* test results for the calibration sample of this study and several the *CS* test results from Santamarina & Cho (2001)

Material name	Provided by	Friction angle, ϕ_{cs}	Intercept of *CSL* at 1 kPa in *e*-log*p'*	Slope of *CSL* in *e*-log*p'*
ASTM Graded Sand	Provided by Santamarina & Cho (2001)	30.0°	0.869	-0.080
Glass Beads		21.0°	0.807	-0.039
Ottawa 20-30 Sand		28.0°	0.806	-0.053
Sandboil Sand		33.0°	0.791	-0.049
Calibration sample	Present study	30.3°	0.786	-0.039

5.5.4 Selected soils sample simple *CS* testing results

Six samples were selected from the continuous sampling to represent the study site for the simple *CS* test. These soils were Sample #1.2, Sample #1.3, Sample #1.5, Sample #2.3, Sample #2.4 and Sample #2.6. The simple *CS* test was performed on these soils because they are classified as granular soils and have the potential to liquefy during cyclic loading. Detailed results of the simple *CS* test are presented in Appendix G. The final results of the simple *CS* test on all these soils are shown in Figures 5.17 to 5.22. The important parameters from these tests include the critical state friction angle, ϕ_{cs}, the slope of the *CSL*, λ, and the intercept of the *CSL* with 1 kPa mean stress, Γ. They are summarised in Table 5.7.

After the critical state parameters of the soils were identified, they were used to interpret the in-situ state parameter.

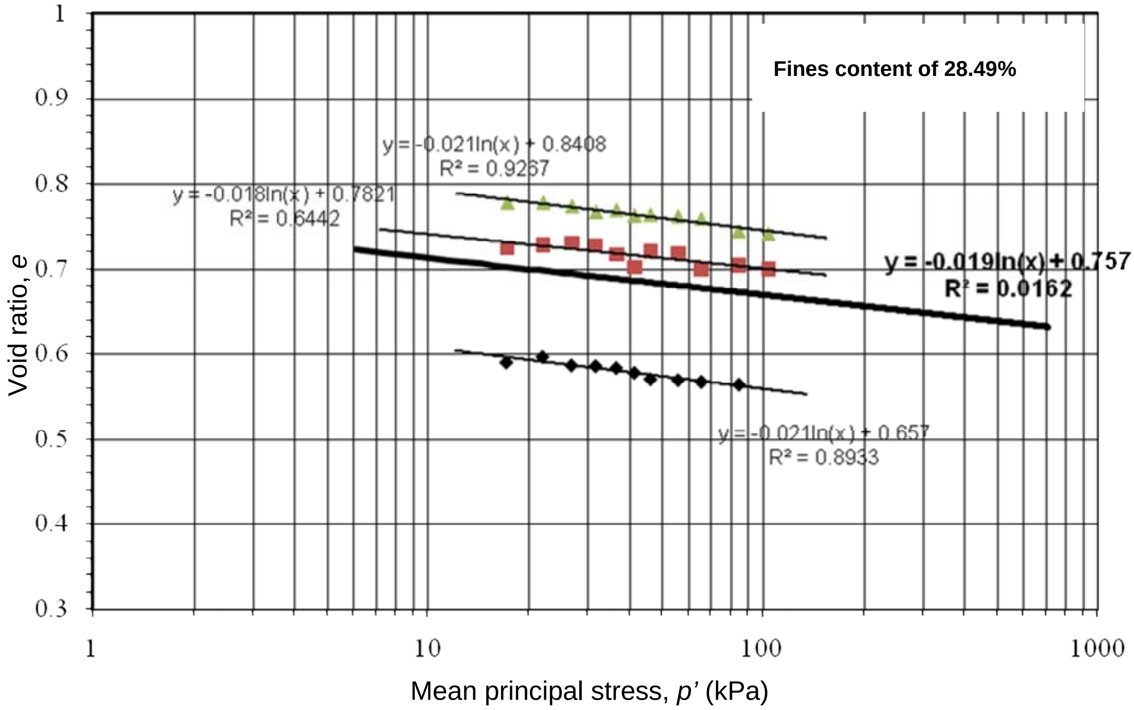


Figure 5.17 Results of the simple critical state testing for sample #1.2

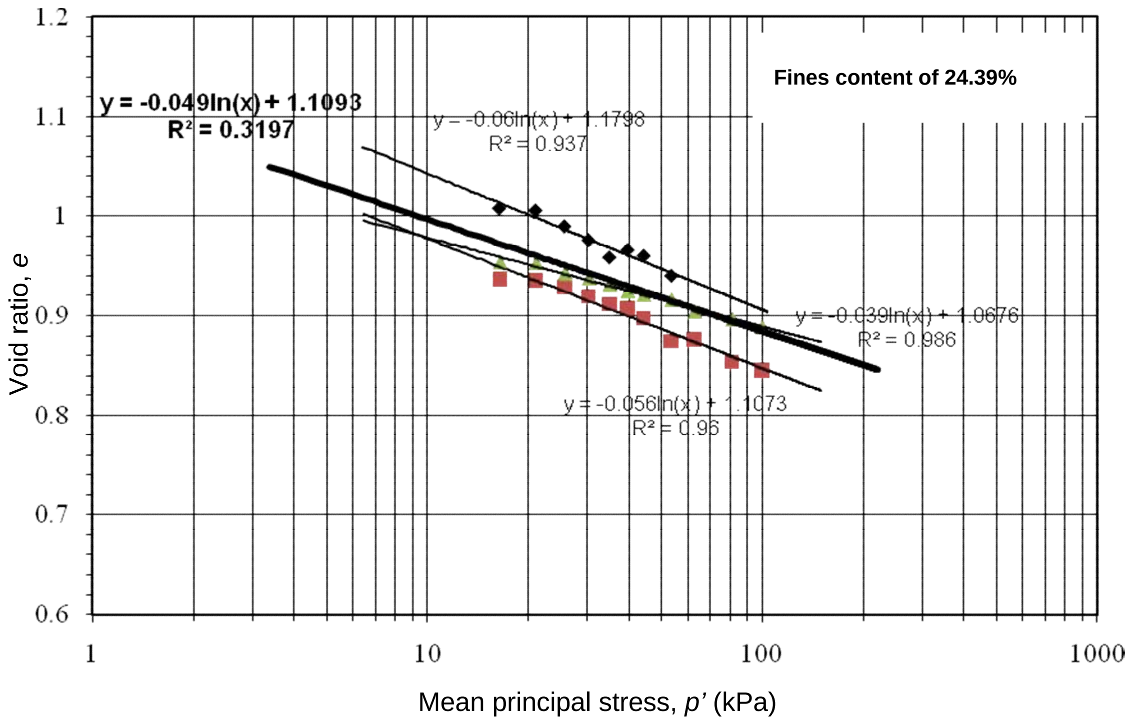


Figure 5.18 Results of the simple critical state testing for sample #1.3

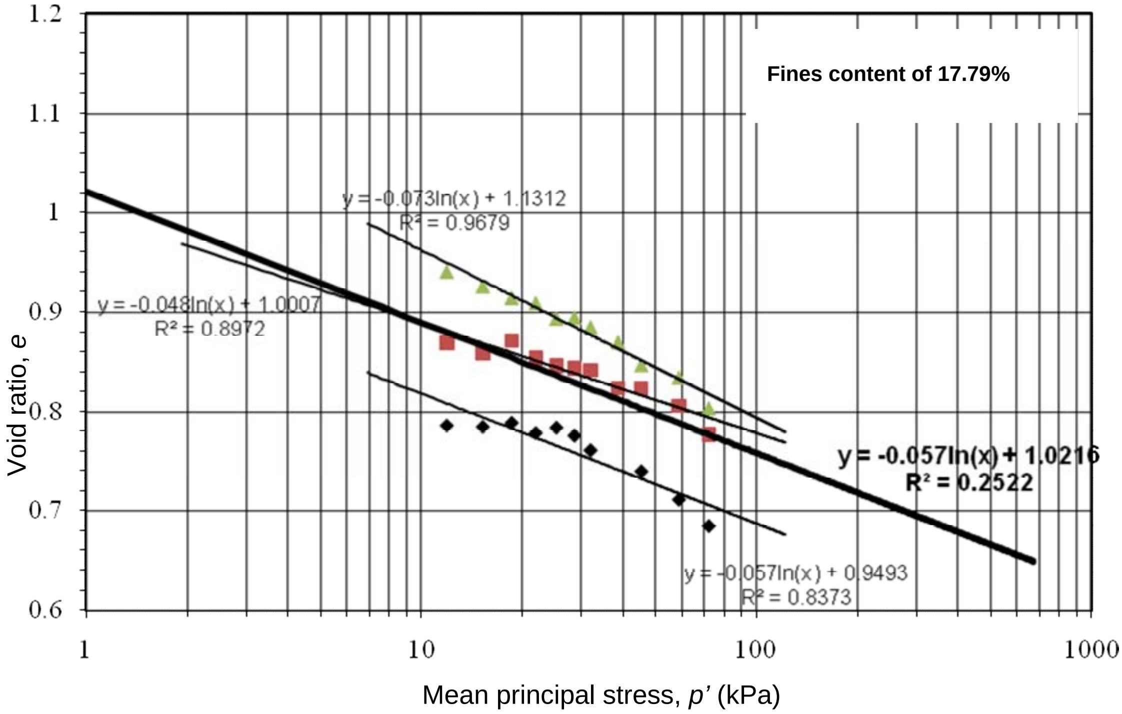


Figure 5.19 Results of the simple critical state testing for sample #1.5

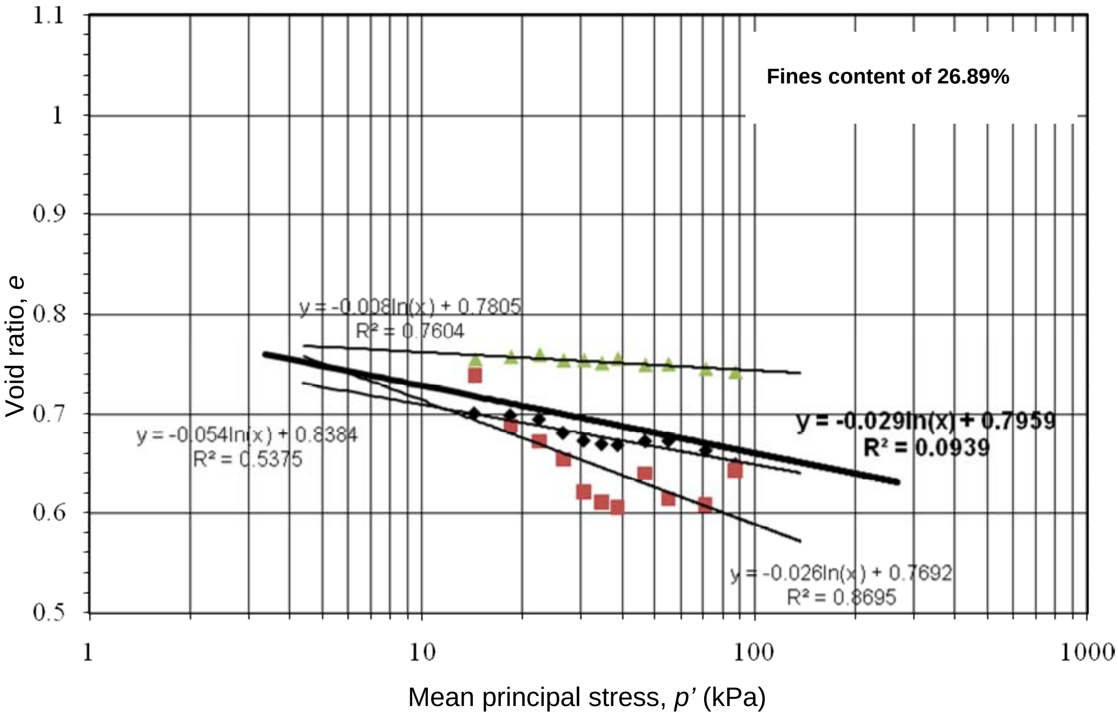


Figure 5.20 Results of the simple critical state testing for sample #2.3

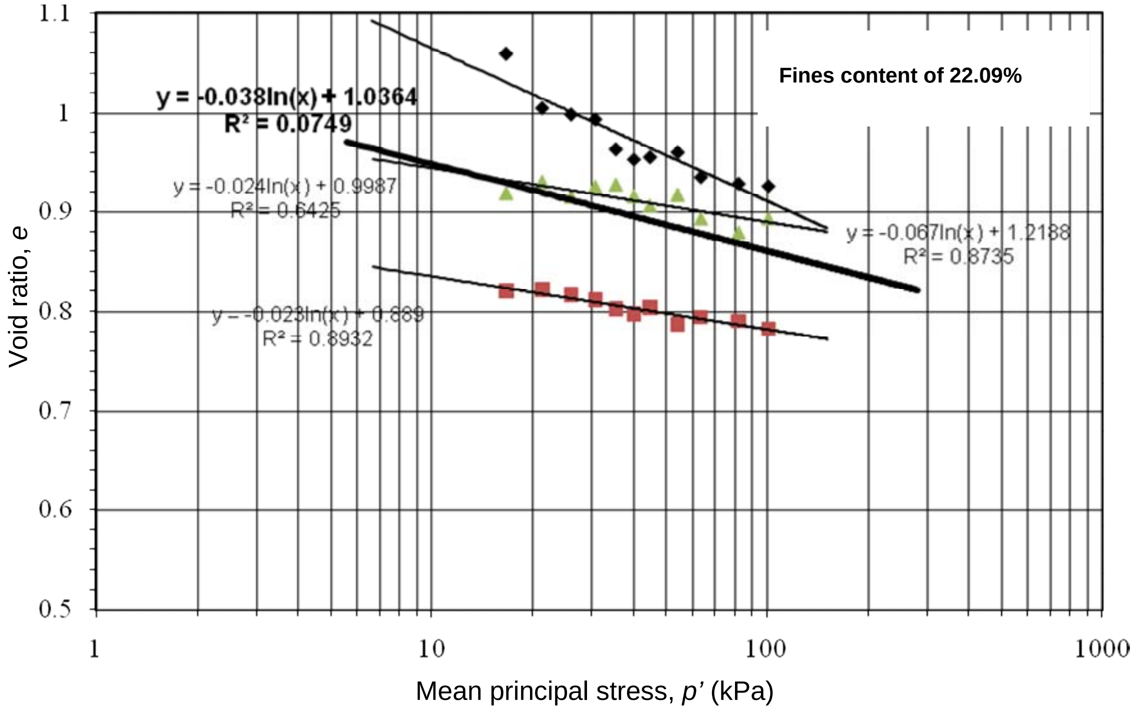


Figure 5.21 Results of the simple critical state testing for sample #2.4

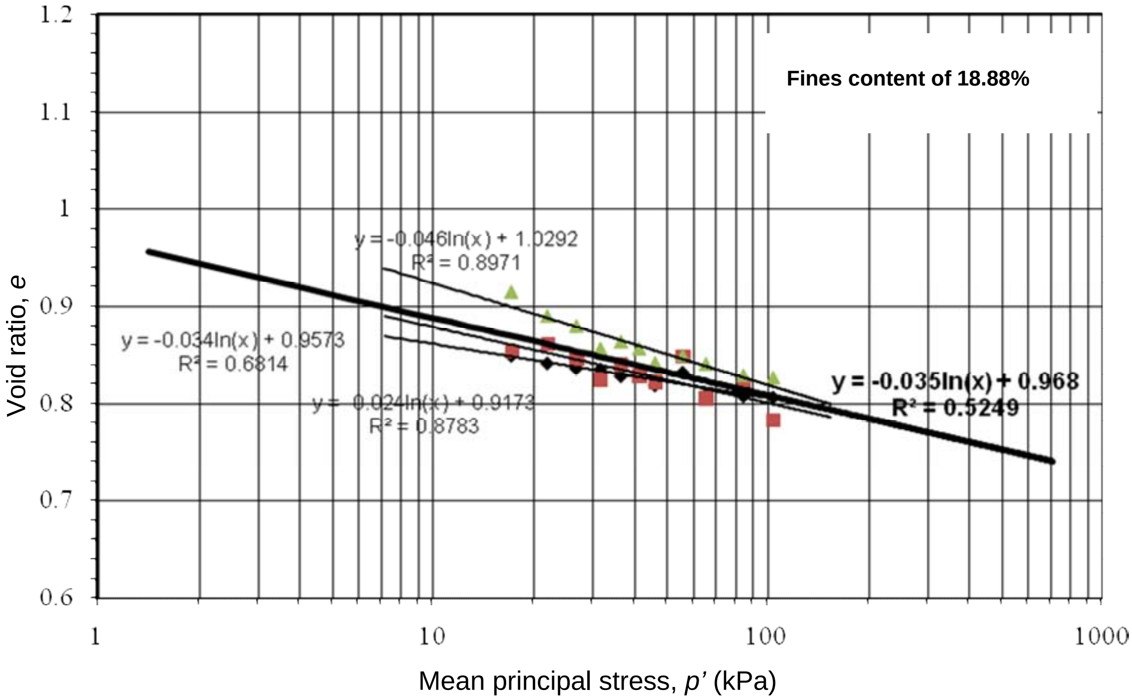


Figure 5.22 Results of the simple critical state testing for sample #2.6

Table 5.7 Simple *CS* test results for the selected sample of this study

Sample no.	Trial no.	Friction angle, ϕ_{cs}	Intercepth of *CSL* at 1 kPa in *e*-log*p'*	Slope of *CSL* in *e*-log*p'*
Sample #1.2	Trial#1	29.0°	0.657	-0.021
	Trial#2	28.0°	0.841	-0.021
	Trial#3	28.0°	0.781	-0.018
	Average	28.3°	0.757	-0.019
Sample #1.3	Trial#1	26.0°	1.179	-0.061
	Trial#2	24.5°	1.107	-0.560
	Trial#3	24.5°	1.068	-0.039
	Average	25.0°	1.109	-0.049
Sample #1.5	Trial#1	30.5°	0.949	-0.057
	Trial#2	30.0°	1.131	-0.073
	Trial#3	29.5°	1.001	-0.048
	Average	30.0°	1.022	-0.057
Sample #2.3	Trial#1	28.0°	0.838	-0.054
	Trial#2	30.0°	0.781	-0.008
	Trial#3	35.0°	0.769	0.026
	Average	31.0°	0.796	-0.029
Sample #2.4	Trial#1	34.0°	1.219	-0.067
	Trial#2	35.0°	0.999	-0.024
	Trial#3	35.0°	0.889	-0.023
	Average	34.7°	1.036	-0.038
Sample #2.6	Trial#1	26.5°	0.917	-0.024
	Trial#2	28.0°	1.029	-0.046
	Trial#3	30.5°	0.957	-0.034
	Average	28.3°	0.968	-0.035

5.6 INTERPRETING THE IN-SITU STATE PARAMETER

Determining the in-situ state parameter, ψ, requires interpreting data from in-situ testing, which in this case was conducted by the *CPT* and *DMT*. As mentioned previously, cone penetration testing has become the common practice for testing cohesionless soils, with the state-of- the-art *CPT* offering continuous data measurement with very good repeatability and accuracy at relatively low cost and with quick results. The *DMT* also offers more or less the same features. The difficulty with these in-situ test methods is that the state parameter value of interest is not directly measured. It is instead interpreted from the test results. However, this is the only means by which to obtain the in-situ state parameter.

5.6.1 Interpreting in-situ state parameter from *CPT* data

The interpretation of the in-situ state parameter, ψ, from the *CPT* data followed the framework suggested by Jefferies & Been (2006). Three parameters are needed to infer the in-situ state parameter: the dimensionless cone resistance based on the mean stress, Q_p, a soil specific coefficient, k, and the rigidity specific coefficient, m.

$$\psi = \frac{-\ln(Q_p / k)}{m} \qquad (5.2)$$

The dimensionless cone resistance was estimated from the normalised parameter of tip resistance, Q, and coefficient earth at rest, K_0.

$$Q_p = \frac{3 \times Q}{(1 + (2 \times K_0))} \qquad (5.3)$$

Mayne (2007) suggested that Q can be determined as follows:

$$Q = \frac{(q_c - \sigma_{v0})}{\sigma'_{v0}} \qquad (5.4)$$

To determine K_0, the correlation by Mayne (2007) was used:

$$K_0 = 0.192 \times (q_c / p_a)^{0.22} \times (\sigma'_{v0} / p_a)^{-0.31} \times OCR^{0.27} \qquad (5.5)$$

The correlation requires the overconsolidation ratio, *OCR*, which can be obtained by an iterative process using Equations 5.5 and 5.6. The *OCR* values are varied until both coefficients at rest, K_0, are similar (Mayne, 2007; Mayne & Kulhawy, 1982).

$$K_0 = \left[1 - \sin(\phi')\right] \times OCR^{\sin\phi'} \quad \text{(5.6)}$$

The internal friction angle, ϕ', was determined by using a relationship proposed by (Kulhawy & Mayne, 1990) and Mayne (2006) as follows:

$$\phi' = 17.6 + 11 \times \log\left(\frac{q_c}{(\sigma'_{v0} \times p_a)^{0.5}}\right) \quad \text{(5.7)}$$

The soil specific coefficient, *k*, and rigidity specific coefficient, *m*, were determined using the following relationships:

$$k = 8 + \frac{0.35}{(\lambda - 0.01)} \quad \text{(5.8a)}$$

$$m = 8.1 - (2.3 \times \log(\lambda)) \quad \text{(5.8b)}$$

These correlations were proposed by Jefferies & Been (2006) and the slope of the *CSL*, λ, was established from Table 5.7.

The interpretation of the in-situ state parameter is applicable only for the layers which are selected for the simple *CS* test. These are the layers from 1.2 to 2.6 m depth, a layer from 2.6 to 4.6 m depth and a layer from approximately 6.0 to 9.0 m depth. The results of the in-situ state parameter interpreted from the *CPT* data are presented in Tables 5.7 to 5.13. Details of the interpretation are given in Appendix H.

The analysis using *CPT* #1 and the simple *CS* test on selected soil from *BH* #1 (see Table 5.8) indicated that soils located at depths from 1.2 to 2.6 m and from 6.0 to 9.0 m at the test site could be identified as dilative soils. A thin layer at the bottom of the soils, located from 2.6 to 4.6 m in depth was found to be a contractive layer. The thickness of this contractive layer is about 0.6 m.

Table 5.8 Results of the in-situ state parameter interpreted from the *CPT* #1 data and simple *CS* test at *BH* #1

OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	*Q*	*Qp*	*k*	*m*	Ψ	$\lambda_{BH\#1}$	**Remarks**
2.10	0.7	16.55	**19.32**	63	81.515	46.89	12.06	-0.046	0.019	DILATIVE
4.84	1.0	28.90	**28.86**	158	157.329	46.89	12.06	-0.100	0.019	DILATIVE
3.05	0.8	25.62	**27.98**	95	110.681	46.89	12.06	-0.071	0.019	DILATIVE
2.83	0.8	27.42	**30.46**	89	106.821	46.89	12.06	-0.068	0.019	DILATIVE
1.21	0.5	20.21	**26.94**	41	61.966	46.89	12.06	-0.023	0.019	DILATIVE
1.13	0.5	21.28	**28.91**	39	60.041	46.89	12.06	-0.021	0.019	DILATIVE
0.73	0.4	18.31	**27.51**	29	47.688	46.89	12.06	-0.001	0.019	DILATIVE
1.26	0.5	24.01	**31.88**	43	64.571	46.89	12.06	-0.027	0.019	DILATIVE
1.47	0.5	26.55	**34.15**	49	71.008	16.97	11.11	-0.129	0.049	DILATIVE
1.44	0.5	27.10	**35.08**	48	70.149	16.97	11.11	-0.128	0.049	DILATIVE
1.40	0.5	27.65	**36.02**	47	69.343	16.97	11.11	-0.127	0.049	DILATIVE
1.05	0.5	25.01	**34.81**	37	58.423	16.97	11.11	-0.111	0.049	DILATIVE
0.32	0.3	15.79	**29.20**	17	32.540	16.97	11.11	-0.059	0.049	DILATIVE
0.09	0.2	10.24	**26.03**	9	20.623	16.97	11.11	-0.018	0.049	DILATIVE
0.06	0.2	8.88	**25.62**	8	17.689	16.97	11.11	-0.004	0.049	DILATIVE
0.03	0.1	7.16	**24.97**	6	14.406	16.97	11.11	0.015	0.049	CONTRACTIVE
0.03	0.1	7.33	**25.59**	6	14.317	16.97	11.11	0.015	0.049	CONTRACTIVE
0.03	0.1	7.90	**26.45**	6	14.852	16.97	11.11	0.012	0.049	CONTRACTIVE
0.99	0.4	32.64	**46.66**	36	57.401	15.45	10.96	-0.120	0.057	DILATIVE
0.24	0.2	18.69	**37.98**	14	28.024	15.45	10.96	-0.054	0.057	DILATIVE
0.38	0.3	22.67	**41.14**	18	34.290	15.45	10.96	-0.073	0.057	DILATIVE
0.59	0.3	27.77	**45.11**	24	42.944	15.45	10.96	-0.093	0.057	DILATIVE
0.40	0.3	24.12	**43.21**	19	35.260	15.45	10.96	-0.075	0.057	DILATIVE
0.48	0.3	26.37	**45.24**	21	38.456	15.45	10.96	-0.083	0.057	DILATIVE
1.48	0.5	43.79	**57.39**	51	74.691	15.45	10.96	-0.144	0.057	DILATIVE
0.63	0.4	30.59	**49.10**	25	44.463	15.45	10.96	-0.096	0.057	DILATIVE
0.36	0.3	24.65	**45.62**	17	33.307	15.45	10.96	-0.070	0.057	DILATIVE
0.46	0.3	27.80	**48.22**	21	37.872	15.45	10.96	-0.082	0.057	DILATIVE
0.12	0.2	16.99	**41.47**	10	21.043	15.45	10.96	-0.028	0.057	DILATIVE
0.08	0.2	14.71	**40.39**	8	17.813	15.45	10.96	-0.013	0.057	DILATIVE
0.07	0.2	14.40	**40.61**	7	17.141	15.45	10.96	-0.009	0.057	DILATIVE
0.60	0.3	32.61	**53.31**	24	43.192	15.45	10.96	-0.094	0.057	DILATIVE
0.36	0.3	26.88	**50.04**	17	33.155	15.45	10.96	-0.070	0.057	DILATIVE
0.74	0.4	36.89	**57.31**	28	48.770	15.45	10.96	-0.105	0.057	DILATIVE

Examination of the in-situ state parameters using *CPT* #1 and the simple *CS* test on selected soil from *BH* #2 is shown in Table 5.9. The analysis indicated that soil at a depth of 1.2 to 2.6 m is located in a dilative layer. Almost half of the bottom part of a layer from 2.6 to 4.6 m in depth was found to be a contractive. The thickness of this contractive layer is about 0.6 m. The analysis also found another contractive layer at a depth of 7.8 to 8.4 m.

Table 5.9 Results of the in-situ state parameter interpreted from the *CPT* #1 data and simple *CS* test at *BH* #2

OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	Q	Qp	k	m	Ψ	$\lambda_{BH\#2}$	Remarks
2.10	0.7	16.55	**19.32**	63	81.515	26.42	11.64	-0.097	0.029	DILATIVE
4.84	1.0	28.90	**28.86**	158	157.329	26.42	11.64	-0.153	0.029	DILATIVE
3.05	0.8	25.62	**27.98**	95	110.681	26.42	11.64	-0.123	0.029	DILATIVE
2.83	0.8	27.42	**30.46**	89	106.821	26.42	11.64	-0.120	0.029	DILATIVE
1.21	0.5	20.21	**26.94**	41	61.966	26.42	11.64	-0.073	0.029	DILATIVE
1.13	0.5	21.28	**28.91**	39	60.041	26.42	11.64	-0.071	0.029	DILATIVE
0.73	0.4	18.31	**27.51**	29	47.688	26.42	11.64	-0.051	0.029	DILATIVE
1.26	0.5	24.01	**31.88**	43	64.571	26.42	11.64	-0.077	0.029	DILATIVE
1.47	0.5	26.55	**34.15**	49	71.008	20.50	11.37	-0.109	0.038	DILATIVE
1.44	0.5	27.10	**35.08**	48	70.149	20.50	11.37	-0.108	0.038	DILATIVE
1.40	0.5	27.65	**36.02**	47	69.343	20.50	11.37	-0.107	0.038	DILATIVE
1.05	0.5	25.01	**34.81**	37	58.423	20.50	11.37	-0.092	0.038	DILATIVE
0.32	0.3	15.79	**29.20**	17	32.540	20.50	11.37	-0.041	0.038	DILATIVE
0.09	0.2	10.24	**26.03**	9	20.623	20.50	11.37	-0.001	0.038	DILATIVE
0.06	0.2	8.88	**25.62**	8	17.689	20.50	11.37	0.013	0.038	CONTRACTIVE
0.03	0.1	7.16	**24.97**	6	14.406	20.50	11.37	0.031	0.038	CONTRACTIVE
0.03	0.1	7.33	**25.59**	6	14.317	20.50	11.37	0.032	0.038	CONTRACTIVE
0.03	0.1	7.90	**26.45**	6	14.852	20.50	11.37	0.028	0.038	CONTRACTIVE
0.99	0.4	32.64	**46.66**	36	57.401	22.00	11.45	-0.084	0.035	DILATIVE
0.24	0.2	18.69	**37.98**	14	28.024	22.00	11.45	-0.021	0.035	DILATIVE
0.38	0.3	22.67	**41.14**	18	34.290	22.00	11.45	-0.039	0.035	DILATIVE
0.59	0.3	27.77	**45.11**	24	42.944	22.00	11.45	-0.058	0.035	DILATIVE
0.40	0.3	24.12	**43.21**	19	35.260	22.00	11.45	-0.041	0.035	DILATIVE
0.48	0.3	26.37	**45.24**	21	38.456	22.00	11.45	-0.049	0.035	DILATIVE
1.48	0.5	43.79	**57.39**	51	74.691	22.00	11.45	-0.107	0.035	DILATIVE
0.63	0.4	30.59	**49.10**	25	44.463	22.00	11.45	-0.061	0.035	DILATIVE
0.36	0.3	24.65	**45.62**	17	33.307	22.00	11.45	-0.036	0.035	DILATIVE
0.46	0.3	27.80	**48.22**	21	37.872	22.00	11.45	-0.047	0.035	DILATIVE
0.12	0.2	16.99	**41.47**	10	21.043	22.00	11.45	0.004	0.035	CONTRACTIVE
0.08	0.2	14.71	**40.39**	8	17.813	22.00	11.45	0.018	0.035	CONTRACTIVE
0.07	0.2	14.40	**40.61**	7	17.141	22.00	11.45	0.022	0.035	CONTRACTIVE
0.60	0.3	32.61	**53.31**	24	43.192	22.00	11.45	-0.059	0.035	DILATIVE
0.36	0.3	26.88	**50.04**	17	33.155	22.00	11.45	-0.036	0.035	DILATIVE
0.74	0.4	36.89	**57.31**	28	48.770	22.00	11.45	-0.070	0.035	DILATIVE

The results of the analysis using *CPT* #2 and the simple *CS* test on soil from *BH* #1 show that most of the soils are classified as dilative, except for a thin layer from 2.2 to 2.4 m depth as shown in Table 5.10.

Analysis of the in-situ state parameter using *CPT* #2 and the simple *CS* test on selected soil from *BH* #2 (Table 5.11) indicated that soils in a layer from 1.2 to 2.6 m in depth and a layer from 6.0 to 9.0 m exhibit dilative behaviour. The bottom part of the layer, from 2.6 to 4.6 m in depth, was found to contract. The thickness of this contractive layer was about 0.6 m. Two thin contractive layers were also found at depths of 7.6 to 7.8 m and 8.0 to 8.4 m.

Table 5.10 Results of the in-situ state parameter interpreted from the *CPT* #2 data and simple CS test at *BH* #1

OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	*Q*	*Qp*	*k*	*m*	Ψ	$\lambda_{BH\#1}$	Remarks
6.38	1.2	29.49	**28.02**	218	195.363	46.89	12.06	-0.118	0.019	DILATIVE
7.28	1.3	36.70	**34.18**	270	230.257	46.89	12.06	-0.132	0.019	DILATIVE
4.77	1.0	32.86	**32.99**	159	160.257	46.89	12.06	-0.102	0.019	DILATIVE
2.26	0.7	24.89	**28.96**	71	90.921	46.89	12.06	-0.055	0.019	DILATIVE
2.37	0.7	27.98	**32.32**	75	95.562	46.89	12.06	-0.059	0.019	DILATIVE
0.20	0.2	10.79	**22.09**	14	27.848	46.89	12.06	0.043	0.019	CONTRACTIVE
0.47	0.3	15.47	**25.76**	22	38.878	46.89	12.06	0.016	0.019	CONTRACTIVE
0.77	0.4	19.47	**28.95**	30	48.979	46.89	12.06	-0.004	0.019	DILATIVE
1.18	0.5	24.13	**32.59**	41	62.126	16.97	11.11	-0.117	0.049	DILATIVE
1.75	0.6	29.75	**36.88**	58	79.752	16.97	11.11	-0.139	0.049	DILATIVE
1.70	0.6	30.26	**37.77**	56	78.566	16.97	11.11	-0.138	0.049	DILATIVE
1.22	0.5	26.73	**35.96**	42	63.785	16.97	11.11	-0.119	0.049	DILATIVE
0.37	0.3	16.77	**29.82**	19	34.892	16.97	11.11	-0.065	0.049	DILATIVE
0.17	0.2	12.80	**27.65**	12	25.570	16.97	11.11	-0.037	0.049	DILATIVE
0.17	0.2	13.11	**28.32**	12	25.552	16.97	11.11	-0.037	0.049	DILATIVE
0.07	0.2	9.57	**26.40**	8	18.576	16.97	11.11	-0.008	0.049	DILATIVE
0.07	0.2	9.74	**26.95**	8	18.444	16.97	11.11	-0.007	0.049	DILATIVE
0.08	0.2	10.43	**27.86**	9	19.162	16.97	11.11	-0.011	0.049	DILATIVE
0.54	0.3	24.46	**40.47**	23	40.775	15.45	10.96	-0.089	0.057	DILATIVE
0.14	0.2	14.76	**34.60**	10	22.440	15.45	10.96	-0.034	0.057	DILATIVE
3.03	0.7	56.22	**62.74**	105	126.278	15.45	10.96	-0.192	0.057	DILATIVE
2.97	0.7	56.69	**63.55**	102	124.614	15.45	10.96	-0.190	0.057	DILATIVE
0.19	0.2	17.48	**37.69**	12	25.387	15.45	10.96	-0.045	0.057	DILATIVE
1.11	0.5	36.29	**50.65**	39	61.666	15.45	10.96	-0.126	0.057	DILATIVE
0.97	0.4	34.74	**50.17**	35	56.603	15.45	10.96	-0.118	0.057	DILATIVE
0.34	0.3	22.86	**42.78**	17	32.403	15.45	10.96	-0.068	0.057	DILATIVE
0.29	0.3	21.87	**42.70**	15	30.041	15.45	10.96	-0.061	0.057	DILATIVE
0.10	0.2	15.27	**38.77**	9	19.843	15.45	10.96	-0.023	0.057	DILATIVE
0.27	0.3	21.92	**43.62**	15	29.022	15.45	10.96	-0.058	0.057	DILATIVE
0.10	0.2	15.45	**39.73**	9	19.452	15.45	10.96	-0.021	0.057	DILATIVE
0.06	0.1	13.22	**38.65**	7	16.290	15.45	10.96	-0.005	0.057	DILATIVE
0.82	0.4	36.05	**54.45**	31	51.531	15.45	10.96	-0.110	0.057	DILATIVE
0.41	0.3	27.43	**49.27**	19	35.359	15.45	10.96	-0.076	0.057	DILATIVE
0.81	0.4	36.99	**56.23**	30	51.011	15.45	10.96	-0.109	0.057	DILATIVE

The results of the analysis using *CPT* #3 and the simple *CS* test on selected soil from *BH* #1 found two contractive layers at the study site. The first one was located at a depth of 1.8 to 2.4 m, and another between 4.0 and 4.6 m. The remaining soils were dilative. The results are shown in Table 5.12.

Table 5.11 Results of the in-situ state parameter interpreted from the *CPT* #2 data and simple *CS* test at *BH* #2

OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	*Q*	*Qp*	*k*	*m*	Ψ	$\lambda_{BH\#2}$	Remarks
6.38	1.2	29.49	**28.02**	218	195.363	26.42	11.64	-0.172	0.029	DILATIVE
7.28	1.3	36.70	**34.18**	270	230.257	26.42	11.64	-0.186	0.029	DILATIVE
4.77	1.0	32.86	**32.99**	159	160.257	26.42	11.64	-0.155	0.029	DILATIVE
2.26	0.7	24.89	**28.96**	71	90.921	26.42	11.64	-0.106	0.029	DILATIVE
2.37	0.7	27.98	**32.32**	75	95.562	26.42	11.64	-0.110	0.029	DILATIVE
0.20	0.2	10.79	**22.09**	14	27.848	26.42	11.64	-0.005	0.029	DILATIVE
0.47	0.3	15.47	**25.76**	22	38.878	26.42	11.64	-0.033	0.029	DILATIVE
0.77	0.4	19.47	**28.95**	30	48.979	26.42	11.64	-0.053	0.029	DILATIVE
1.18	0.5	24.13	**32.59**	41	62.126	20.50	11.37	-0.098	0.038	DILATIVE
1.75	0.6	29.75	**36.88**	58	79.752	20.50	11.37	-0.120	0.038	DILATIVE
1.70	0.6	30.26	**37.77**	56	78.566	20.50	11.37	-0.118	0.038	DILATIVE
1.22	0.5	26.73	**35.96**	42	63.785	20.50	11.37	-0.100	0.038	DILATIVE
0.37	0.3	16.77	**29.82**	19	34.892	20.50	11.37	-0.047	0.038	DILATIVE
0.17	0.2	12.80	**27.65**	12	25.570	20.50	11.37	-0.019	0.038	DILATIVE
0.17	0.2	13.11	**28.32**	12	25.552	20.50	11.37	-0.019	0.038	DILATIVE
0.07	0.2	9.57	**26.40**	8	18.576	20.50	11.37	0.009	0.038	CONTRACTIVE
0.07	0.2	9.74	**26.95**	8	18.444	20.50	11.37	0.009	0.038	CONTRACTIVE
0.08	0.2	10.43	**27.86**	9	19.162	20.50	11.37	0.006	0.038	CONTRACTIVE
0.54	0.3	24.46	**40.47**	23	40.775	22.00	11.45	-0.054	0.035	DILATIVE
0.14	0.2	14.76	**34.60**	10	22.440	22.00	11.45	-0.002	0.035	DILATIVE
3.03	0.7	56.22	**62.74**	105	126.278	22.00	11.45	-0.153	0.035	DILATIVE
2.97	0.7	56.69	**63.55**	102	124.614	22.00	11.45	-0.151	0.035	DILATIVE
0.19	0.2	17.48	**37.69**	12	25.387	22.00	11.45	-0.013	0.035	DILATIVE
1.11	0.5	36.29	**50.65**	39	61.666	22.00	11.45	-0.090	0.035	DILATIVE
0.97	0.4	34.74	**50.17**	35	56.603	22.00	11.45	-0.083	0.035	DILATIVE
0.34	0.3	22.86	**42.78**	17	32.403	22.00	11.45	-0.034	0.035	DILATIVE
0.29	0.3	21.87	**42.70**	15	30.041	22.00	11.45	-0.027	0.035	DILATIVE
0.10	0.2	15.27	**38.77**	9	19.843	22.00	11.45	0.009	0.035	CONTRACTIVE
0.27	0.3	21.92	**43.62**	15	29.022	22.00	11.45	-0.024	0.035	DILATIVE
0.10	0.2	15.45	**39.73**	9	19.452	22.00	11.45	0.011	0.035	CONTRACTIVE
0.06	0.1	13.22	**38.65**	7	16.290	22.00	11.45	0.026	0.035	CONTRACTIVE
0.82	0.4	36.05	**54.45**	31	51.531	22.00	11.45	-0.074	0.035	DILATIVE
0.41	0.3	27.43	**49.27**	19	35.359	22.00	11.45	-0.041	0.035	DILATIVE
0.81	0.4	36.99	**56.23**	30	51.011	22.00	11.45	-0.073	0.035	DILATIVE

Analysis using *CPT* #3 and the simple *CS* test on selected soil from *BH* #2 indicated that a 0.6 m thick layer, located at a depth of 4.2 to 4.6 m and a 0.2 m thick layer located at a depth of 6.0 to 6.2 m, exhibited contractive behaviour. The overall results are shown in Table 5.13.

Table 5.12 Results of the in-situ state parameter interpreted from the *CPT* #3 data and simple *CS* test at *BH* #1

OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	*Q*	*Qp*	*k*	*m*	Ψ	$\lambda_{BH\#1}$	**Remarks**
5.52	1.1	27.50	**26.78**	182	171.943	46.89	12.06	-0.108	0.019	DILATIVE
5.81	1.1	32.73	**31.67**	200	186.312	46.89	12.06	-0.114	0.019	DILATIVE
3.77	0.9	29.34	**30.79**	120	131.425	46.89	12.06	-0.085	0.019	DILATIVE
3.53	0.8	31.52	**33.56**	114	127.621	46.89	12.06	-0.083	0.019	DILATIVE
0.60	0.4	15.47	**24.15**	25	43.423	46.89	12.06	0.006	0.019	CONTRACTIVE
0.40	0.3	14.22	**24.53**	20	36.480	46.89	12.06	0.021	0.019	CONTRACTIVE
0.40	0.3	14.65	**25.35**	20	36.341	46.89	12.06	0.021	0.019	CONTRACTIVE
1.13	0.5	23.14	**31.54**	39	60.479	46.89	12.06	-0.021	0.019	DILATIVE
1.37	0.5	26.03	**34.02**	46	68.018	16.97	11.11	-0.125	0.049	DILATIVE
1.52	0.5	28.17	**36.00**	51	73.070	16.97	11.11	-0.131	0.049	DILATIVE
1.43	0.5	28.14	**36.54**	48	70.109	16.97	11.11	-0.128	0.049	DILATIVE
1.38	0.5	28.54	**37.37**	47	68.857	16.97	11.11	-0.126	0.049	DILATIVE
0.80	0.4	23.15	**34.34**	30	50.369	16.97	11.11	-0.098	0.049	DILATIVE
0.13	0.2	11.81	**27.29**	11	23.309	16.97	11.11	-0.029	0.049	DILATIVE
0.10	0.2	11.07	**27.25**	10	21.385	16.97	11.11	-0.021	0.049	DILATIVE
0.05	0.1	8.68	**26.12**	7	16.823	16.97	11.11	0.001	0.049	CONTRACTIVE
0.01	0.1	4.29	**23.64**	4	9.565	16.97	11.11	0.052	0.049	CONTRACTIVE
0.00003	0.0	0.98	**21.82**	1	3.803	16.97	11.11	0.135	0.049	CONTRACTIVE
0.05	0.1	10.43	**31.17**	7	16.361	15.45	10.96	-0.005	0.057	DILATIVE
3.81	0.8	62.24	**66.27**	136	152.961	15.45	10.96	-0.209	0.057	DILATIVE
3.73	0.8	62.84	**67.21**	133	150.764	15.45	10.96	-0.208	0.057	DILATIVE
4.86	1.0	74.10	**75.28**	187	192.600	15.45	10.96	-0.230	0.057	DILATIVE
5.05	1.0	77.46	**78.18**	197	200.504	15.45	10.96	-0.234	0.057	DILATIVE
4.29	0.9	72.45	**75.50**	160	172.856	15.45	10.96	-0.220	0.057	DILATIVE
3.99	0.9	71.20	**75.31**	146	162.488	15.45	10.96	-0.215	0.057	DILATIVE
3.69	0.8	69.70	**74.94**	133	152.026	15.45	10.96	-0.209	0.057	DILATIVE
3.55	0.8	69.66	**75.52**	128	147.766	15.45	10.96	-0.206	0.057	DILATIVE
2.70	0.7	61.64	**70.80**	93	117.604	15.45	10.96	-0.185	0.057	DILATIVE
1.50	0.5	47.21	**61.78**	52	76.114	15.45	10.96	-0.145	0.057	DILATIVE
1.36	0.5	45.81	**61.36**	47	71.193	15.45	10.96	-0.139	0.057	DILATIVE
0.79	0.4	36.48	**55.68**	30	50.560	15.45	10.96	-0.108	0.057	DILATIVE
1.20	0.5	44.46	**61.51**	42	65.386	15.45	10.96	-0.132	0.057	DILATIVE
1.88	0.6	55.94	**69.78**	64	89.829	15.45	10.96	-0.161	0.057	DILATIVE
0.16	0.2	20.40	**46.66**	11	23.235	15.45	10.96	-0.037	0.057	DILATIVE

5.6.2 Interpreting in-situ state parameter from *DMT* data

The relationship between the horizontal stress index, K_D, and the in-situ state parameter, ψ, was described by Yu (2004). He proposed the following correlation:

Table 5.13 Results of the in-situ state parameter interpreted from the *CPT* #3 data and simple *CS* test at *BH* #2

OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	*Q*	*Qp*	*k*	*m*	Ψ	$\lambda_{BH\#2}$	Remarks
5.52	1.1	27.50	**26.78**	182	171.943	26.42	11.64	-0.161	0.029	DILATIVE
5.81	1.1	32.73	**31.67**	200	186.312	26.42	11.64	-0.168	0.029	DILATIVE
3.77	0.9	29.34	**30.79**	120	131.425	26.42	11.64	-0.138	0.029	DILATIVE
3.53	0.8	31.52	**33.56**	114	127.621	26.42	11.64	-0.135	0.029	DILATIVE
0.60	0.4	15.47	**24.15**	25	43.423	26.42	11.64	-0.043	0.029	DILATIVE
0.40	0.3	14.22	**24.53**	20	36.480	26.42	11.64	-0.028	0.029	DILATIVE
0.40	0.3	14.65	**25.35**	20	36.341	26.42	11.64	-0.027	0.029	DILATIVE
1.13	0.5	23.14	**31.54**	39	60.479	26.42	11.64	-0.071	0.029	DILATIVE
1.37	0.5	26.03	**34.02**	46	68.018	20.50	11.37	-0.106	0.038	DILATIVE
1.52	0.5	28.17	**36.00**	51	73.070	20.50	11.37	-0.112	0.038	DILATIVE
1.43	0.5	28.14	**36.54**	48	70.109	20.50	11.37	-0.108	0.038	DILATIVE
1.38	0.5	28.54	**37.37**	47	68.857	20.50	11.37	-0.107	0.038	DILATIVE
0.80	0.4	23.15	**34.34**	30	50.369	20.50	11.37	-0.079	0.038	DILATIVE
0.13	0.2	11.81	**27.29**	11	23.309	20.50	11.37	-0.011	0.038	DILATIVE
0.10	0.2	11.07	**27.25**	10	21.385	20.50	11.37	-0.004	0.038	DILATIVE
0.05	0.1	8.68	**26.12**	7	16.823	20.50	11.37	0.017	0.038	CONTRACTIVE
0.01	0.1	4.29	**23.64**	4	9.565	20.50	11.37	0.067	0.038	CONTRACTIVE
0.00003	0.0	0.98	**21.82**	1	3.803	20.50	11.37	0.148	0.038	CONTRACTIVE
0.05	0.1	10.43	**31.17**	7	16.361	22.00	11.45	0.026	0.035	CONTRACTIVE
3.81	0.8	62.24	**66.27**	136	152.961	22.00	11.45	-0.169	0.035	DILATIVE
3.73	0.8	62.84	**67.21**	133	150.764	22.00	11.45	-0.168	0.035	DILATIVE
4.86	1.0	74.10	**75.28**	187	192.600	22.00	11.45	-0.190	0.035	DILATIVE
5.05	1.0	77.46	**78.18**	197	200.504	22.00	11.45	-0.193	0.035	DILATIVE
4.29	0.9	72.45	**75.50**	160	172.856	22.00	11.45	-0.180	0.035	DILATIVE
3.99	0.9	71.20	**75.31**	146	162.488	22.00	11.45	-0.175	0.035	DILATIVE
3.69	0.8	69.70	**74.94**	133	152.026	22.00	11.45	-0.169	0.035	DILATIVE
3.55	0.8	69.66	**75.52**	128	147.766	22.00	11.45	-0.166	0.035	DILATIVE
2.70	0.7	61.64	**70.80**	93	117.604	22.00	11.45	-0.146	0.035	DILATIVE
1.50	0.5	47.21	**61.78**	52	76.114	22.00	11.45	-0.108	0.035	DILATIVE
1.36	0.5	45.81	**61.36**	47	71.193	22.00	11.45	-0.103	0.035	DILATIVE
0.79	0.4	36.48	**55.68**	30	50.560	22.00	11.45	-0.073	0.035	DILATIVE
1.20	0.5	44.46	**61.51**	42	65.386	22.00	11.45	-0.095	0.035	DILATIVE
1.88	0.6	55.94	**69.78**	64	89.829	22.00	11.45	-0.123	0.035	DILATIVE
0.16	0.2	20.40	**46.66**	11	23.235	22.00	11.45	-0.005	0.035	DILATIVE

$$\psi = -0.002\times\left(\frac{K_D}{K_0}\right)^2 + 0.015\times\left(\frac{K_D}{K_0}\right) + 0.0026 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5.9)$$

This empirical approach relies on the *DMT* horizontal stress index, K_D, and requires the coefficient earth at rest, K_0. In this study, Jacky's equation (1944, cited by Schnaid, 2009) was used to estimate K_0.

Table 5.14 Results of the in-situ state parameter interpreted from the *DMT* #1 data

K_D	ϕ' *DMT* FRICTION ANGLE (Marchetti, 2001)	K_o (Jacky's equation)	ψ (State Parameter)	Remarks
35.12	45.55	0.29	-28.29	DILATIVE
22.56	43.91	0.31	-9.73	DILATIVE
13.53	41.83	0.33	-2.69	DILATIVE
11.07	40.96	0.34	-1.58	DILATIVE
10.57	40.75	0.35	-1.39	DILATIVE
7.29	39.03	0.37	-0.48	DILATIVE
6.84	38.72	0.37	-0.39	DILATIVE
6.04	38.12	0.38	-0.26	DILATIVE
4.37	36.49	0.41	-0.07	DILATIVE
6.84	38.73	0.37	-0.39	DILATIVE
4.91	37.08	0.40	-0.12	DILATIVE
4.73	36.90	0.40	-0.10	DILATIVE
4.56	36.71	0.40	-0.08	DILATIVE
3.27	34.95	0.43	0.00	CONTRACTIVE
2.46	33.38	0.45	0.02	CONTRACTIVE
3.11	34.68	0.43	0.01	CONTRACTIVE
3.02	34.53	0.43	0.01	CONTRACTIVE
3.28	34.98	0.43	0.00	DILATIVE
2.97	34.44	0.43	0.01	CONTRACTIVE
7.63	39.25	0.37	-0.55	DILATIVE
14.32	42.07	0.33	-3.11	DILATIVE
2.64	33.79	0.44	0.02	CONTRACTIVE
1.19	29.08	0.51	0.03	CONTRACTIVE
0.58	24.45	0.59	0.02	CONTRACTIVE
1.25	29.38	0.51	0.03	CONTRACTIVE
0.51	23.52	0.60	0.01	CONTRACTIVE
0.23	17.72	0.70	0.01	CONTRACTIVE
-0.06				
-0.08				
0.15	14.31	0.75	0.01	CONTRACTIVE
0.12	12.76	0.78	0.00	CONTRACTIVE
0.09	10.85	0.81	0.00	CONTRACTIVE
0.99	27.96	0.53	0.02	CONTRACTIVE
0.05	4.72	0.92	0.00	CONTRACTIVE

$$K_0 = 1 - \sin\phi' \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5.10)$$

Marchetti (1997, cited by Marchetti et al., 2001) offered a useful relationship to estimate the internal friction angle directly from the *DMT* horizontal stress index, as follows:

$$\phi' = 28 + (14.6 \times \log(K_D)) - (2.1 \times \log^2(K_D)) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5.11)$$

Similar to estimating ψ from *CPT* data, interpretation of the in-situ state parameter from *DMT* data was only applied to the layers which were selected for the simple *CS* test.

Those were the soil layers located between depths of 1.2 to 2.6 m, 2.6 to 4.6 m, and approximately 6.0 to 9.0 m depth. The results are presented in Table 5.14 and detailed calculations are provided as Appendix I.

Analysis of the in-situ state parameter using the *DMT* data indicated that soils in a layer from 1.2 to 2.6 m deep and a layer from 6.0 to 9.0 m deep were dilative soils. Three layers were found to be contractive (from 3.6 to 4.4 m, from 5.8 to 6.0 m deep, and 6.4 to 9.0 m).

The in-situ state parameter evaluations were compiled to examine the overall results as shown in Table 5.15. The in-situ state parameter interpreted from the *CPT* data revealed that a layer from 4.0 to 4.6 m deep at the study site was a contractive layer. There were two other layers that were also likely to be contractive. They were located at depths of 2.0 to 2.4 m and between 7.8 and 8.4 m.

Interpretation of the in-situ state parameter using *DMT* data also predicted that a layer at about 3.8 to 4.4 m in depth was contractive. The evaluation using these data also found a thin layer at 6.0 m to be contractive. In addition, a relatively thick layer from 6.6 to 9.0 m in depth exhibited contractive behaviour.

5.7 CONCLUSION

To determine the critical state line of soils, it is important to understand the characteristics of natural granular soils. A test apparatus was established, and the testing was undertaken and calibrated. Furthermore, a comparison with several samples from other sources was conducted.

Six natural sand deposits from different depths from two boreholes at the study site were selected. All of these soils were classified using the *USCS* Classification as SM (Silty SAND). From each sample, three specimens were prepared for the simple *CS* test.

The result of the simple *CS* test on each specimen proved very promising as shown by the coefficient of determination. In terms of the slope of the *CSL*, λ, the results represent the sample reasonably well. However, in terms of the intercept of the *CSL* at 1 kPa mean stress, the results exhibit some scatter. It seems that the variation in the *CSL* is higher when the fines content is greater than 20%. It is suggested that this outcome account for the variability of natural soil deposits.

By using both the simple *CS* test and in-situ testing, the in-situ state parameter, ψ, was inferred. To determine the ψ conclusively requires interpreting the in-situ test data, which in this study was obtained from the *CPT* and *DMT*. The results of interpretations using both in-situ test methods suggested that, at a depth of 4.0 to 4.6 m, exists a contractive layer and that this layer will liquefy during any seismic loading. Another layer that was expected to liquefy was located at a depth of 7.8 and 8.4 m below the existing ground level. These disparities are also partly attributable to soil variability.

The next chapter deals with the liquefaction assessment derived from both the *CPT* and *DMT* procedures. Furthermore, the following chapter also details a comparison between both procedures and the effect of the liquefaction on the ground surface.

Table 5.15 Compilation results of the in-situ state parameter

DEPTH (mm)	CPT#1		CPT#2		CPT#3		DMT	Remarks
	$\lambda_{BH\#1}$	$\lambda_{BH\#2}$	$\lambda_{BH\#1}$	$\lambda_{BH\#2}$	$\lambda_{BH\#1}$	$\lambda_{BH\#2}$		
200								
400								
600								
800								
1000								
1200	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
1400	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
1600	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
1800	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	1st COARSE GRAINED LAYER
2000	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	DILATIVE	DILATIVE	
2200	DILATIVE	DILATIVE	CONTRACTIVE	DILATIVE	CONTRACTIVE	DILATIVE	DILATIVE	
2400	DILATIVE	DILATIVE	CONTRACTIVE	DILATIVE	CONTRACTIVE	DILATIVE	DILATIVE	
2600	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
2800	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
3000	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
3200	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
3400	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
3600	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	2nd COARSE GRAINED LAYER
3800	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	
4000	DILATIVE	CONTRACTIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	
4200	CONTRACTIVE	CONTRACTIVE	DILATIVE	CONTRACTIVE	CONTRACTIVE	CONTRACTIVE	CONTRACTIVE	
4400	CONTRACTIVE	CONTRACTIVE	DILATIVE	CONTRACTIVE	CONTRACTIVE	CONTRACTIVE	CONTRACTIVE	
4600	CONTRACTIVE	CONTRACTIVE	DILATIVE	CONTRACTIVE	CONTRACTIVE	CONTRACTIVE	DILATIVE	
4800								
5000								
5200								
5400								
5600								
5800								
6000	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	CONTRACTIVE	
6200	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
6400	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
6600	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	
6800	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	
7000	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	
7200	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	
7400	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	3rd COARSE GRAINED LAYER
7600	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	
7800	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	DILATIVE	DILATIVE	DILATIVE	
8000	DILATIVE	CONTRACTIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	
8200	DILATIVE	CONTRACTIVE	DILATIVE	CONTRACTIVE	DILATIVE	DILATIVE	CONTRACTIVE	
8400	DILATIVE	CONTRACTIVE	DILATIVE	CONTRACTIVE	DILATIVE	DILATIVE	CONTRACTIVE	
8600	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	
8800	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	
9000	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	DILATIVE	CONTRACTIVE	

Chapter Six

ASSESSING THE LIQUEFACTION POTENTIAL OF THE ST. KILDA FORMATION AT GILLMAN

6.1 INTRODUCTION

This chapter considers the simplified procedures for assessing the liquefaction potential of soil that were proposed by Seed and Idriss in 1971. As mentioned in Chapter 2, the Seed and Idriss procedure requires the evaluation of loading induced by an earthquake (cyclic stress ratio, *CSR*) and the ability of the soil to resist this loading (cyclic resistance ratio, *CRR*). In this study, the *CRR* of the in-situ soil was determined by interpreting the data from the cone penetration test (*CPT*) and flat dilatometer test (*DMT*). The basic rule of liquefaction analysis using the simplified procedure is as follows: if the *CSR* is greater than the *CRR*, then it is likely that liquefaction will occur during the seismic loading, and vice versa.

At the beginning of the chapter, the general simplified liquefaction assessment procedure, illustrated by means of a flowchart is discussed. In addition, the results from laboratory tests (fines content, moisture content and liquid limit) are incorporated into the process.

Subsequently, the establishment of the *CSR* value is explained. This process consists of several sections which present the procedure used to determine the peak ground acceleration (*PGA*), total and effective stresses, the stress reduction factor and the magnitude scaling factor. The method used to acquire the *CRR* is then explained. This includes the *CRR* estimated from the *CPT* and *DMT* in-situ testing.

Finally, the last section examines soil ageing and its effect on the ability of the soil to resist earthquake loading. Furthermore, re-evaluation is performed and presented. In addition, preliminary ground settlement induced by liquefaction and its manifestations are discussed.

6.2 LIQUEFACTION ASSESSMENT PROCESS

The overall process for the assessment of liquefaction is presented in the form of a flowchart in Figure 6.1, which shows that the procedure begins by conducting in-situ testing and obtaining soil samples for laboratory testing and further inspection. The in-situ testing data are used to calculate or estimate several parameters in order to establish both the *CSR* and *CRR* values. As mentioned in Chapter 2, considering the capability of the method and the complexity of the liquefaction phenomenon, the electric cone penetration test (*CPT*) and the flat dilatometer test (*DMT*) were used in this study.

Soil samples from the continuous sampling are used to classify the soil and to enable simple critical state parameter testing. The soil types can be used to confirm the characteristics of the soil. Simple critical state parameter testing was also used for liquefaction assessment in order that the results of all tests could be compared and confirmed, as outlined in the previous chapter.

As *CPT* in-situ testing involves high strain testing, an ageing correction factor is necessary to ascertain the ultimate *CRR* value (Arango et al., 2000; Lewis et al., 2004; and Andrus et al., 2009). Then, the $CSR\text{-}q_{c1,N}$ and the ultimate $CRR\text{-}q_{c1,N}$ at the respective depths are plotted onto a graph. Any $CSR\text{-}q_{c1,N}$ point above the $CRR\text{-}_{qc1,N}$ curve is considered to represent likely liquefaction during earthquake loading. On the other hand, those points that plot below the curve are regarded as layers where liquefaction is highly unlikely.

As noted by Totani et al. (2001), the in-situ *DMT* method is sensitive to the ageing effect, so no ageing correction factor is applied. The $CSR\text{-}K_D$ and $CRR\text{-}K_D$ values at each 200 mm depth interval are plotted onto a graph. Next, a similar rule to that of the *CPT* method is applied: any $CSR\text{-}K_D$ results above the $CRR\text{-}K_D$ curve are considered as being likely to liquefy during earthquake loading, whereas those which fall below the curve are regarded as being non liquefiable.

Finally, the in-situ testing liquefaction assessment results are obtained. Both of the results are presented and compared with one another.

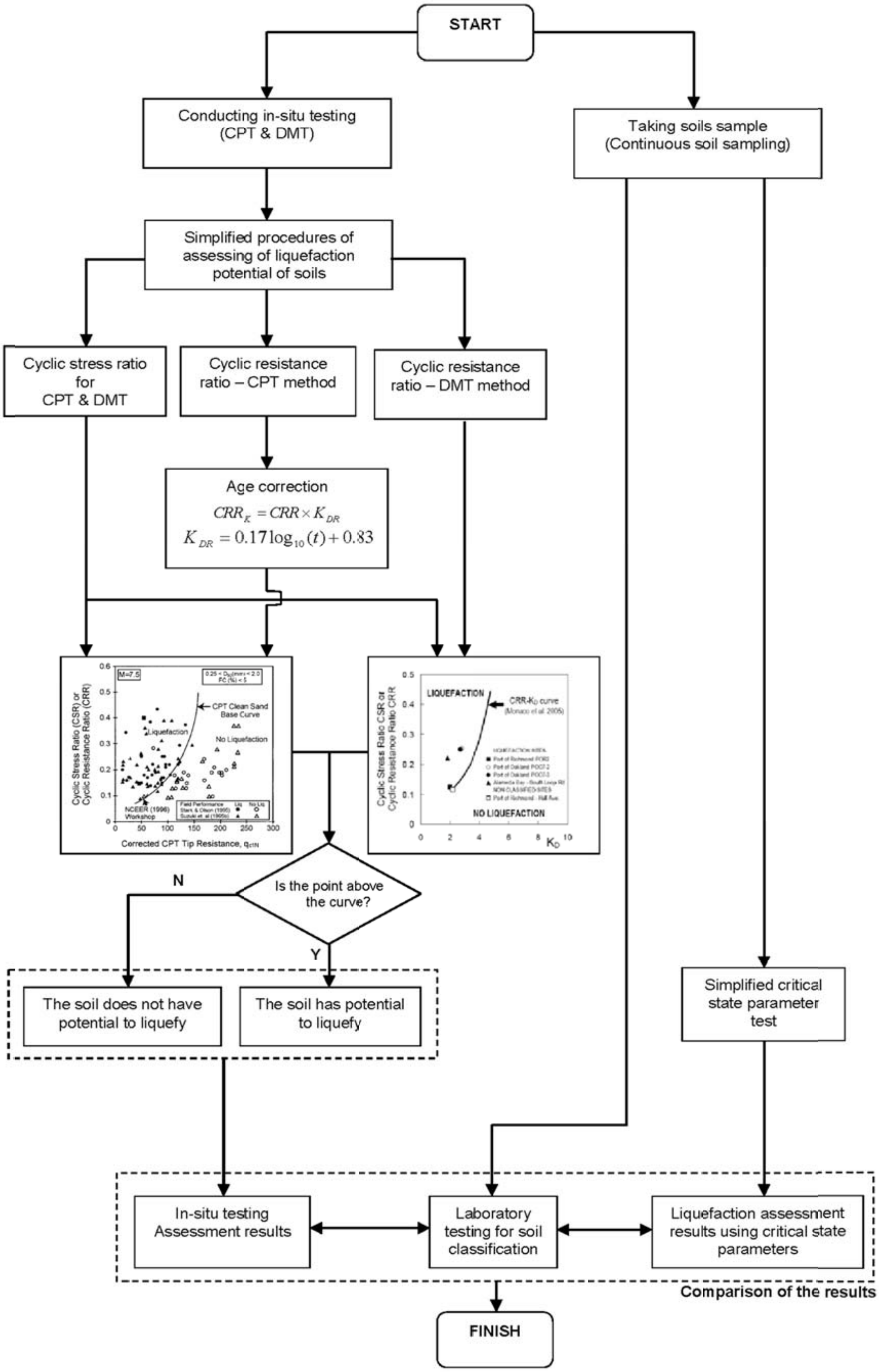


Figure 6.1 Liquefaction assessment flowchart

6.3 DETERMINATION OF CSR FOR THE ST. KILDA FORMATION

As stated in Chapter 2, *CSR* was determined by using a model originally proposed by Seed and Idriss in 1971, which was subsequently modified by Hwang et al. (2004) and Idriss and Boulanger (2004). The model is as follows:

$$CSR_{M=7.5} = \left(\tau_{av} / \sigma'_{vo}\right) = 0.65\left(a_{\max} / g\right)\left(\sigma_{vo} / \sigma'_{vo}\right) r_d \,/\, MSF(M) \text{ ……….. } (6.1)$$

The procedure used to establish the *CSR* in this study is shown in Figure 6.2. The sequence begins with data collection, which includes obtaining input related to earthquake motions, conducting a site investigation and reviewing historical data. All the related data are used in the analysis process, which is followed by the finalisation of the necessary outputs, such as site-specific ground acceleration (a_{max}), overburden stresses (σ_{vo} and σ'_{vo}), the stress reduction coefficient (r_d) and the magnitude scaling factor (*MSF*). Most of the *CSR* parameters are defined using empirical approximations or pre-determined models. Finally, the *CSR* value is calculated using Equation 6.1.

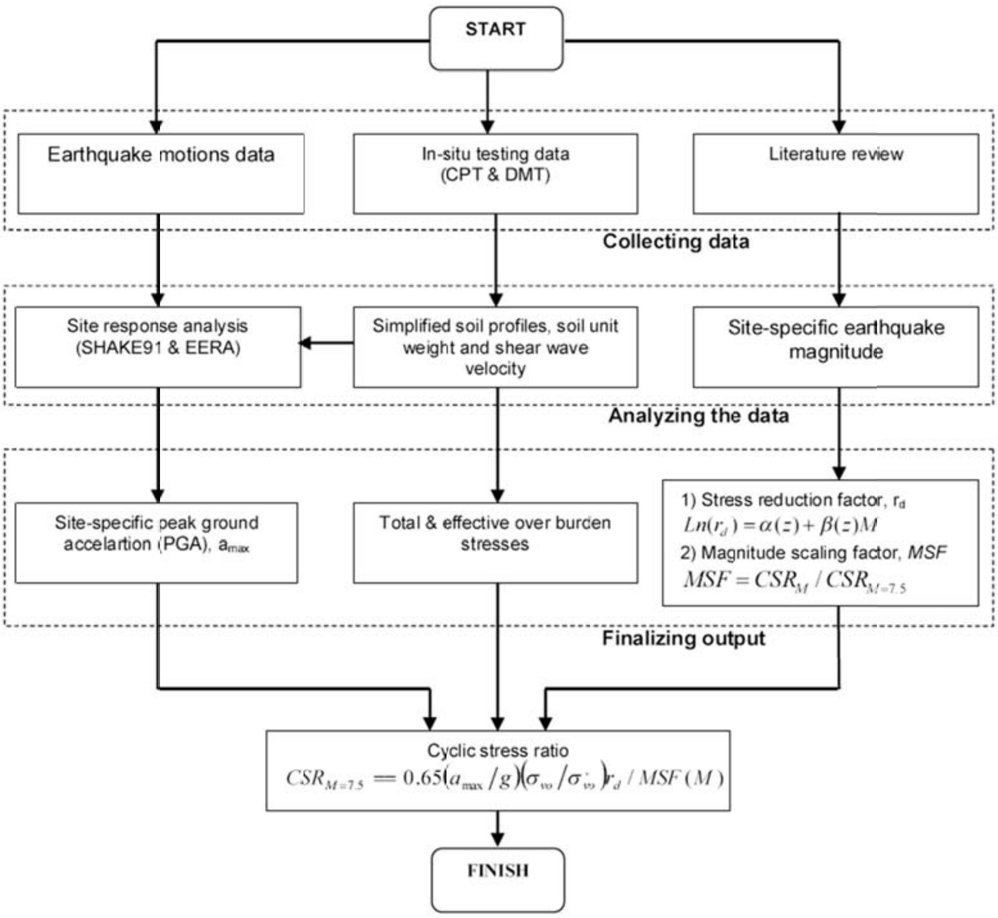


Figure 6.2 Sequence of steps to determine cyclic stress ratio

6.3.1 Peak ground acceleration

A major influence on the *CSR* induced by an earthquake is the peak horizontal ground acceleration, a_{max}. Therefore, a site-specific ground response analysis was carried out to obtain the representative site ground acceleration. Detailed explanations regarding the site-specific ground response analysis were provided in Chapter 4. The *PGA* adopted for the liquefaction assessment in this study was obtained from this site-specific ground response analysis. For liquefaction assessment using the *CPT* method a value of 0.202 *g* was adopted; whereas for the assessment based on the *DMT* method, a value of 0.217 *g* was used.

6.3.2 Stress reduction and magnitude scaling factors

Stress reduction factor

The stress reduction coefficient/factor, r_d, adopted in this study was estimated as a function of depth and earthquake magnitude, *M*, as suggested by Idriss and Boulanger (2004), see Equations 2.4a to 2.4c in Chapter 2, which varies from a magnitude of 5.0 to 7.5 scale. These magnitudes are based on the published literature, as mentioned in Chapters 2 and 3, which implies that the maximum possible earthquake in the Adelaide region is in the range of 5.0 to 7.5. However, to limit the relevance of this analysis, an increment of 0.5 was adopted. Therefore, the subsequent stress reduction factors were developed from magnitudes of 5.0, 5.5, 6.0, 6.5, 7.0 and 7.5. Details of the stress reduction factors are shown in Figure 6.3. In addition, the suggested average stress reduction factor from the 1996 *NCEER* and 1998 *NCEER/NSF* Workshops, which depends solely on depth, is also shown on the figure.

Magnitude scaling factor

In terms of the magnitude scaling factor, most of the prominent empirical liquefaction studies are based on a 7.5 magnitude earthquake. Thus, a magnitude scaling factor, *MSF*, is necessary to adjust the *CSR* induced by other earthquake magnitudes.

The method proposed by Idriss (1999) was used in this study because: (1) it is derived from high quality samples obtained by frozen sampling techniques; (2) it includes the main features of dynamic soil behaviour; and 3) the approximations using this correlation are supported by recommendations from the significant 1996 *NCEER* and 1998

NCEER/NSF Workshops. The *MSF* values obtained by the Idriss (1999) correlation are shown in Table 6.1.

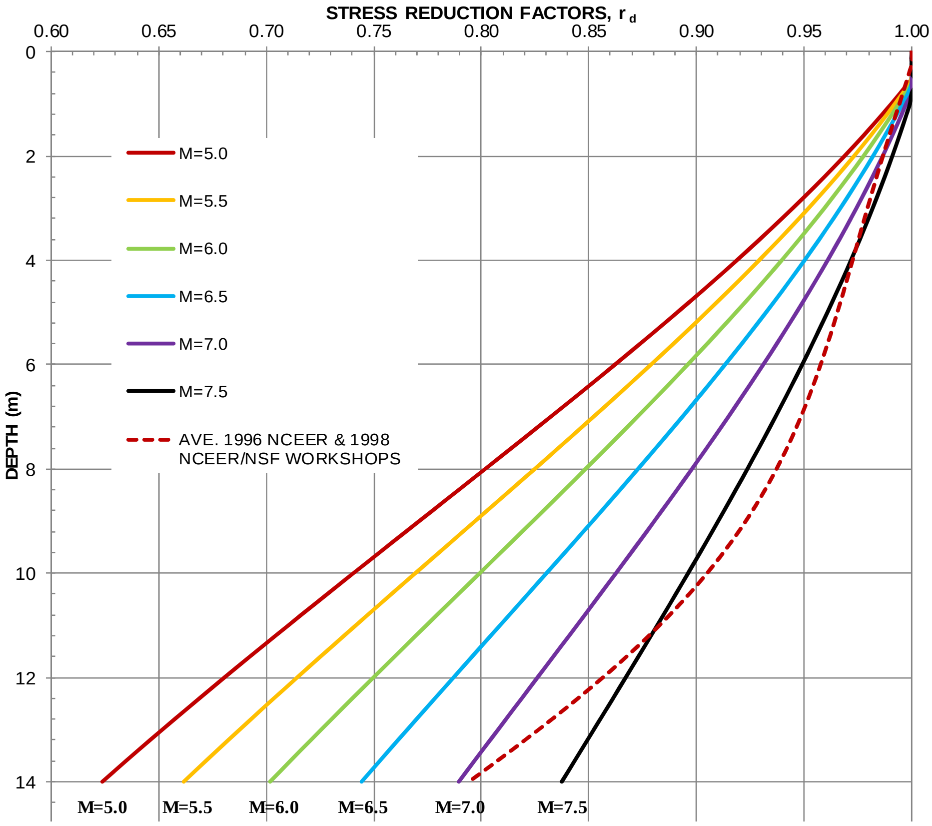


Figure 6.3 Stress reduction factor profiles

Table 6.1 Summary of *CSR* parameters for the liquefaction assessment

Type of in-situ testing	Cyclic stress ratio parameters				
	a_{max}	σ_{v0}	σ'_{v0}	r_d	*MSF*
CPT	0.202 g	Varies with soil unit weight and its depth	Varies with total overburden stress and the position of the soil relative to the level of the ground water	Varies with depth and the earthquake magnitude scales	1.8 for M=5.0 1.69 for M=5.5 1.48 for M=6.0 1.3 for M=6.5 1.14 for M=7.0 1.0 for M=7.5
DMT	0.217g				

6.3.3 Cyclic stress ratio (*CSR*)

A summary of the *CSR* parameters and their values is shown in Table 6.1. The *CSR* represents the magnitude of energy that induces the soil to liquefy. As stated in the previous section, earthquake magnitudes from 5.0 to 7.5 in increments of 0.5 were used in this study. The *CSR* values presented here incorporate variations in peak ground acceleration, earthquake magnitude scales and data from the adopted in-situ testing methods (*CPT* and *DMT*).

CPT cyclic stress ratio (CPT-CSR)

CPT-CSR values were calculated using Equation 2.1b in Chapter 2. The estimated *CPT-CSR* values plotted against the normalised cone tip resistances are presented in Figures 6.4, 6.5 and 6.6. As seen in the plots, the *CSR* values increase when the earthquake magnitude scales rise. This demonstrates that, as one would expect, the greater the magnitude of the earthquake, the greater the likelihood of liquefaction. In some cases in this study, the rise of earthquake magnitude from 5.0 to 7.5 caused the *CSR* values to increase by a factor of 1.5.

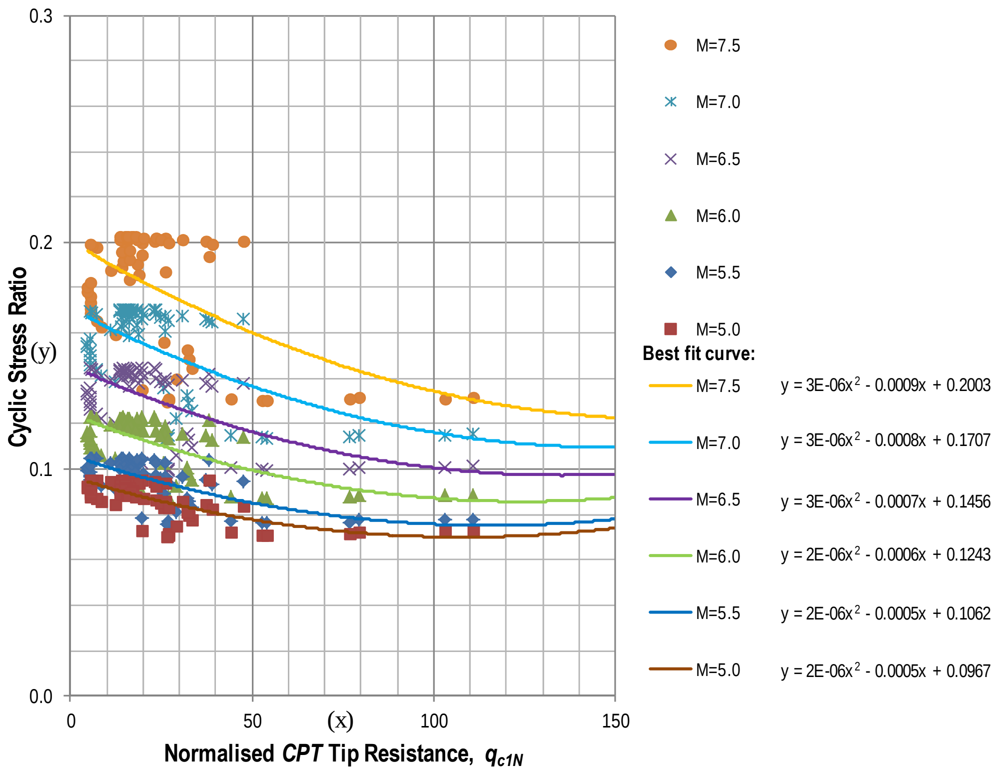


Figure 6.4 Cyclic stress ratio (*CSR*) versus normalised cone penetration resistance of *CPT* #1

In addition, the calculated *CPT-CSR* values were also plotted and tabulated against depth, as shown in Tables 6.2, 6.3 and 6.4. These tables show a similar pattern to that of the *CSR* values versus normalised cone tip resistance, where an increase in earthquake magnitude results in a rise in the *CSR* value. Furthermore, these tables present the distribution of the *CSR* values with depth.

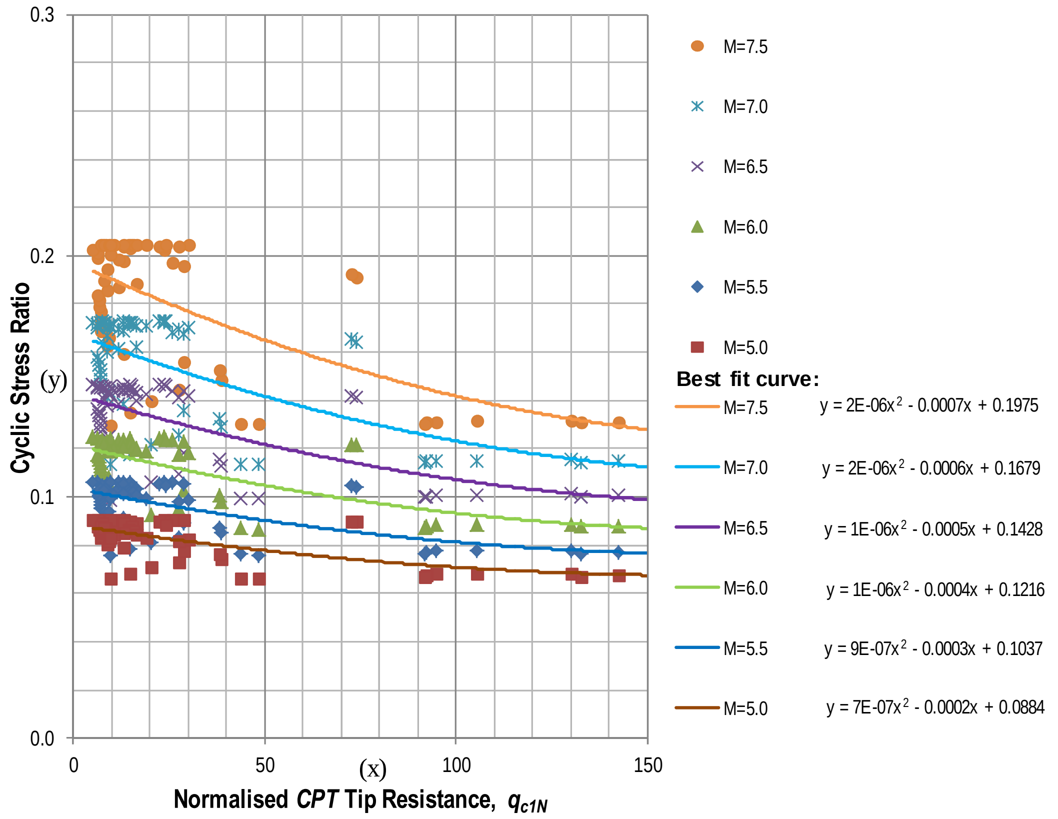


Figure 6.5 Cyclic stress ratio (*CSR*) versus normalised cone penetration resistance of *CPT* #2

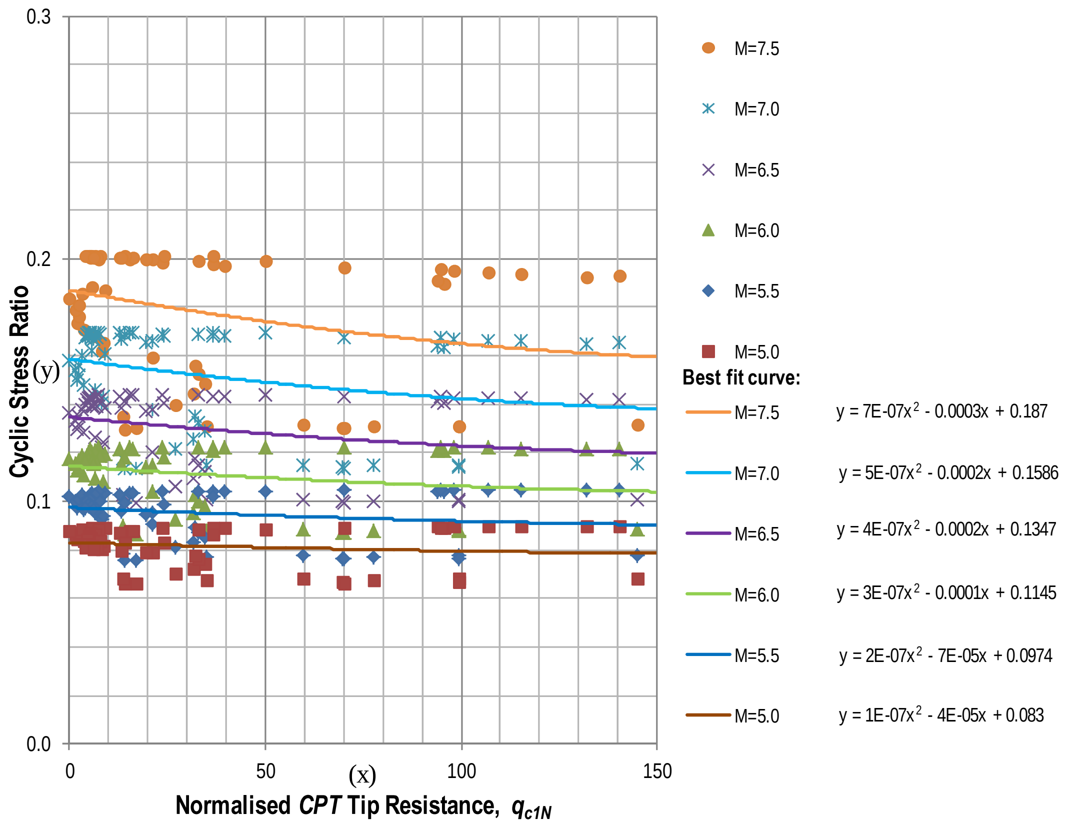
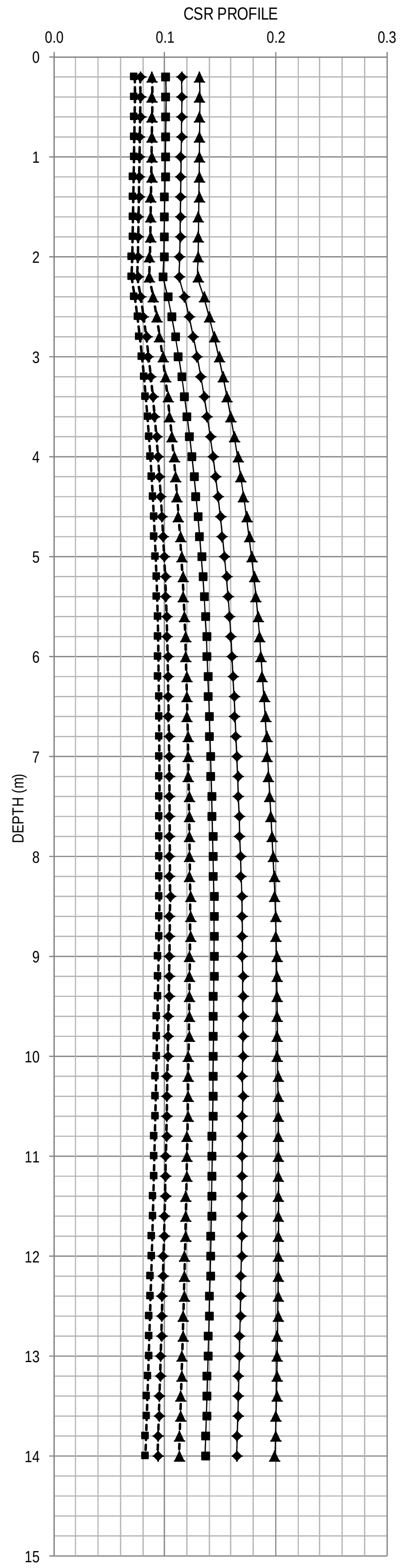


Figure 6.6 Cyclic stress ratio (*CSR*) versus normalised cone penetration resistance of *CPT* #3

Table 6.2 Cyclic stress ratio (*CSR*) versus depth at *CPT* #1

Depth (m)	Cyclic Stress Ration (CSR)					
	M=5.0	M=5.5	M=6.0	M=6.5	M=7.0	M=7.5
0.2	0.073	0.078	0.089	0.101	0.115	0.131
0.4	0.073	0.078	0.089	0.101	0.115	0.132
0.6	0.073	0.078	0.089	0.101	0.115	0.132
0.8	0.073	0.078	0.088	0.101	0.115	0.131
1.0	0.072	0.077	0.088	0.101	0.115	0.131
1.2	0.072	0.077	0.088	0.100	0.115	0.131
1.4	0.072	0.077	0.088	0.100	0.114	0.131
1.6	0.071	0.076	0.087	0.100	0.114	0.131
1.8	0.071	0.076	0.087	0.099	0.114	0.130
2.0	0.071	0.076	0.087	0.099	0.114	0.130
2.2	0.070	0.075	0.086	0.099	0.113	0.130
2.4	0.073	0.078	0.090	0.103	0.118	0.135
2.6	0.075	0.081	0.093	0.106	0.122	0.140
2.8	0.078	0.083	0.096	0.110	0.126	0.145
3.0	0.080	0.086	0.098	0.113	0.129	0.149
3.2	0.081	0.087	0.100	0.115	0.133	0.153
3.4	0.083	0.089	0.103	0.118	0.136	0.156
3.6	0.084	0.091	0.105	0.120	0.138	0.160
3.8	0.086	0.093	0.106	0.122	0.141	0.163
4.0	0.087	0.094	0.108	0.125	0.144	0.166
4.2	0.088	0.095	0.110	0.126	0.146	0.169
4.4	0.089	0.096	0.111	0.128	0.148	0.171
4.6	0.090	0.098	0.113	0.130	0.150	0.174
4.8	0.091	0.099	0.114	0.132	0.152	0.176
5.0	0.092	0.099	0.115	0.133	0.154	0.178
5.2	0.093	0.100	0.116	0.134	0.156	0.180
5.4	0.093	0.101	0.117	0.136	0.157	0.182
5.6	0.094	0.102	0.118	0.137	0.158	0.184
5.8	0.094	0.102	0.119	0.138	0.160	0.186
6.0	0.094	0.103	0.119	0.138	0.161	0.187
6.2	0.094	0.103	0.119	0.139	0.161	0.188
6.4	0.095	0.103	0.120	0.140	0.163	0.189
6.6	0.095	0.104	0.120	0.140	0.163	0.191
6.8	0.095	0.104	0.121	0.141	0.164	0.192
7.0	0.095	0.104	0.121	0.141	0.165	0.193
7.2	0.095	0.104	0.121	0.142	0.166	0.194
7.4	0.095	0.104	0.122	0.142	0.166	0.195
7.6	0.095	0.104	0.122	0.143	0.167	0.196
7.8	0.095	0.105	0.122	0.143	0.168	0.197
8.0	0.095	0.105	0.122	0.144	0.168	0.198
8.2	0.095	0.105	0.123	0.144	0.169	0.198
8.4	0.095	0.105	0.123	0.144	0.170	0.199
8.6	0.095	0.105	0.123	0.144	0.170	0.200
8.8	0.095	0.104	0.123	0.144	0.170	0.200
9.0	0.094	0.104	0.123	0.144	0.170	0.201
9.2	0.094	0.104	0.122	0.144	0.170	0.201
9.4	0.094	0.104	0.122	0.144	0.170	0.201
9.6	0.093	0.103	0.122	0.144	0.170	0.201
9.8	0.093	0.103	0.122	0.144	0.170	0.202
10.0	0.093	0.103	0.121	0.144	0.170	0.202
10.2	0.092	0.102	0.121	0.143	0.170	0.202
10.4	0.092	0.102	0.121	0.143	0.170	0.202
10.6	0.091	0.102	0.121	0.143	0.170	0.202
10.8	0.091	0.101	0.120	0.143	0.170	0.202
11.0	0.091	0.101	0.120	0.143	0.170	0.203
11.2	0.090	0.101	0.120	0.143	0.170	0.203
11.4	0.090	0.100	0.119	0.142	0.170	0.203
11.6	0.089	0.100	0.119	0.142	0.170	0.203
11.8	0.089	0.099	0.119	0.142	0.169	0.203
12.0	0.088	0.099	0.118	0.141	0.169	0.202
12.2	0.088	0.098	0.118	0.141	0.169	0.202
12.4	0.087	0.098	0.117	0.140	0.168	0.202
12.6	0.087	0.097	0.117	0.140	0.168	0.202
12.8	0.086	0.097	0.116	0.140	0.168	0.202
13.0	0.086	0.096	0.116	0.139	0.167	0.201
13.2	0.085	0.096	0.115	0.139	0.167	0.201
13.4	0.084	0.095	0.115	0.138	0.166	0.201
13.6	0.084	0.095	0.114	0.137	0.166	0.200
13.8	0.083	0.094	0.113	0.137	0.165	0.200
14.0	0.083	0.093	0.113	0.136	0.165	0.199



For M=5.0
For M=5.5
For M=6.0
For M=6.5
For M=7.0
For M=7.5

Table 6.3 Cyclic stress ratio (*CSR*) versus depth at *CPT* #2

Depth (m)	Cyclic Stress Ration (CSR)					
	M=5.0	M=5.5	M=6.0	M=6.5	M=7.0	M=7.5
0.2	0.073	0.078	0.089	0.101	0.115	0.131
0.4	0.073	0.078	0.089	0.101	0.115	0.132
0.6	0.073	0.078	0.089	0.101	0.115	0.132
0.8	0.073	0.078	0.088	0.101	0.115	0.131
1.0	0.072	0.077	0.088	0.101	0.115	0.131
1.2	0.072	0.077	0.088	0.100	0.115	0.131
1.4	0.072	0.077	0.088	0.100	0.114	0.131
1.6	0.071	0.076	0.087	0.100	0.114	0.131
1.8	0.071	0.076	0.087	0.099	0.114	0.130
2.0	0.071	0.076	0.087	0.099	0.114	0.130
2.2	0.070	0.075	0.086	0.099	0.113	0.130
2.4	0.073	0.078	0.090	0.103	0.118	0.135
2.6	0.075	0.081	0.093	0.106	0.122	0.140
2.8	0.078	0.083	0.096	0.110	0.126	0.145
3.0	0.079	0.085	0.098	0.113	0.129	0.149
3.2	0.081	0.087	0.100	0.115	0.133	0.153
3.4	0.083	0.089	0.103	0.118	0.136	0.156
3.6	0.084	0.091	0.105	0.120	0.139	0.160
3.8	0.086	0.093	0.107	0.123	0.141	0.163
4.0	0.087	0.094	0.108	0.125	0.144	0.166
4.2	0.088	0.095	0.110	0.127	0.146	0.169
4.4	0.090	0.097	0.112	0.129	0.149	0.172
4.6	0.091	0.098	0.113	0.130	0.151	0.174
4.8	0.091	0.099	0.114	0.132	0.153	0.177
5.0	0.092	0.100	0.116	0.134	0.155	0.179
5.2	0.093	0.101	0.117	0.135	0.156	0.181
5.4	0.094	0.102	0.118	0.136	0.158	0.184
5.6	0.094	0.103	0.119	0.138	0.160	0.185
5.8	0.095	0.103	0.120	0.139	0.161	0.187
6.0	0.095	0.104	0.120	0.140	0.162	0.189
6.2	0.095	0.104	0.121	0.140	0.163	0.190
6.4	0.096	0.104	0.121	0.141	0.164	0.191
6.6	0.096	0.105	0.122	0.142	0.165	0.193
6.8	0.096	0.105	0.123	0.143	0.167	0.195
7.0	0.097	0.106	0.123	0.144	0.168	0.196
7.2	0.097	0.106	0.123	0.144	0.168	0.197
7.4	0.097	0.106	0.124	0.145	0.169	0.198
7.6	0.097	0.106	0.124	0.145	0.169	0.199
7.8	0.097	0.106	0.124	0.145	0.170	0.200
8.0	0.097	0.106	0.124	0.146	0.171	0.201
8.2	0.097	0.106	0.125	0.146	0.172	0.202
8.4	0.097	0.106	0.125	0.147	0.172	0.202
8.6	0.096	0.106	0.125	0.147	0.172	0.203
8.8	0.096	0.106	0.125	0.147	0.173	0.203
9.0	0.096	0.106	0.124	0.147	0.173	0.204
9.2	0.095	0.105	0.124	0.146	0.173	0.204
9.4	0.095	0.105	0.124	0.146	0.173	0.204
9.6	0.095	0.105	0.124	0.146	0.173	0.204
9.8	0.094	0.105	0.123	0.146	0.173	0.204
10.0	0.094	0.104	0.123	0.146	0.172	0.204
10.2	0.093	0.104	0.123	0.145	0.172	0.205
10.4	0.093	0.103	0.122	0.145	0.172	0.205
10.6	0.093	0.103	0.122	0.145	0.172	0.205
10.8	0.092	0.103	0.122	0.145	0.172	0.205
11.0	0.092	0.102	0.121	0.144	0.172	0.205
11.2	0.091	0.102	0.121	0.144	0.172	0.205
11.4	0.091	0.101	0.121	0.144	0.172	0.205
11.6	0.090	0.101	0.120	0.144	0.171	0.205
11.8	0.090	0.100	0.120	0.143	0.171	0.205
12.0	0.089	0.100	0.120	0.143	0.171	0.205
12.2	0.089	0.100	0.119	0.143	0.171	0.205
12.4	0.088	0.099	0.119	0.142	0.171	0.205
12.6	0.088	0.099	0.118	0.142	0.170	0.204
12.8	0.087	0.098	0.118	0.141	0.170	0.204

For M=5.0 For M=5.5 For M=6.0
For M=6.5 For M=7.0 For M=7.5

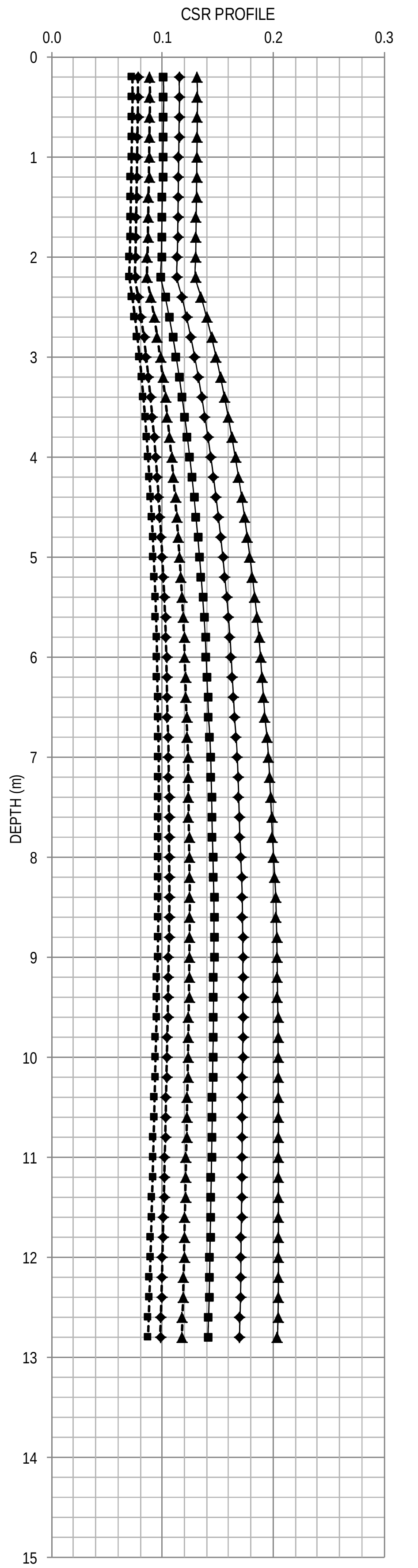
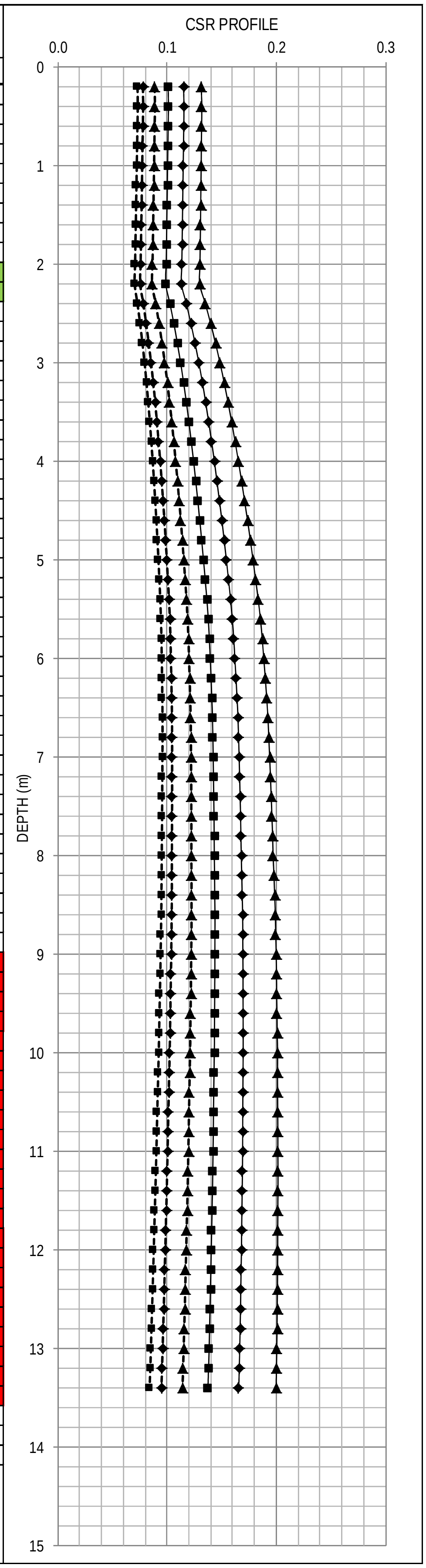


Table 6.4 Cyclic stress ratio (*CSR*) versus depth at *CPT#3*

Depth (m)	Cyclic Stress Ration (CSR)					
	M=5.0	M=5.5	M=6.0	M=6.5	M=7.0	M=7.5
0.2	0.073	0.078	0.089	0.101	0.115	0.131
0.4	0.073	0.078	0.089	0.101	0.115	0.132
0.6	0.073	0.078	0.089	0.101	0.115	0.132
0.8	0.073	0.078	0.088	0.101	0.115	0.131
1.0	0.072	0.077	0.088	0.101	0.115	0.131
1.2	0.072	0.077	0.088	0.100	0.115	0.131
1.4	0.072	0.077	0.088	0.100	0.114	0.131
1.6	0.071	0.076	0.087	0.100	0.114	0.131
1.8	0.071	0.076	0.087	0.099	0.114	0.130
2.0	0.071	0.076	0.087	0.099	0.114	0.130
2.2	0.070	0.075	0.086	0.099	0.113	0.130
2.4	0.073	0.078	0.090	0.103	0.118	0.135
2.6	0.075	0.081	0.093	0.106	0.122	0.140
2.8	0.077	0.083	0.095	0.109	0.126	0.144
3.0	0.079	0.085	0.098	0.112	0.129	0.149
3.2	0.081	0.087	0.100	0.115	0.132	0.152
3.4	0.083	0.089	0.102	0.118	0.135	0.156
3.6	0.084	0.091	0.104	0.120	0.138	0.159
3.8	0.086	0.092	0.106	0.122	0.141	0.162
4.0	0.087	0.094	0.108	0.124	0.143	0.165
4.2	0.088	0.095	0.110	0.126	0.146	0.168
4.4	0.089	0.096	0.111	0.128	0.148	0.171
4.6	0.090	0.098	0.113	0.130	0.150	0.174
4.8	0.091	0.099	0.114	0.132	0.152	0.176
5.0	0.092	0.100	0.115	0.133	0.154	0.179
5.2	0.093	0.101	0.117	0.135	0.156	0.181
5.4	0.094	0.102	0.118	0.136	0.158	0.183
5.6	0.094	0.103	0.119	0.138	0.160	0.185
5.8	0.095	0.103	0.120	0.139	0.161	0.187
6.0	0.095	0.104	0.120	0.139	0.162	0.189
6.2	0.095	0.104	0.121	0.140	0.163	0.190
6.4	0.096	0.104	0.121	0.141	0.164	0.191
6.6	0.096	0.105	0.122	0.142	0.165	0.192
6.8	0.096	0.105	0.122	0.142	0.166	0.193
7.0	0.096	0.105	0.122	0.142	0.166	0.194
7.2	0.096	0.105	0.122	0.142	0.166	0.195
7.4	0.096	0.105	0.122	0.143	0.167	0.195
7.6	0.095	0.105	0.122	0.143	0.167	0.196
7.8	0.095	0.104	0.122	0.143	0.168	0.197
8.0	0.095	0.104	0.122	0.143	0.168	0.197
8.2	0.095	0.104	0.122	0.143	0.168	0.198
8.4	0.095	0.104	0.122	0.144	0.169	0.199
8.6	0.095	0.104	0.122	0.144	0.169	0.199
8.8	0.094	0.104	0.122	0.144	0.169	0.199
9.0	0.094	0.104	0.122	0.144	0.169	0.200
9.2	0.094	0.104	0.122	0.144	0.170	0.200
9.4	0.093	0.103	0.122	0.144	0.170	0.200
9.6	0.093	0.103	0.122	0.144	0.170	0.201
9.8	0.093	0.103	0.121	0.143	0.170	0.201
10.0	0.092	0.102	0.121	0.143	0.170	0.201
10.2	0.092	0.102	0.121	0.143	0.169	0.201
10.4	0.091	0.102	0.120	0.143	0.169	0.201
10.6	0.091	0.101	0.120	0.143	0.169	0.201
10.8	0.091	0.101	0.120	0.142	0.169	0.201
11.0	0.090	0.100	0.119	0.142	0.169	0.201
11.2	0.090	0.100	0.119	0.142	0.169	0.202
11.4	0.089	0.100	0.119	0.142	0.169	0.202
11.6	0.089	0.099	0.118	0.141	0.169	0.201
11.8	0.088	0.099	0.118	0.141	0.168	0.201
12.0	0.088	0.098	0.117	0.140	0.168	0.201
12.2	0.087	0.098	0.117	0.140	0.168	0.201
12.4	0.087	0.097	0.117	0.140	0.168	0.201
12.6	0.086	0.097	0.116	0.139	0.167	0.201
12.8	0.086	0.096	0.116	0.139	0.167	0.201
13.0	0.085	0.096	0.115	0.138	0.167	0.200
13.2	0.085	0.095	0.115	0.138	0.166	0.200
13.4	0.084	0.095	0.114	0.137	0.166	0.200



For M=5.0 For M=5.5 For M=6.0
For M=6.5 For M=7.0 For M=7.5

Two interesting features are revealed from the tables as follows: (1) the lowest *CSR* value (identified by green shading) occurs at a depth of approximately 2.2 m; (2) the most critical layer which exhibits the highest impact during an earthquake is the layer at a depth of 7.8 to 11.0 m, depending on the magnitude of the earthquake (identified by red shading); and (3) an increase of 0.5 in earthquake magnitudes causes a rise of the severe thickness by a factor of 1.5.

DMT cyclic stress ratio (DMT-CSR)

When *DMT-CSR* values are plotted against the horizontal stress index, K_D, as shown in Figure 6.7, it can be seen that the *CSR* values rise when earthquake magnitude increases. In some cases, as shown in the figure, if the earthquake magnitude increases from 5.0 to 7.5, the *CSR* values are amplified by a factor of 2.5. This demonstrates, as one would expect, that stronger earthquakes, resulting in increased energy release, have a greater propensity to cause liquefaction than earthquakes of lower magnitude.

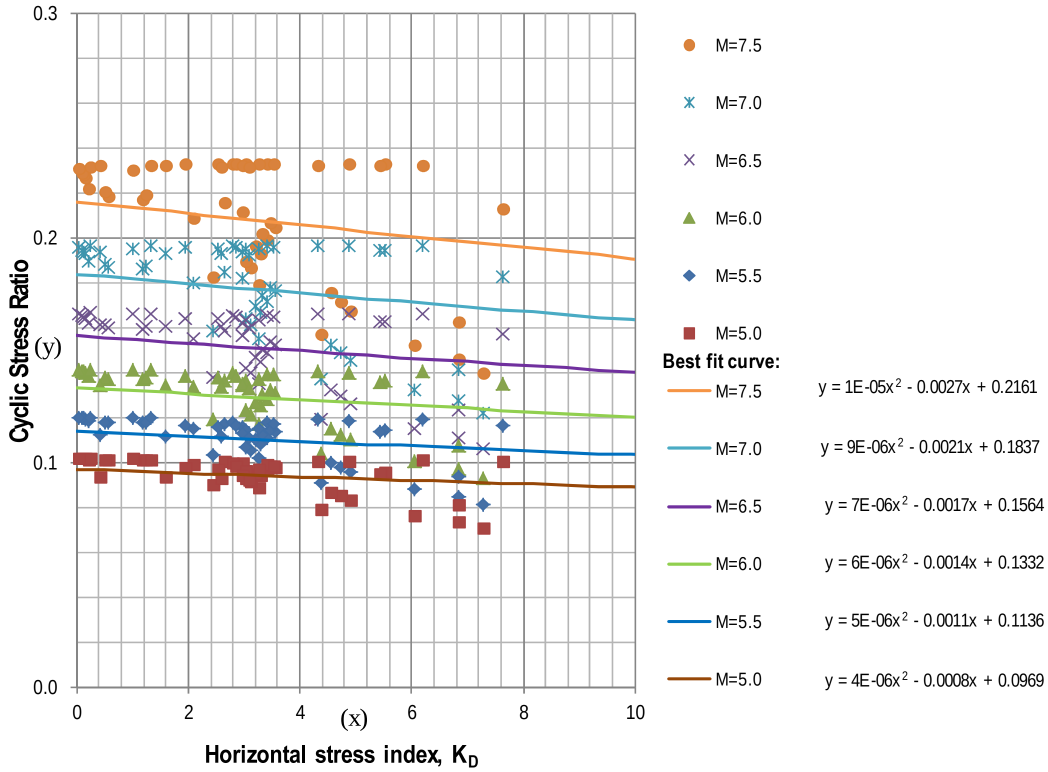
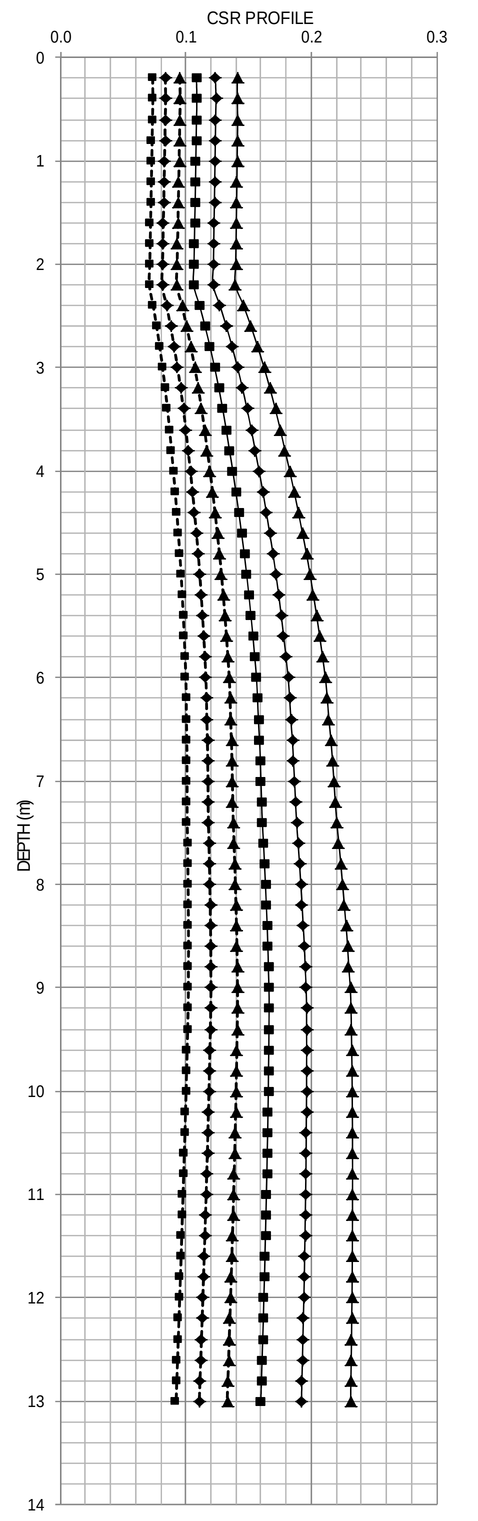


Figure 6.7 Cyclic stress ratio (*CSR*) versus horizontal stress index, K_D from *DMT*#1

In addition, the *DMT-CSR* values were tabulated, as shown in Table 6.5, to examine the distribution of these values in relation to depth. The results are similar to those of *CPT-CSR* versus depth, and it can be observed that: (1) the lowest *CSR* value (identified by green shading) is observed at approximately 2.2 m depth; (2) the layer which receives the highest impact during an earthquake is a critical layer at a depth of between 7.8 to 9.8 m depending on the magnitude of the earthquake (identified by red shading); and (3) an increase in earthquake magnitude results in a larger *CSR* value, as well as an increase in thickness.

Table 6.5 Cyclic stress ratio (*CSR*) versus depth at *DMT*#1

Depth (m)	Cyclic Stress Ration (CSR)					
	M=5.0	M=5.5	M=6.0	M=6.5	M=7.0	M=7.5
0.2	0.074	0.084	0.095	0.108	0.124	0.141
0.4	0.074	0.084	0.095	0.109	0.124	0.141
0.6	0.073	0.084	0.095	0.109	0.124	0.141
0.8	0.073	0.083	0.095	0.108	0.124	0.141
1.0	0.073	0.083	0.095	0.108	0.123	0.141
1.2	0.073	0.083	0.094	0.108	0.123	0.141
1.4	0.072	0.082	0.094	0.107	0.123	0.140
1.6	0.072	0.082	0.094	0.107	0.123	0.140
1.8	0.072	0.082	0.093	0.107	0.122	0.140
2.0	0.071	0.081	0.093	0.106	0.122	0.140
2.2	0.071	0.081	0.093	0.106	0.122	0.140
2.4	0.074	0.085	0.097	0.111	0.127	0.146
2.6	0.077	0.088	0.101	0.115	0.132	0.152
2.8	0.079	0.091	0.104	0.119	0.137	0.157
3.0	0.081	0.093	0.107	0.123	0.141	0.162
3.2	0.083	0.096	0.110	0.126	0.145	0.167
3.4	0.085	0.098	0.113	0.129	0.149	0.171
3.6	0.087	0.100	0.115	0.132	0.152	0.175
3.8	0.089	0.102	0.117	0.135	0.155	0.179
4.0	0.090	0.104	0.119	0.137	0.158	0.183
4.2	0.091	0.105	0.121	0.140	0.161	0.186
4.4	0.093	0.107	0.123	0.142	0.164	0.190
4.6	0.094	0.108	0.125	0.144	0.167	0.193
4.8	0.095	0.110	0.127	0.147	0.170	0.196
5.0	0.096	0.111	0.128	0.148	0.172	0.199
5.2	0.097	0.112	0.130	0.150	0.174	0.202
5.4	0.098	0.113	0.131	0.152	0.176	0.204
5.6	0.099	0.114	0.132	0.153	0.178	0.207
5.8	0.099	0.115	0.134	0.155	0.180	0.209
6.0	0.100	0.116	0.135	0.156	0.182	0.211
6.2	0.100	0.116	0.135	0.157	0.183	0.213
6.4	0.100	0.117	0.136	0.158	0.184	0.214
6.6	0.101	0.117	0.136	0.159	0.185	0.216
6.8	0.101	0.117	0.137	0.159	0.186	0.217
7.0	0.101	0.118	0.137	0.160	0.187	0.218
7.2	0.101	0.118	0.137	0.160	0.187	0.219
7.4	0.101	0.118	0.138	0.161	0.188	0.220
7.6	0.101	0.118	0.138	0.162	0.190	0.222
7.8	0.102	0.119	0.139	0.163	0.191	0.224
8.0	0.102	0.119	0.140	0.163	0.192	0.225
8.2	0.102	0.119	0.140	0.164	0.193	0.226
8.4	0.102	0.120	0.140	0.165	0.194	0.228
8.6	0.102	0.120	0.141	0.165	0.195	0.229
8.8	0.102	0.120	0.141	0.166	0.195	0.230
9.0	0.102	0.120	0.141	0.166	0.196	0.231
9.2	0.102	0.120	0.141	0.166	0.196	0.232
9.4	0.101	0.120	0.141	0.166	0.196	0.232
9.6	0.101	0.119	0.141	0.166	0.196	0.232
9.8	0.101	0.119	0.140	0.166	0.196	0.233
10.0	0.100	0.118	0.140	0.166	0.196	0.233
10.2	0.100	0.118	0.140	0.166	0.196	0.233
10.4	0.099	0.118	0.139	0.165	0.196	0.233
10.6	0.099	0.117	0.139	0.165	0.196	0.233
10.8	0.098	0.117	0.139	0.165	0.196	0.233
11.0	0.098	0.116	0.138	0.164	0.196	0.233
11.2	0.097	0.116	0.138	0.164	0.195	0.233
11.4	0.097	0.115	0.137	0.164	0.195	0.233
11.6	0.096	0.115	0.137	0.163	0.195	0.233
11.8	0.096	0.114	0.136	0.163	0.194	0.233
12.0	0.095	0.114	0.136	0.162	0.194	0.233
12.2	0.095	0.113	0.135	0.162	0.194	0.232
12.4	0.094	0.112	0.135	0.161	0.193	0.232
12.6	0.093	0.112	0.134	0.161	0.193	0.232
12.8	0.093	0.111	0.134	0.160	0.193	0.232
13.0	0.092	0.111	0.133	0.160	0.192	0.231



6.4 DETERMINATION OF CYCLIC RESISTANCE RATIO (*CRR*) AND LIQUEFACTION ASSESSMENT OF THE ST. KILDA FORMATION

As mentioned in Chapter 2, many procedures utilising in-situ testing have also been developed to determine the cyclic resistance ratio (*CRR*) of soils for liquefaction evaluation. Considering the capability of the method and the complexity of the liquefaction phenomenon, two in-situ tests, the electric cone penetration test (*CPT*) and the flat dilatometer test (*DMT*), were again utilised. The estimated *CRR* and *CSR* values were combined to assess the liquefaction potential of the St. Kilda Formation.

6.4.1 The cone penetration test (*CPT*) method for estimating *CRR*

As stated in Chapter 2, the *CRR*-*CPT*-based correlation was adopted for the study because it offers a significant advance over previously available correlations using *CPT* data. The adopted correlations were developed by employing a very large, high quality database of field performance case histories which allowed comparisons with previous researchers. The *CPT* method to estimate the *CRR* is summarised in Figure 6.8.

6.4.1.1 Procedure for estimating *CRR* using the *CPT*

As mentioned in Chapter 2, the procedure was adopted from the 1996 *NCEER* and 1998 *NCEER/NSF* Workshops for *CRR* evaluation using *CPT* data. The general outline is as follows:

- The tip resistance q_c and sleeve friction, f_s, are used to interpret the in-situ vertical stresses.
- A combination of the tip resistance, sleeve friction and in-situ vertical stress is used to estimate the fines content correction, I_c, and normalise the tip resistance to approximately 100 kPa (1 atm) by assuming the soil is fine-grained.
- The I_c values are used to predict the behaviour of the soils.
- The two previous steps are repeated for sandy soils and intermediate soils.
- The final obtained I_c is used for the calculation of the clean-sand equivalent cone penetration resistance, $q_{c1N,cs}$.
- The $q_{c1N,cs}$ value is entered into the $CRR_{7.5}$ equations.

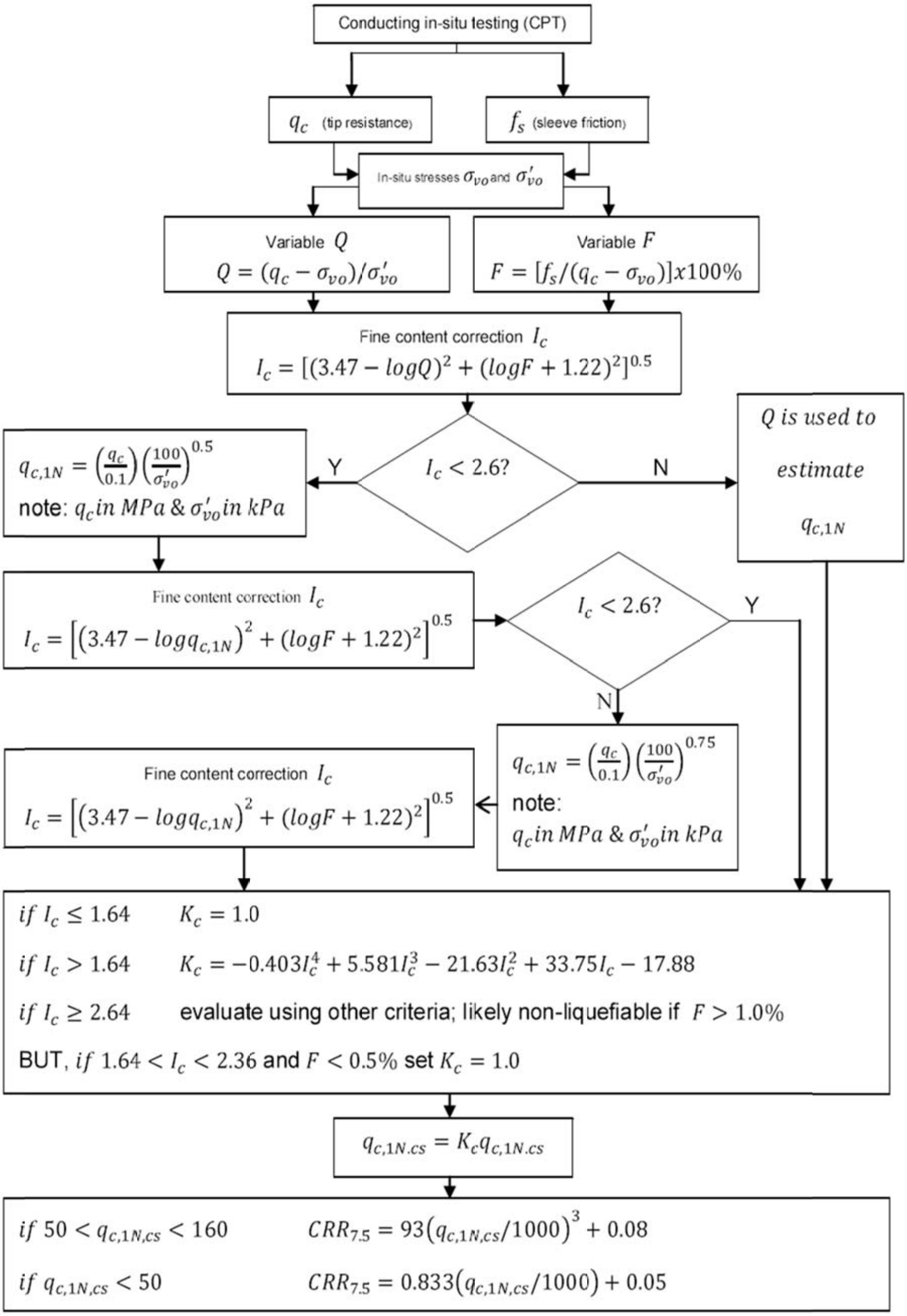


Figure 6.8 Flowchart for determining cyclic resistance ratio (*CRR*) using *CPT* data

It should also be noted that certain guidelines had emerged from the 1996 *NCEER* and 1998 *NCEER/NSF* Workshops that proved valuable during the study:

- C_Q values >1.7 should not be applied.
- The exponent n = 1.0 is the appropriate value for clayey type soils and 0.5 is more appropriate for clean sand.
- The value of n for soils in between clay and sand varies between 0.5 to 1.0.

The results of the *CRR* estimates were plotted against normalised cone penetration resistance from the *CPT* data, as shown in Figure 6.9. The figure demonstrates that the *CRR* curves of the three *CPT* in-situ testings are very consistent and almost plot as a single curve. In the simplified liquefaction analysis, these curves separate the non liquefiable soils from the liquefiable ones.

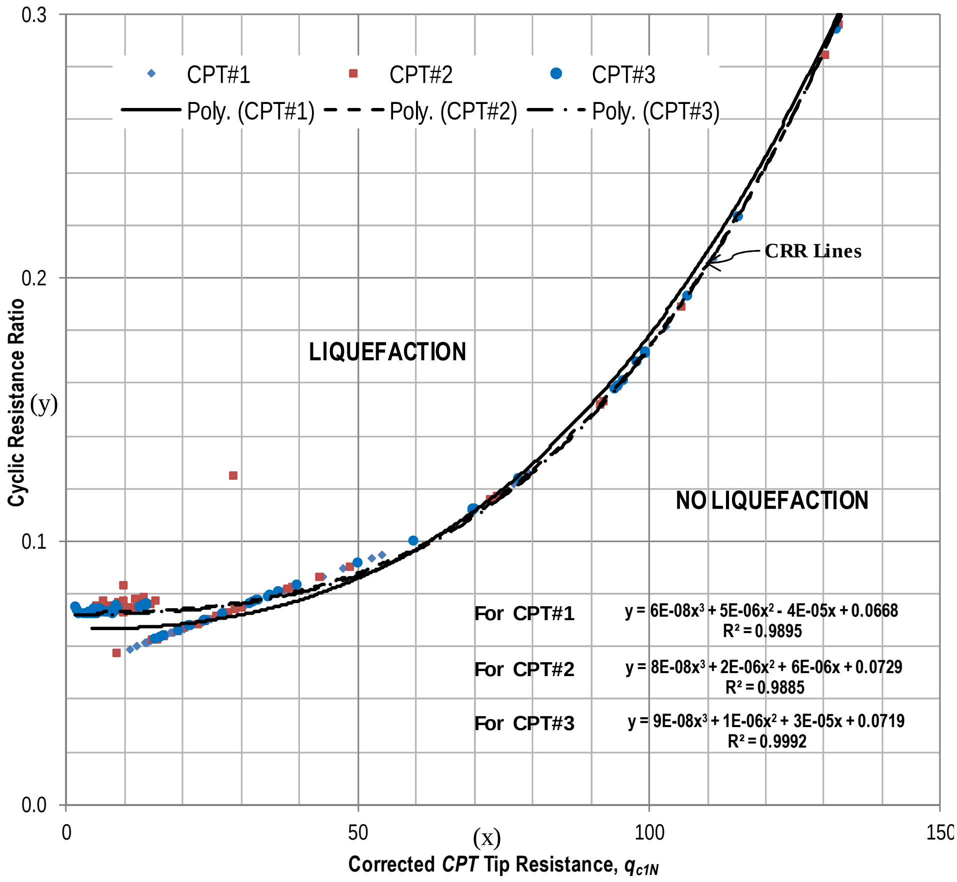


Figure 6.9 Cyclic resistance ratio (*CRR*) versus normalised cone tip resistance

6.4.1.2 Liquefaction assessment of the St. Kilda Formation using *CPT* method

As explained in Chapter 2, the simplified liquefaction assessment using the *CPT* in-situ testing is very straight forward. It is carried out by comparing the *CSR* and *CRR* values at their corresponding normalised cone penetration resistance values. If the comparison is positive, this indicates that liquefaction is likely to occur, and vice versa. Figures 6.10, 6.11 and 6.12 show the liquefaction assessment for *CPT* #1, *CPT* #2 and *CPT* #3 at different earthquake magnitude scales.

The assessments presented in the graphs demonstrate that, as one would expect, an increase in earthquake magnitude results in an increase in the number of liquefiable soils at the site. The increase in earthquake magnitude caused a rise in *CSR* values from the *CRR* curve. The gap identified in this study became even wider when the magnitude increased to 5.5 and beyond. Furthermore, the liquefaction assessments, which were based on the *CPT* method without applying a correction for soil ageing, suggest that most soils of the St. Kilda Formation tend to liquefy in an earthquake of magnitude as low as 5.0. Detailed calculations are presented in Appendix J.

6.4.2 Ageing correction factor for *CPT-CRR*

Several methods for determining the age of the soil deposit in this study were obtained by consulting the research of Burton (1984), Daily et al. (1976) and Belpeiro (1988) as mentioned in Chapter 2. These researchers had established key layers which could be used to estimate the age of each layer of the site in this study. The age of the remaining layers was interpolated from these findings.

Summary of key findings. For the upper 0.6 m of soil, it was very difficult to determine the age of the layer. The nearest reference for dating this layer was found in an area close to Port Gawler. Two samples were taken for radio carbon dating. The first sample was collected at 0.02 m below the surface and was found to be 30 ± 100 years old, and another one was collected at 0.3 m and had been deposited at 1130 ± 80 years *BP*.

Carbon-14, C_{14}, age determinations on shells from the St. Kilda Formation, north of the Adelaide Region near Sandy Point, was range from 3800 ± 500 years *BP* for shells from the base of the unit, to 1120 ± 75 years BP for shells from standard beach ridges at the top of the unit. In addition, the top of Hindmarsh CLAY was deposited during the middle of the Pleistocene or approximately 900,000 years BP (Daily et al., 1976).

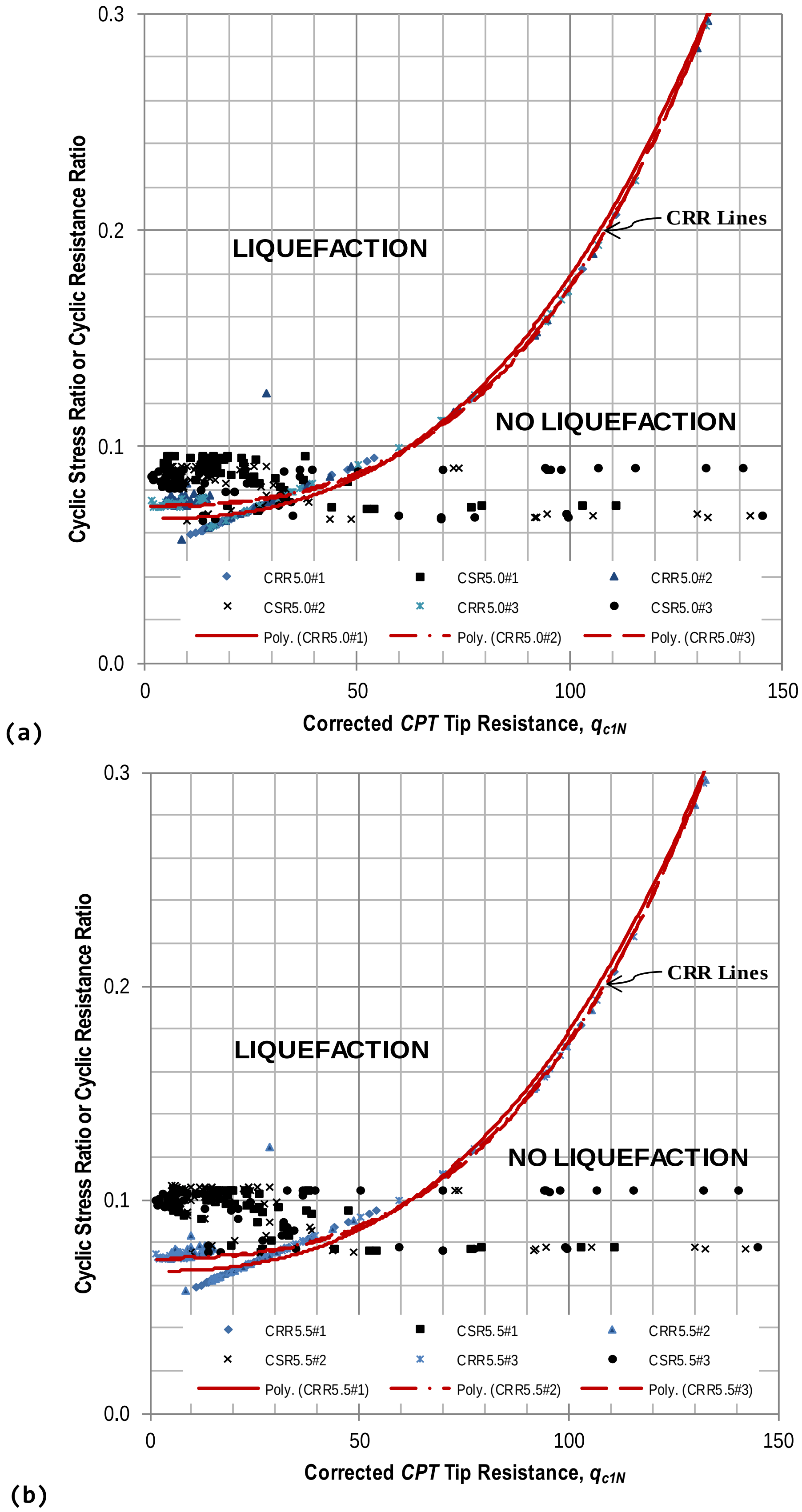
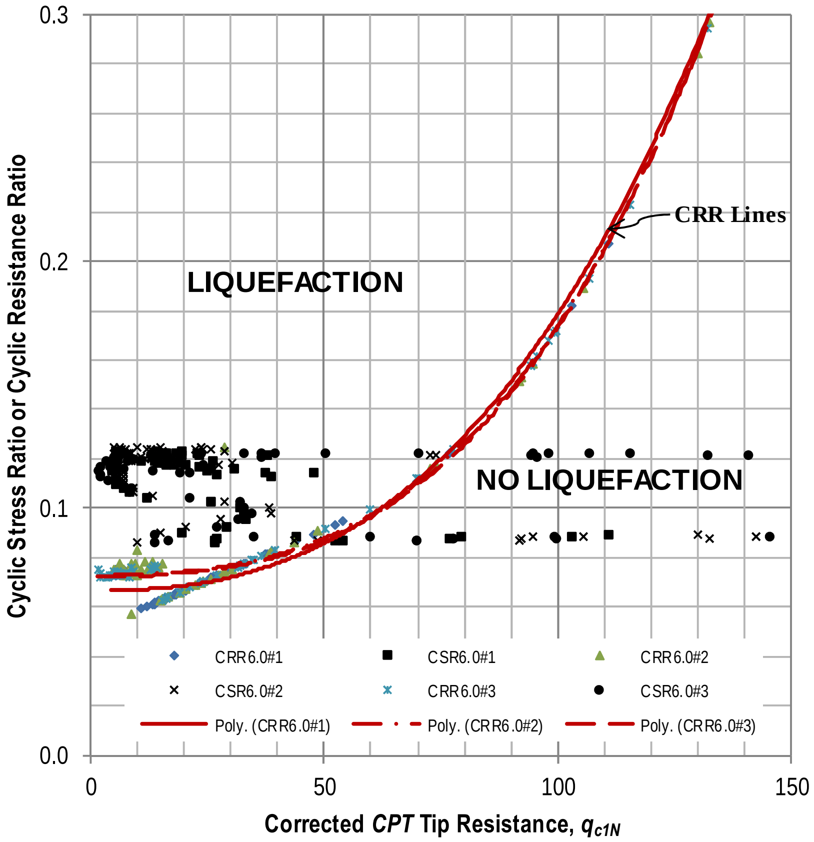
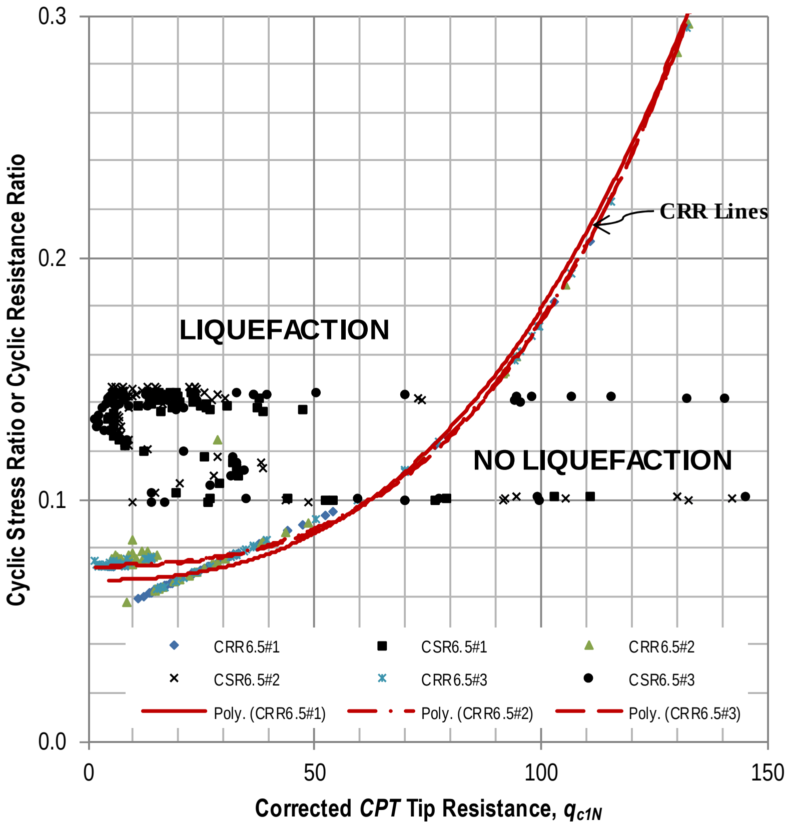


Figure 6.10 Liquefaction assessments at *CPT* #1, *CPT* #2 and *CPT* #3 for earthquake magnitude scale of (a) 5.0 and (b) 5.5

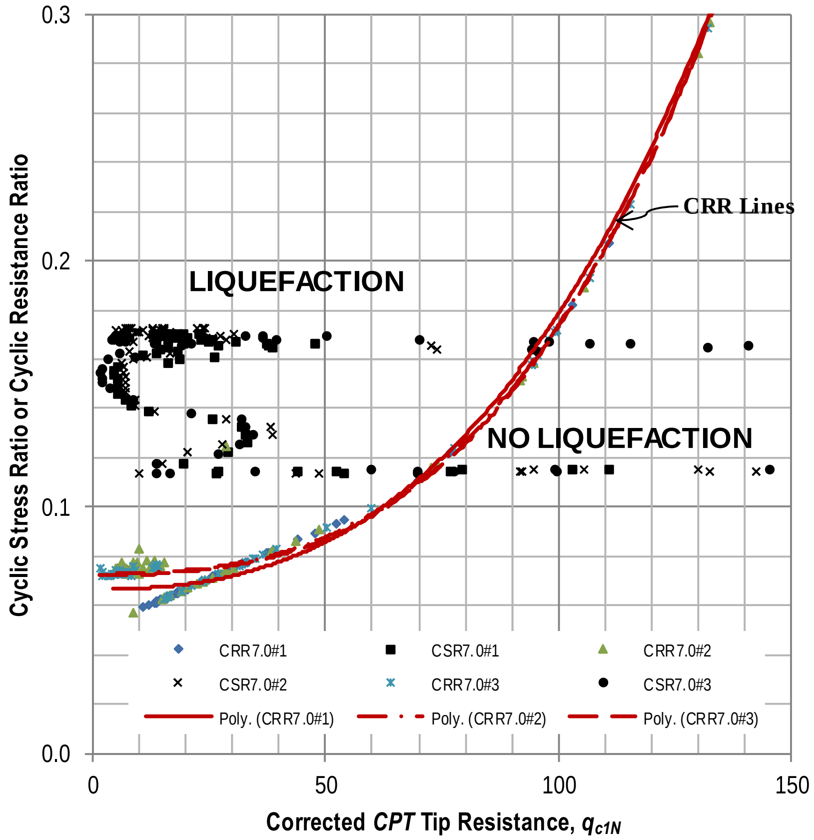


(a)

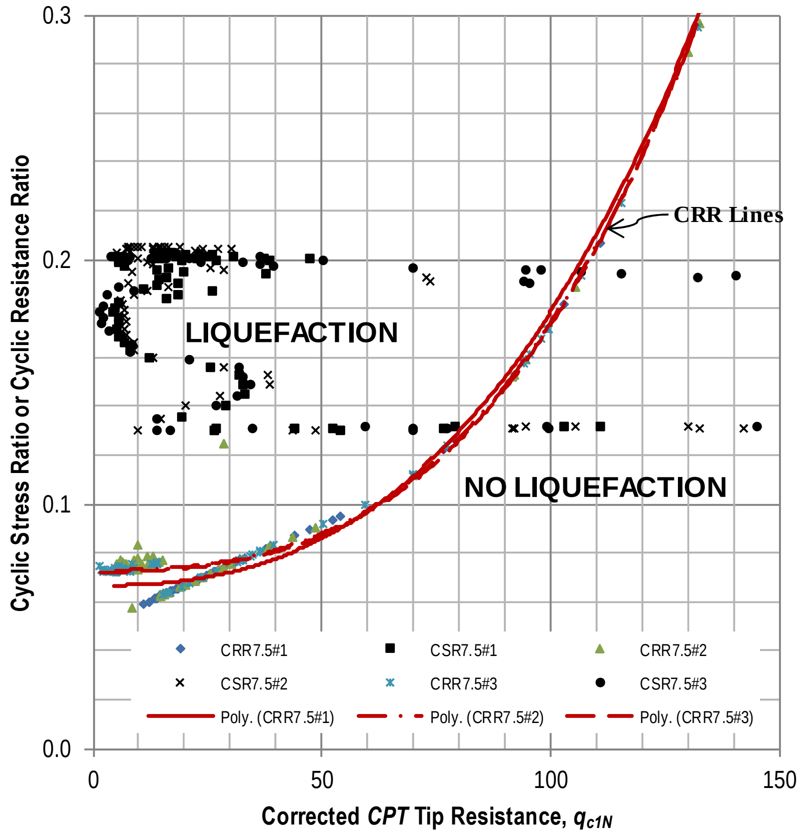


(b)

Figure 6.11 Liquefaction assessments at *CPT* #1, *CPT* #2 and *CPT* #3 for earthquake magnitude scale of (a) 6.0 and (b) 6.5



(a)



(b)

Figure 6.12 Liquefaction assessments at *CPT* #1, *CPT* #2 and *CPT* #3 for earthquake magnitude scale of (a) 7.0 and (b) 7.5

The influence of ageing on the *CRR* of soils has been observed by several researchers since 1977, as mentioned in Chapter 2. But a correction factor for ageing in terms of liquefaction assessment using a *CPT*-based method was not developed until 2008 by Hayati et al. (2008) who proposed:

$$K_{DR} = 0.13\log_{10}(t) + 0.83 \quad (6.2)$$

where K_{DR}= factor to correct the effect of ageing and t= time since initial soil deposition or last critical disturbance.

This correction factor was adopted in the present study, as shown in Table 6.6. Correction factors developed by Kulhawy and Mayne (1990) and Lewis et al. (2008) are also presented in this table. As shown, 30 years is the youngest estimated age of the sediments and when the soil age reaches 1120 years and beyond, the correction by Hayati et al. (2008) is consistent with the results from the models developed by Kulhawy and Mayne (1990) and Lewis et al. (2008).

In addition, the *CPT-CRR* values with and without consideration of ageing effects are plotted with corrected tip resistance as shown in Figure 6.13. The figure shows that the *CPT-CRR* values adjusted for ageing effects are higher than the values without adjustment. This indicates that accounting for soil ageing increases the *CRR* values. In some cases, this study has found that the ageing of the soils may increase the *CRR* value by as much as 1.8 times.

6.4.3 Liquefaction assessment of the St. Kilda Formation using the *CPT* method incorporating ageing

Results of the liquefaction assessment using the *CPT* method incorporating ageing are shown in Figures 6.14 to 6.16. The results indicate that there is no liquefaction at the study site at an earthquake magnitude is either 5.0 or 5.5. Liquefaction at the study site is only triggered by an earthquake of approximately magnitude 6.0 or beyond. An increase in the magnitude of the earthquake will result in further layers liquefying. Details of the layers that liquefy are shown in Tables 6.9 to 6.14 later in this chapter.

Table 6.6 Ageing correction factor for the *CPT-CRR* in the present study (i.e. Hayati et al., 2008) compared with approximations by Kulhawy & Mayne (1990) and Lewis et al. (2008)

DEPTH (mm)	t (years)	Kulhawy & Mayne (1990)	Hayati et al. (2008)	Lewis et al. (2008)	Remarks of age
200	30	1.2	1.1	1.8	
400	30	1.2	1.1	1.8	30 ±100 years B.P. (Burton, 1984)
600	30	1.2	1.1	1.8	
800	1120	1.3	1.3	2.2	1130 ±80 years B.P. (Burton, 1984)
1000	1187	1.3	1.4	2.2	1120 ±75 years B.P. (Daily et al., 1976)
1200	1254	1.3	1.4	2.2	Upper part of the St. Kilda Formation
1400	1321	1.3	1.4	2.2	
1600	1388	1.3	1.4	2.2	
1800	1455	1.3	1.4	2.2	
2000	1522	1.3	1.4	2.2	
2200	1589	1.3	1.4	2.2	
2400	1656	1.3	1.4	2.2	
2600	1723	1.3	1.4	2.2	
2800	1790	1.3	1.4	2.2	
3000	1857	1.3	1.4	2.2	
3200	1924	1.3	1.4	2.2	
3400	1991	1.3	1.4	2.2	
3600	2058	1.3	1.4	2.2	
3800	2125	1.3	1.4	2.2	
4000	2192	1.3	1.4	2.2	
4200	2259	1.3	1.4	2.2	
4400	2326	1.3	1.4	2.2	
4600	2393	1.3	1.4	2.2	
4800	2460	1.3	1.4	2.2	
5000	2527	1.3	1.4	2.2	
5200	2594	1.3	1.4	2.2	
5400	2661	1.3	1.4	2.2	
5600	2728	1.3	1.4	2.3	
5800	2795	1.3	1.4	2.3	
6000	2862	1.3	1.4	2.3	
6200	2929	1.3	1.4	2.3	
6400	2996	1.3	1.4	2.3	
6600	3063	1.3	1.4	2.3	
6800	3130	1.3	1.4	2.3	
7000	3197	1.3	1.4	2.3	
7200	3264	1.3	1.4	2.3	
7400	3331	1.3	1.4	2.3	
7600	3398	1.3	1.4	2.3	
7800	3465	1.3	1.4	2.3	
8000	3532	1.3	1.4	2.3	
8200	3599	1.3	1.4	2.3	
8400	3666	1.3	1.4	2.3	
8600	3733	1.3	1.4	2.3	Base of the St. Kilda Formation
8800	3800	1.3	1.4	2.3	3800 ±500 years B.P. (Daily et al., 1976)
9000	900000	1.4	1.8	2.8	900,000 years B.P. (Daily et al., 1976)
9200	900100	1.4	1.8	2.8	After the Hindmarsh CLAY
9400	900200	1.4	1.8	2.8	
9600	900300	1.4	1.8	2.8	
9800	900400	1.4	1.8	2.8	
10000	900500	1.4	1.8	2.8	
10200	900600	1.4	1.8	2.8	
10400	900700	1.4	1.8	2.8	
10600	900800	1.4	1.8	2.8	
10800	900900	1.4	1.8	2.8	
11000	901000	1.4	1.8	2.8	
11200	901100	1.4	1.8	2.8	
11400	901200	1.4	1.8	2.8	
11600	901300	1.4	1.8	2.8	
11800	901400	1.4	1.8	2.8	
12000	901500	1.4	1.8	2.8	
12200	901600	1.4	1.8	2.8	
12400	901700	1.4	1.8	2.8	
12600	901800	1.4	1.8	2.8	
12800	901900	1.4	1.8	2.8	
13000	902000	1.4	1.8	2.8	
13200	902100	1.4	1.8	2.8	
13400	902200	1.4	1.8	2.8	
13600	902300	1.4	1.8	2.8	
13800	902400	1.4	1.8	2.8	
14000	902500	1.4	1.8	2.8	

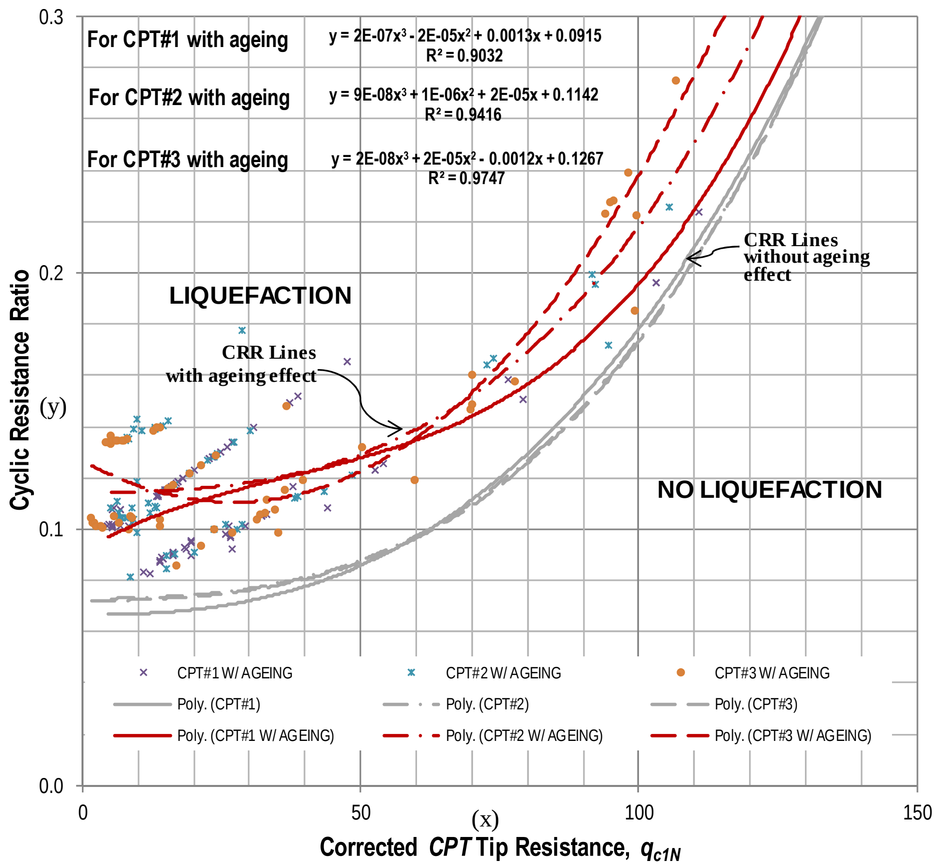


Figure 6.13 *CPT* cyclic resistance ratios with and without ageing effect versus normalised cone penetration resistance

6.4.4 The flat dilatometer test (*DMT*) method for estimating *CRR*

As stated in Chapter 2, two approximations were used to obtain the *DMT-CRR* of the soils at the study site. Correlations by Marchetti (1982) and by Monaco et al. (2005) were used to develop the approximations. Marchetti (1982) provided the initial correlation for obtaining the *DMT-CRR*. On the other hand, the *DMT-CRR* correlation proposed by Monaco et al. (2005) was developed from the same concept as the *SPT* and *CPT* methods, which have been used extensively for liquefaction assessment around the world.

6.4.4.1 Estimating the *CRR* using the *DMT*

Both approximations (Marchetti, 1982 and Monaco et al., 2005) had been developed from the same *DMT* parameter, i.e., the dilatometer horizontal stress index, K_D. A flowchart for estimating the *CRR* from the *DMT* is shown in Figure 6.17. The pre-insertion pore water pressure, U_0, is assumed to be the static pore water pressure at the study site. Determination of the remaining parameters was described previously in Chapter 2.

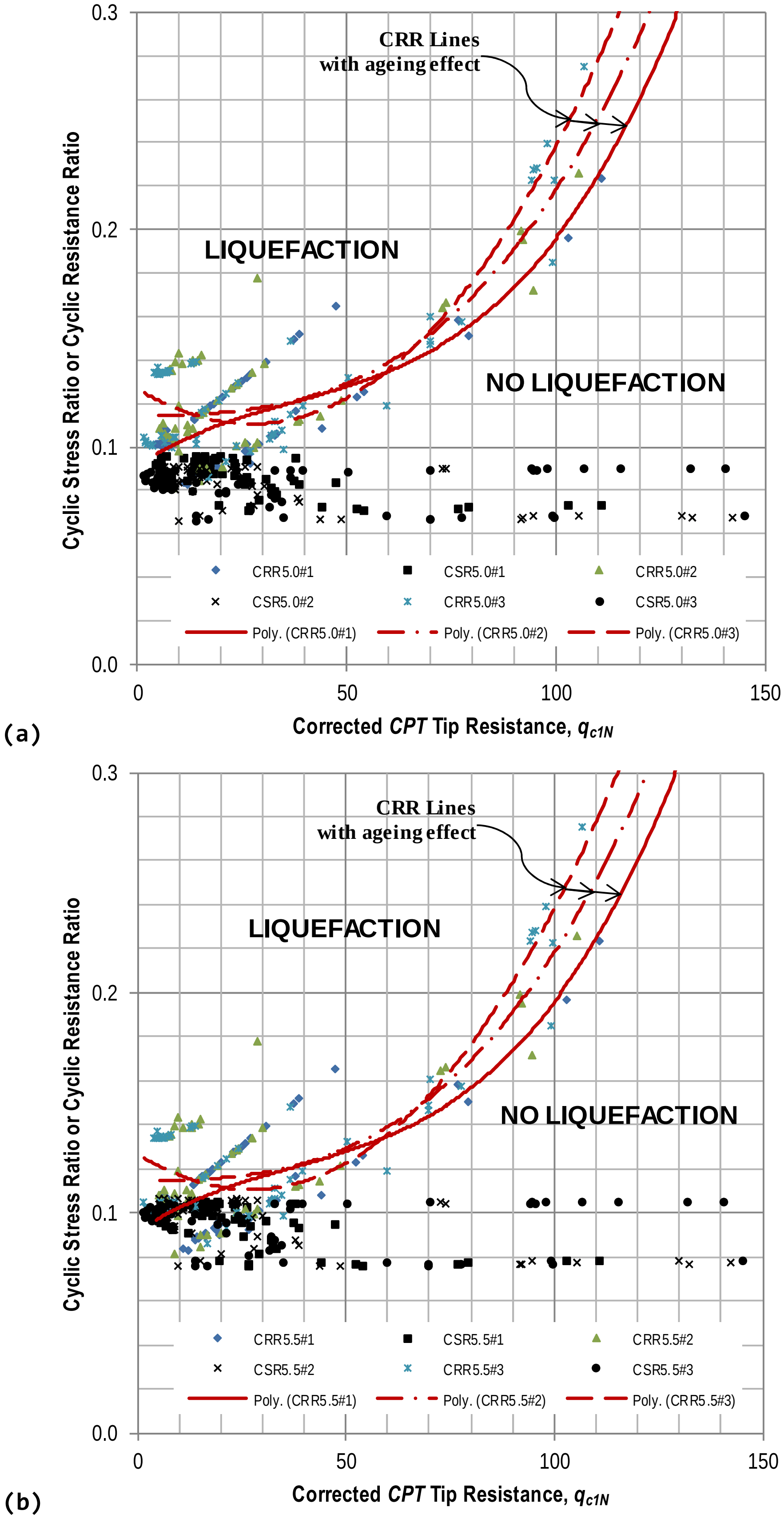


Figure 6.14 Liquefaction assessments including ageing at *CPT* #1, *CPT* #2 and *CPT* #3 with an earthquake magnitude scale of (a) 5.0 and (b) 5.5

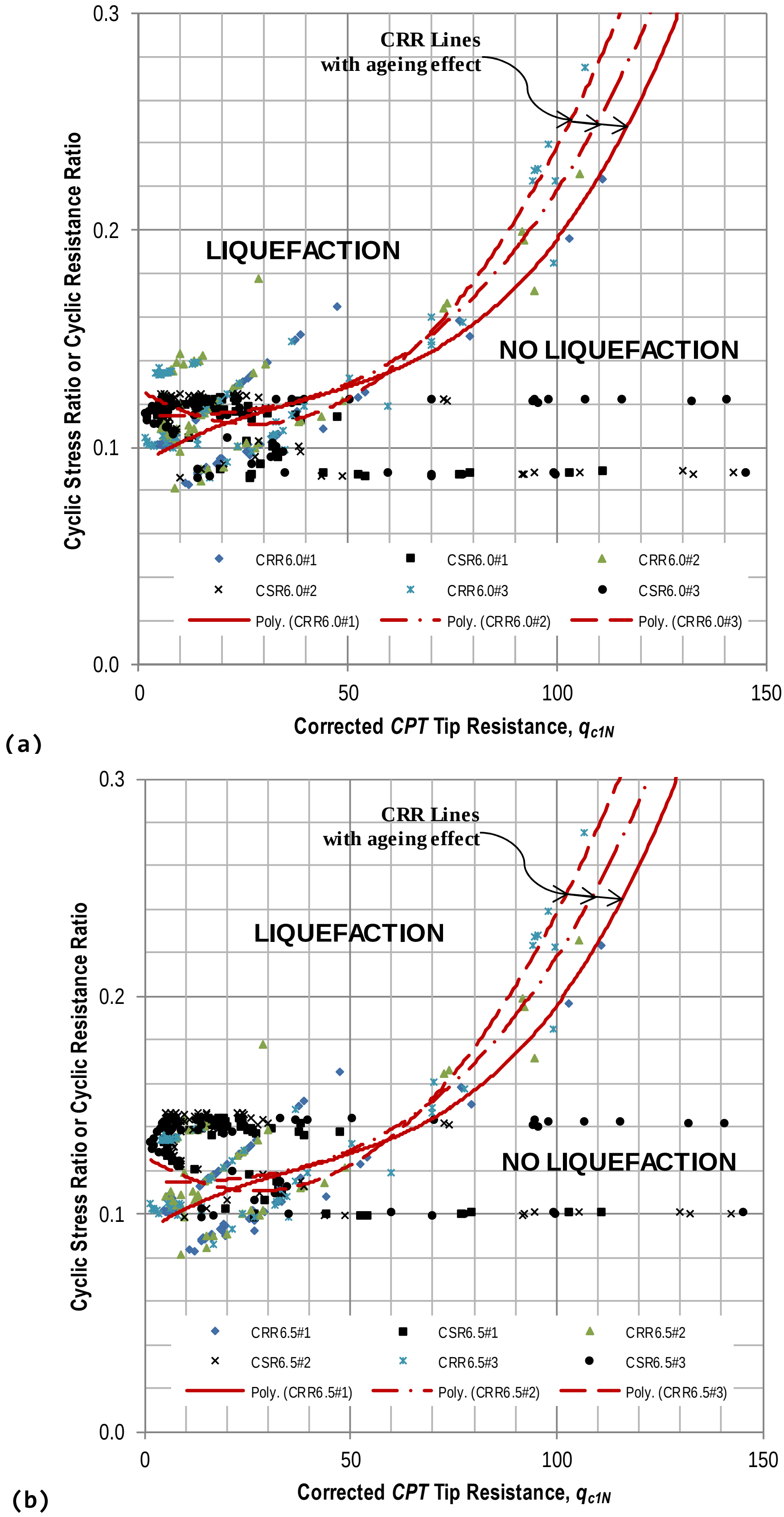
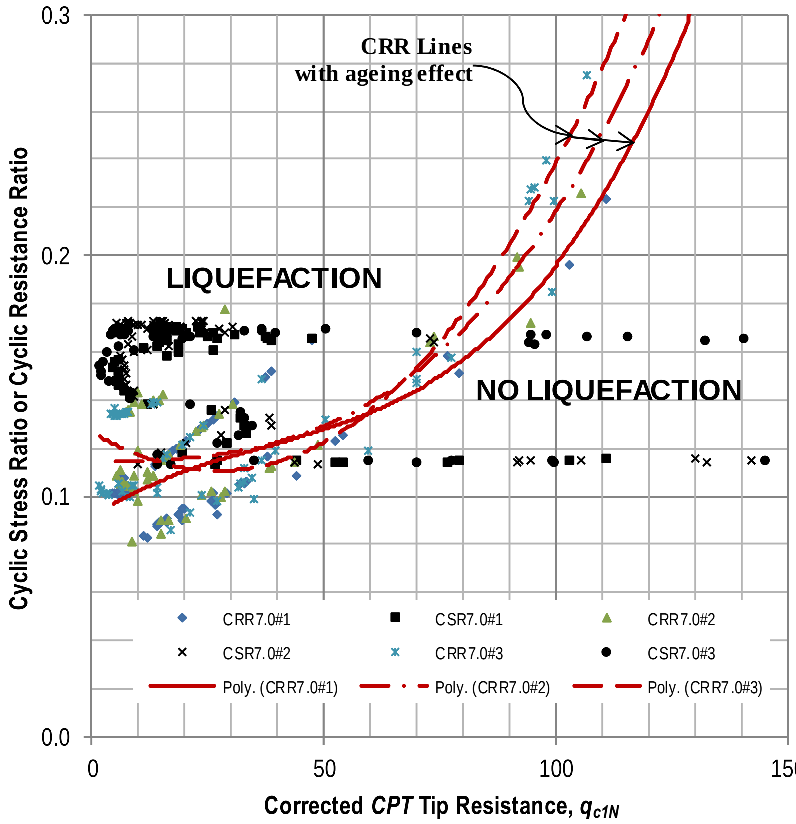
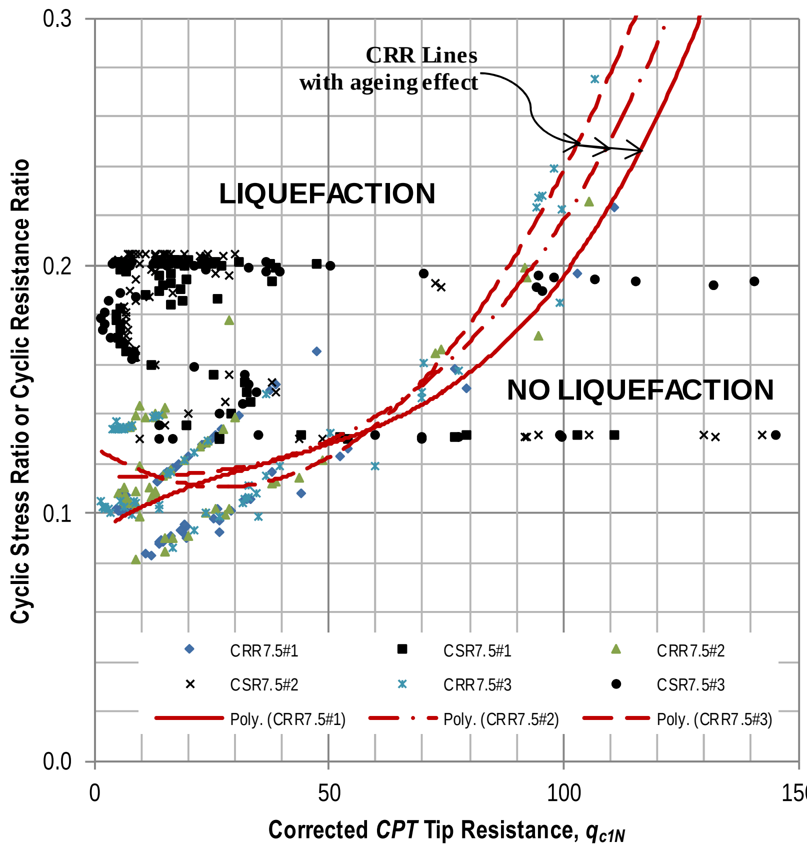


Figure 6.15 Liquefaction assessments including ageing at *CPT* #1, *CPT* #2 and *CPT* #3 with an earthquake magnitude scale of (a) 6.0 and (b) 6.5



(a)



(b)

Figure 6.16 Liquefaction assessments including ageing at *CPT* #1, *CPT* #2 and *CPT* #3 with an earthquake magnitude scale of (a) 7.0 and (b) 7.5

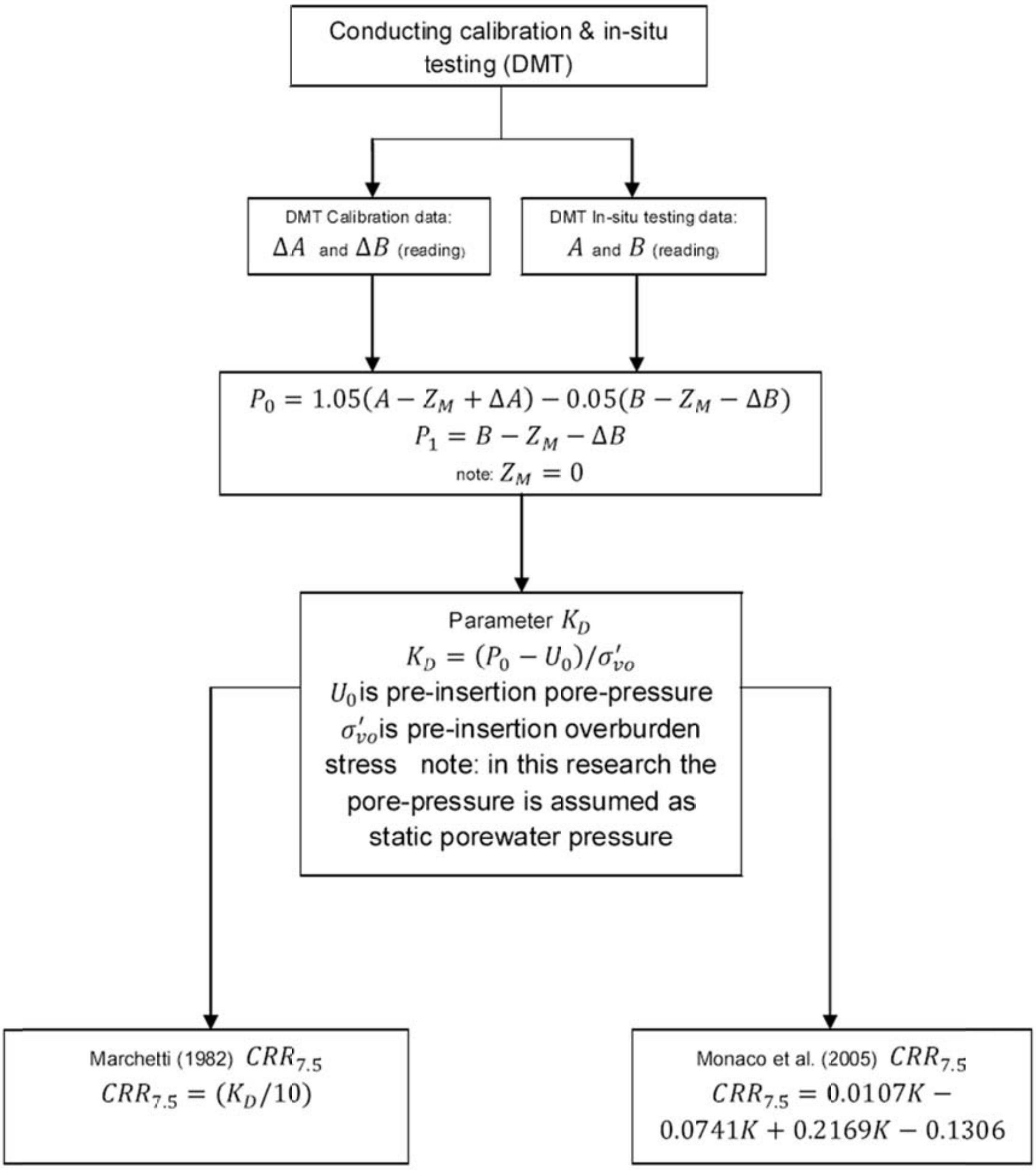


Figure 6.17 Outline for estimating cyclic resistance ratio using *DMT* data, *DMT-CRR*

By using the procedure outlined in Figure 6.18, the *DMT* liquefaction resistance boundaries of both correlations were estimated. The results were plotted onto a chart to graphically record the *DMT-CRR* and its K_D values, as shown in Figure 6.19. The results demonstrate that the approximation by Monaco et al. (2005) is more conservative than the approximation proposed by Marchetti (1982). In some particular cases, where the K_D values lie between 3.0 and 4.2, the difference can be as large as a factor of 1.5.

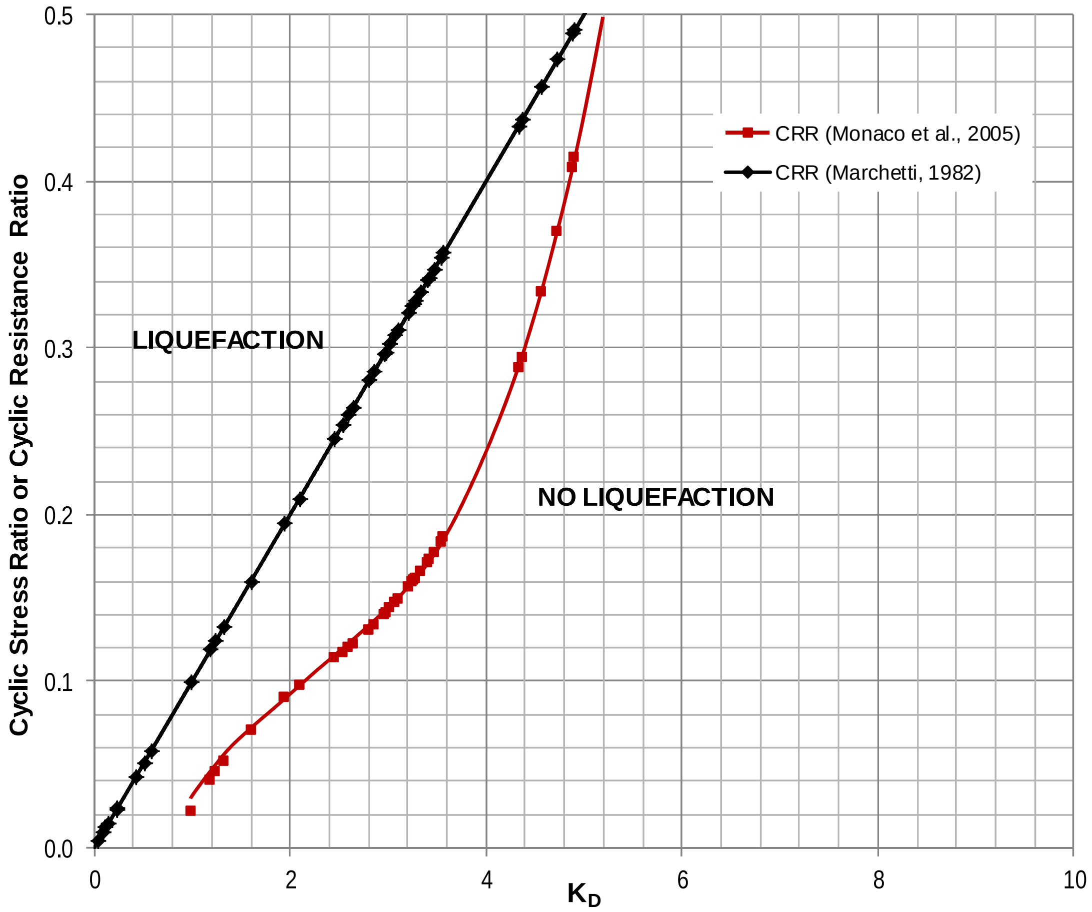


Figure 6.18 Plotting of cyclic resistance ratios versus horizontal stress index of *DMT* parameter

6.4.4.2 Liquefaction assessment of the St. Kilda Formation using the *DMT* method

The *DMT* liquefaction assessments for *CSR* caused by an earthquake of magnitude 5.0 to 7.5, using the Marchetti (1982) and Monaco et al. (2005) correlations, are shown in Figures 6.19 and 6.20, respectively. Both predictions show a similar trend, i.e., the increasing magnitude of an earthquake will cause a larger number of liquefiable soils at a constant horizontal stress index. In addition, as expected, these figures show that the Marchetti (1982) approach over-predicts the liquefaction potential, as suggested by Monaco et al. (2005). Detailed results of the *DMT* liquefaction assessment using both correlations are included in Appendix K. Tables 6.9 to 6.14, later in this chapter, present the final results of the *DMT* liquefaction assessment.

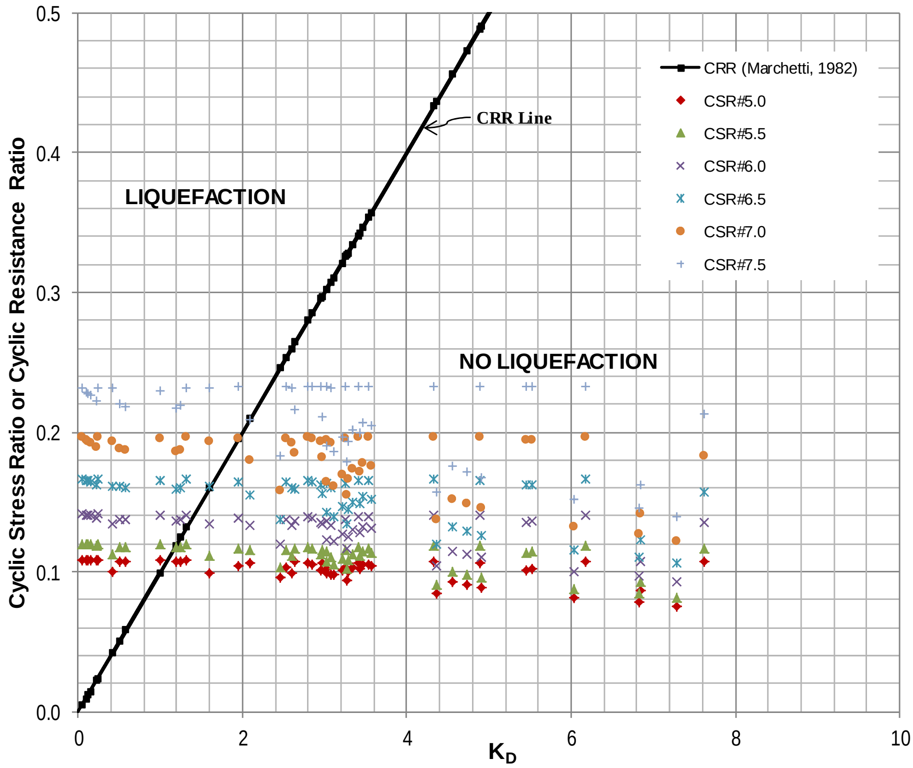


Figure 6.19 Liquefaction assessments of *DMT*-method using the Marchetti (1982) approximation for 5.0, 5.5, 6.0, 6.5, 7.0 and 7.5 earthquake magnitude scales

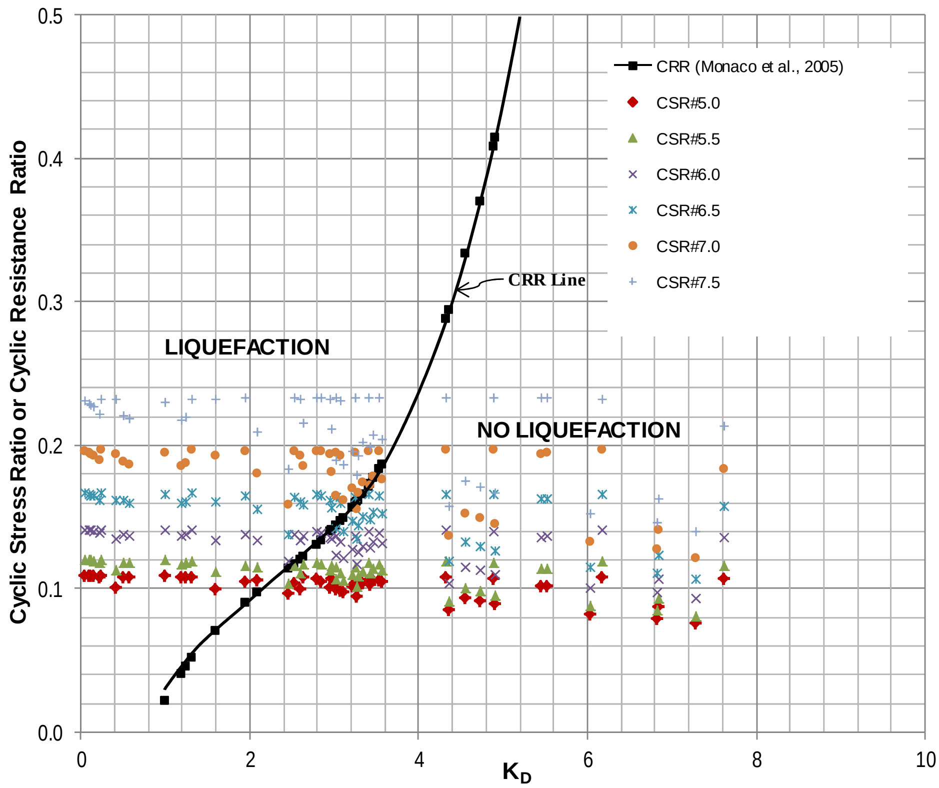


Figure 6.20 Liquefaction assessments of *DMT*-method using the Monaco et al. (2005) approximation for 5.0, 5.5, 6.0, 6.5, 7.0 and 7.5 earthquake magnitude scales

6.5 RE-EXAMINATION AND COMPARISON BETWEEN THE*CPT*-METHOD INCORPORATING AGEING AND THE DMT-METHOD FOR LIQUEFACTION ASSESSMENT

6.5.1 Soil types evaluation

Re-examination of the liquefaction evaluation based on the types of soils is necessary since certain soil types are not susceptible to liquefaction. Seed et al. (2003) proposed a chart for this type of evaluation. The chart by Seed et al. (2003) separates soils into three different zones: A, B and C, as mentioned previously in Chapter 2. Zone A is for soils that have the potential to liquefy provided the natural water content of the soil is more than 0.8 of its liquid limit. Zone B identifies a zone in which further assessment is warranted if the natural water content of the soil is greater than 0.5 of its liquid limit. Zone C identifies a zone of soils where it is likely that no liquefaction will occur during cyclic loading. A plot of the laboratory results superimposed on the Seed et al. (2003) chart is shown in Figure 6.21. The results of the soil type evaluation incorporating fines content (*FC*) and moisture content (*MC*) are shown in Tables 6.7 and 6.8.

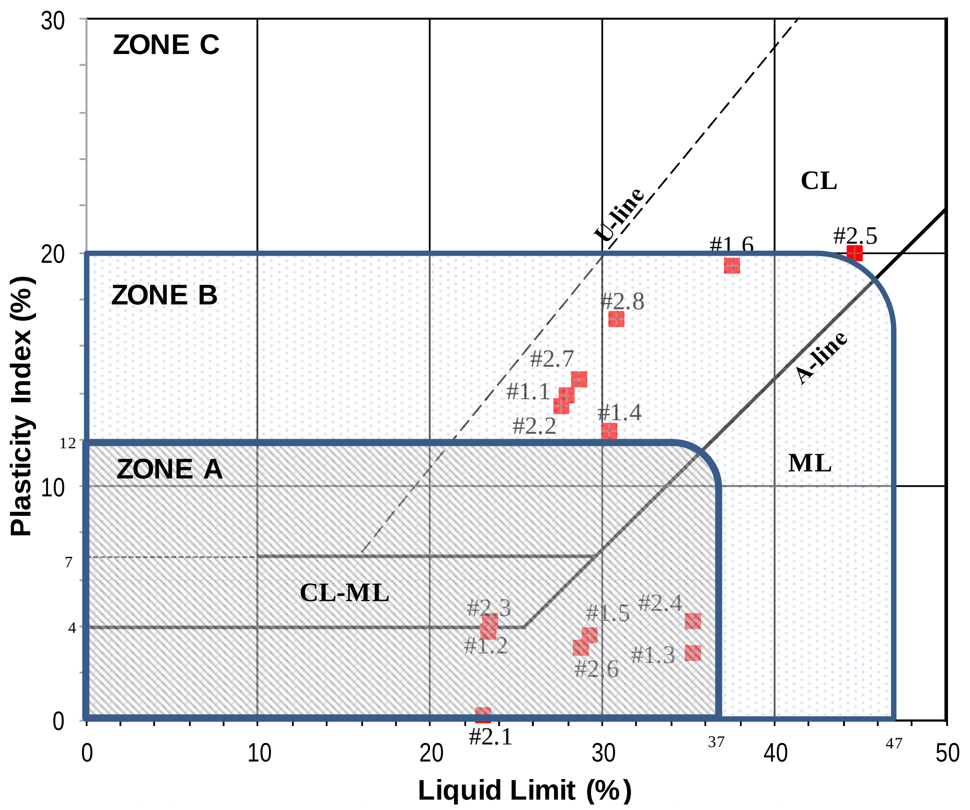


Figure 6.21 Laboratory test results superimposed on the Seed et al. (2003) chart to estimate the liquefaction characteristics of the soils

Table 6.7 Results of the fines content evaluation for samples at *BH* #1

Sample code	Depth (m)	Seed et al. (2003) zone	Lab. results			Remarks
			MC (%)	*LL* (%)	*FC* (%)	
#1.1	0.00 – 1.35	Zone B	7.9	28.0	50.0	No need for further testing
#1.2	1.35 – 2.70	Zone A	39.2	23.4	28.5	Potential to liquefy
#1.3	2.70 – 4.70	Zone A	50.4	35.2	24.4	Potential to liquefy
#1.4	4.70 – 6.00	Zone B	51.9	30.4	53.6	Need further testing
#1.5	6.00 – 9.00	Zone A	33.1	29.3	17.8	Potential to liquefy
#1.6	9.00 – 10.50	Zone B	22.6	37.5	18.0	No need for further testing

NOTE:
- *MC* (Moisture Content)
- *LL* (Liquid Limit)
- *FC* (Fines Content), i.e. <0.075mm

Table 6.8 Results of the fines content evaluation for samples at *BH* #2

Sample code	Depth (m)	Seed et al. (2003) zone	Lab. results			Remarks
			MC (%)	*LL* (%)	*FC* (%)	
#2.1	0.00 – 0.70	Zone A	8.6	23.0	17.0	No need for further testing
#2.2	0.70 – 1.20	Zone B	10.2	27.6	70.1	No need for further testing
#2.3	1.20 – 2.20	Zone A	36.0	23.5	26.9	Potential to liquefy
#2.4	2.20 – 4.30	Zone A	67.3	35.2	22.1	Potential to liquefy
#2.5	4.30 – 6.30	Zone C	69.4	44.7	50.3	Non liquefiable layer
#2.6	6.30 – 8.50	Zone A	26.6	28.8	18.9	Potential to liquefy
#2.7	8.50 – 9.10	Zone B	24.5	28.7	73.7	Need further testing
#2.8	9.10 – 12.45	Zone B	15.2	30.8	68.4	No need for further testing

NOTE:
- *MC* (Moisture Content)
- *LL* (Liquid Limit)
- *FC* (Fines Content), i.e. <0.075mm

6.5.2 State parameter evaluation

The critical state approach was previously discussed in detail in Chapter 4. The results of the critical state approach are used to inform the following evaluation. The dilative behaviour of the tested soil implies that it is unlikely to liquefy during the seismic loading, whereas contractive behaviour suggests the soil is susceptible to liquefaction (Fernandez & Crumley, 2003). The results of the state parameter evaluation are combined with the *CPT* assessment incorporating ageing and the *DMT* methods for liquefaction assessment as shown in the next section.

6.5.3 Comparison of the results after the re-examination

The predicted liquefaction assessment from the proposed *CPT* method incorporating ageing and the *DMT*-based method are compared in Tables 6.9 to 6.14. Furthermore, a soil type evaluation and an in-situ state parameter assessment are included in the tables to assist with the examination of the assessments. General summaries of the results are as follows:

1. The soil type evaluation shows that there are two potential layers which may liquefy during an earthquake event at the study site. These two layers occur at depths of approximately 1.4 to 4.4 m and 6.4 to 9.0 m.

2. Assessment of the soil behaviour based on the critical state approach derived from the *CPT* data indicated four contractive layers distributed at depths from 2.0 to 8.4m. On the other hand, the critical state approach derived from *DMT* data also highlighted four contractive layers. However, they varied in terms of the thickness and depths below ground.

3. The liquefaction assessment using the *CPT* method accounting for ageing shows that increased earthquake magnitude causes an increase in both *CSR* and the number of liquefiable layers. Of interest, with respect to this method, is that the chances of liquefaction are insignificant for the soils at the study site when the earthquake magnitude is 5.5 or below. However, when the earthquake magnitude is increased to 6.0, liquefaction will be a major problem at the study site.

4. The *DMT* liquefaction assessment using the Marchetti (1982) correlation predicted liquefaction for soils located at depths from 6.8 to 9.2 m experiencing earthquake magnitudes between 5.0 and 7.5. Assessment by this method suggests that the magnitude of the earthquake has minimal impact on the behaviour of the soil. At first, this seems a little surprising, since this layer has the lowest fines content of approximately 18%.

5. Liquefaction assessment using the *DMT* correlation, which was formulated based on a relative density as suggested by Monaco et al. (2005), appears to be different from that derived from the original correlation by Marchetti (1982). The *DMT* liquefaction resistance predicted using the approach suggested by Monaco et al. (2005) is very much under-predicted by the Marchetti (1982) approach. In addition,

the Monaco et al. (2005) correlation seems to be sensitive to the magnitude of the earthquake. An increasing earthquake magnitude causes an increase in both *CSR* and the number of liquefiable layers.

It can therefore be concluded that:

1. The liquefaction prediction derived from the *CPT* method accounting for ageing, suggests that the soil from a depth of 9.0 m to the base of the borehole is liquefiable. This appears to be an unreasonable conclusion as the soils are CLAY with a fines content of more than 90%. This indicates that the proposed soil behaviour type index, *Ic,* in the *CPT* liquefaction assessment procedure is unable to account appropriately for the fines content.

2. The overall liquefaction assessment demonstrates good agreement between the *DMT* liquefaction assessment using the Marchetti (1982) correlation, soil type screening and the liquefaction assessment derived from the critical state approach. It seems that the liquefaction assessment using the Marchetti (1982) *DMT* method provides reliable predictions.

6.6 GROUND SETTLEMENT ESTIMATION INDUCED BY LIQUEFACTION

Liquefaction-induced ground settlement of coarse-grained soil depends on the relative density of the soil, the maximum shear strain induced by the earthquake magnitude and the duration of the earthquake (Seed et al., 2003). Hence, it is desirable, subsequent to the liquefaction assessment, to evaluate the ground displacements. Since the study site is relatively flat, and assuming that the lateral displacement will be negligible, therefore, this section examines the vertical settlement at the ground surface as a result of liquefaction using the *CPT*-based approach.

The *CPT*-based method, proposed by Zhang et al. (2002), was used solely to predict the vertical, liquefaction-induced, ground settlements at the site, as there is no such prediction method available for the *DMT*. In addition, Zhang et al. (2002) demonstrated good agreement between the predicted and the measured settlements using two case study sites in California (Marina District and Treasure Island).

Table 6.9 Comparison of liquefaction assessment results for earthquake magnitude of 5.0

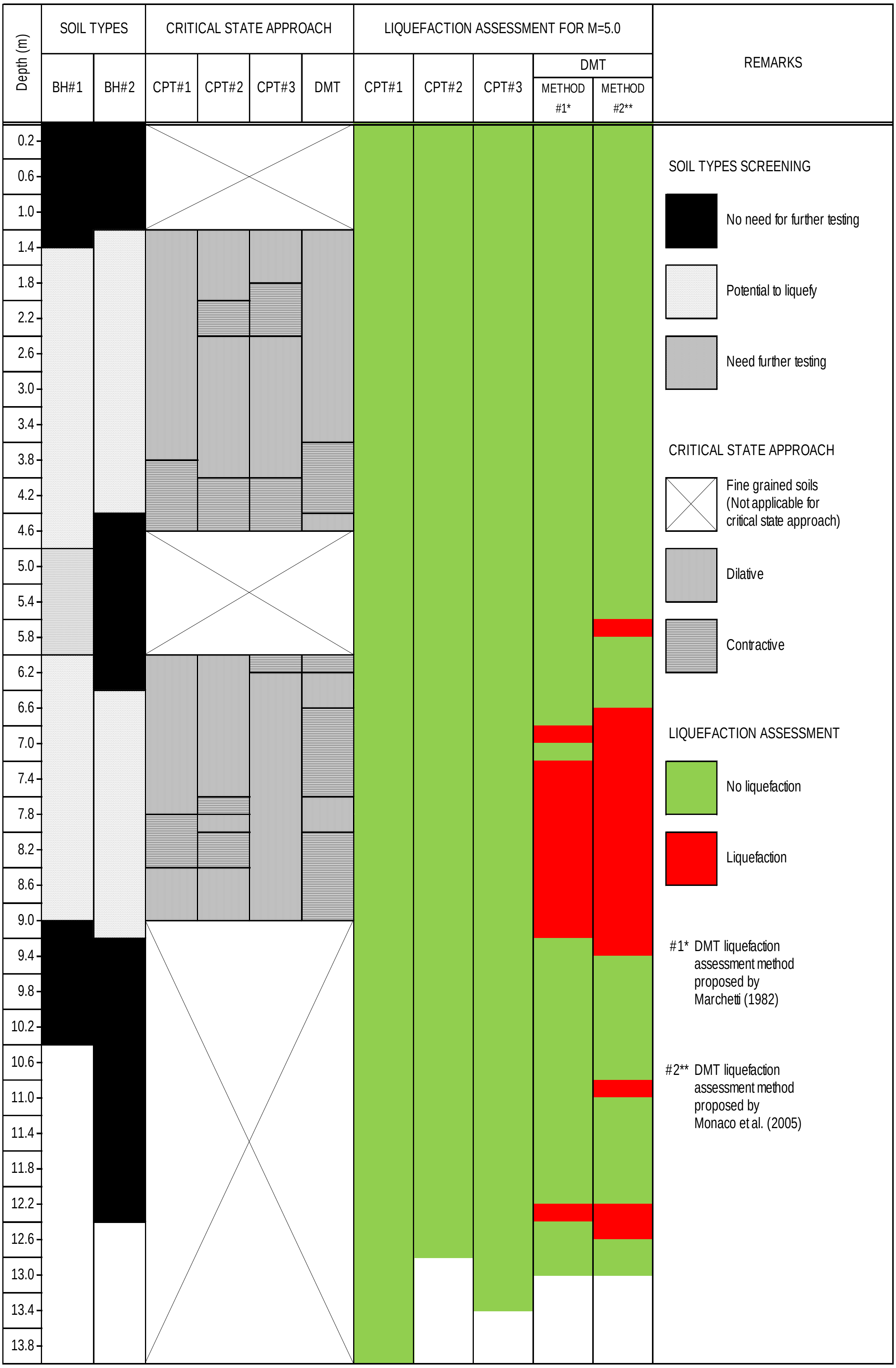


Table 6.10 Comparison of liquefaction assessment results for earthquake magnitude of 5.5

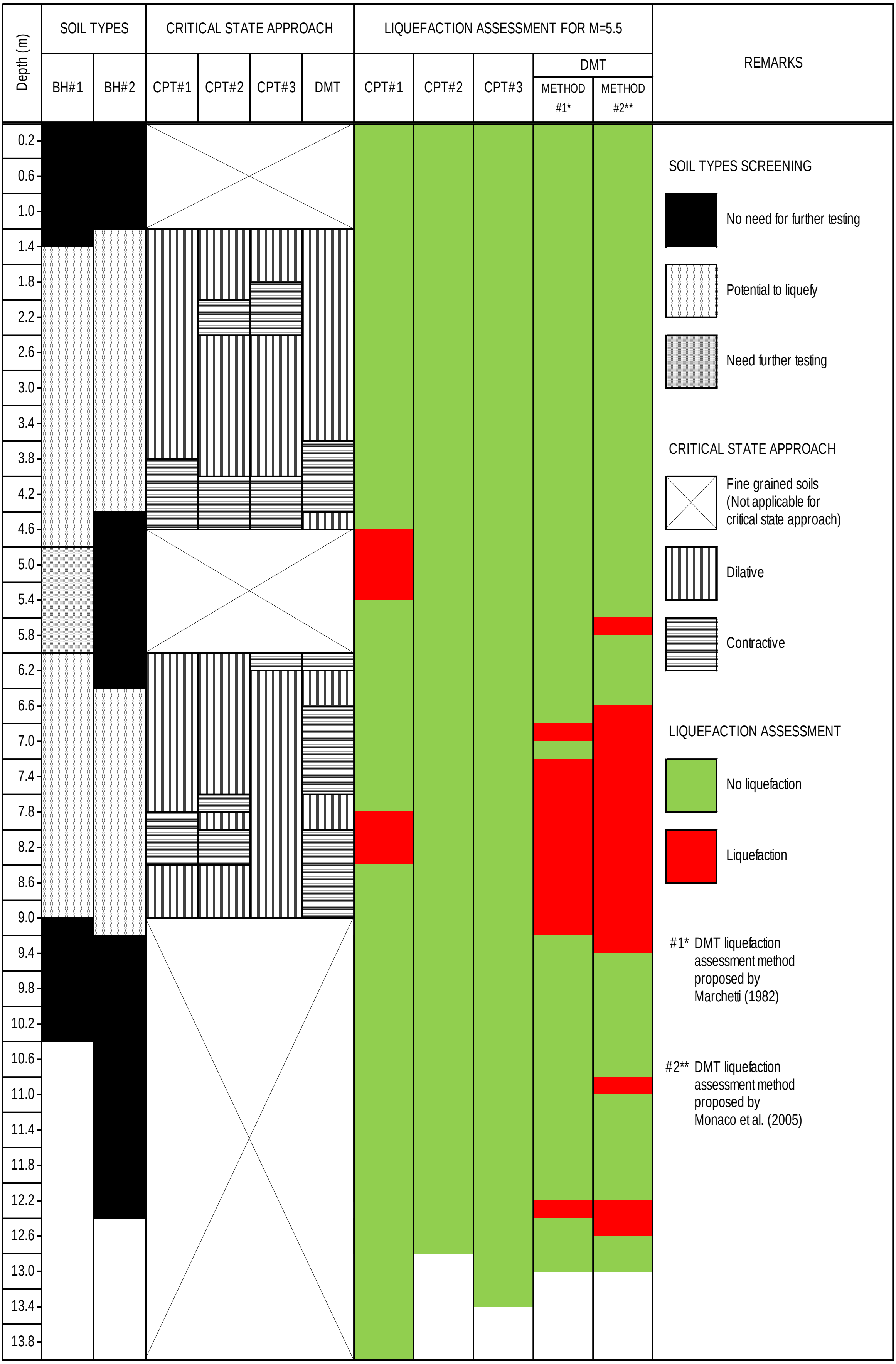


Table 6.11 Comparison of liquefaction assessment results for earthquake magnitude of 6.0

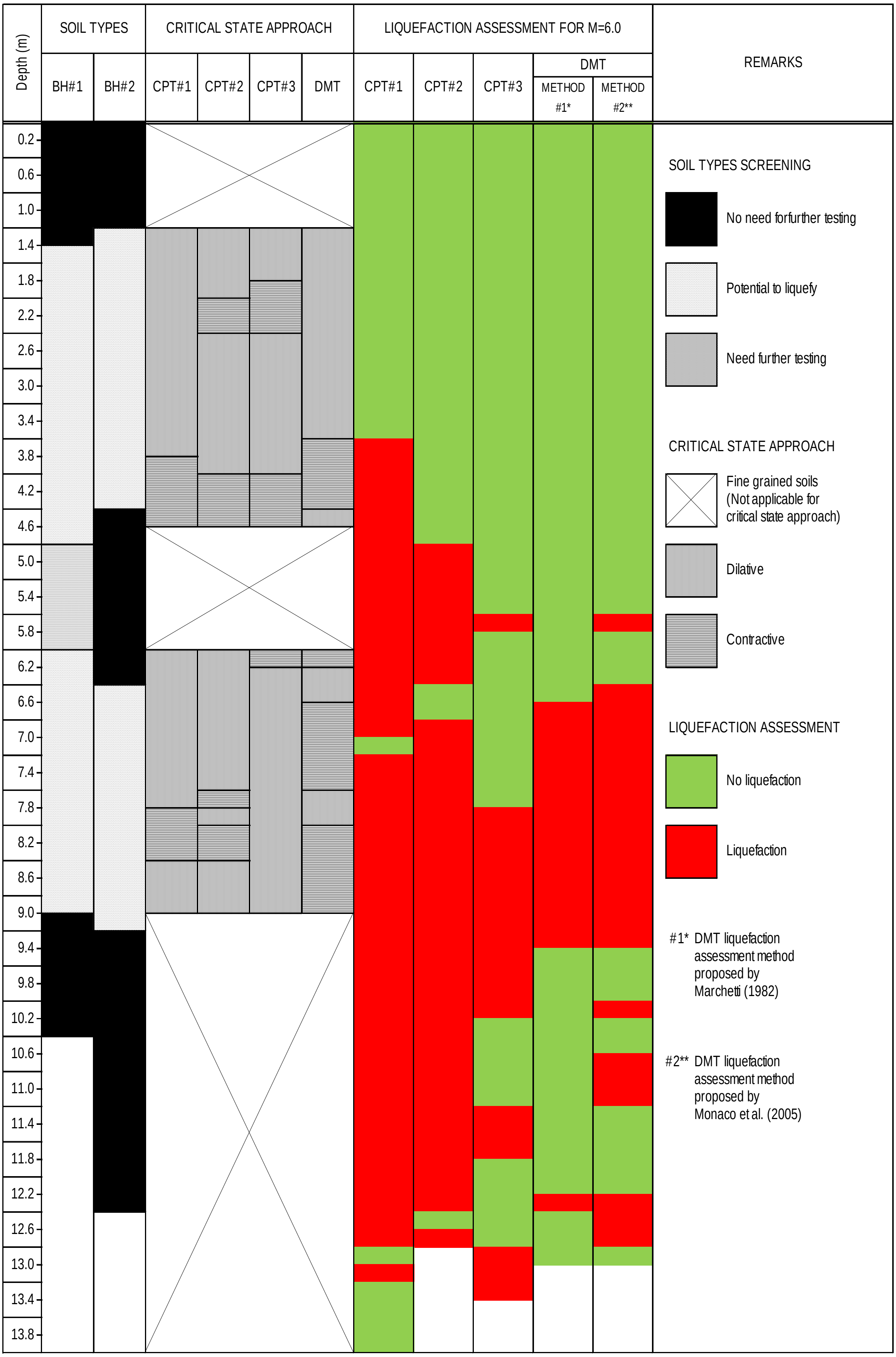


Table 6.12 Comparison of liquefaction assessment results for earthquake magnitude of 6.5

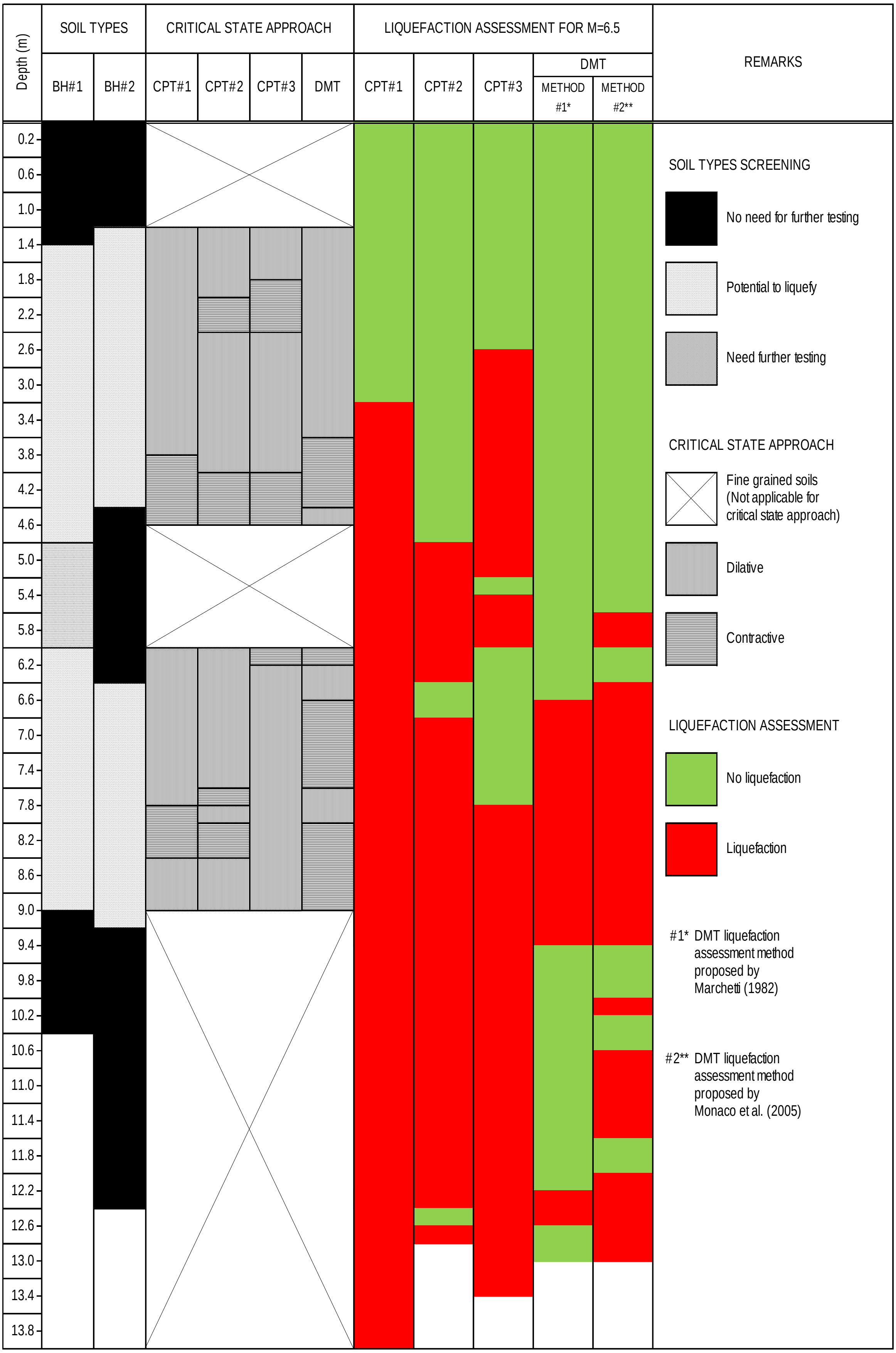


Table 6.13 Comparison of liquefaction assessment results for earthquake magnitude of 7.0

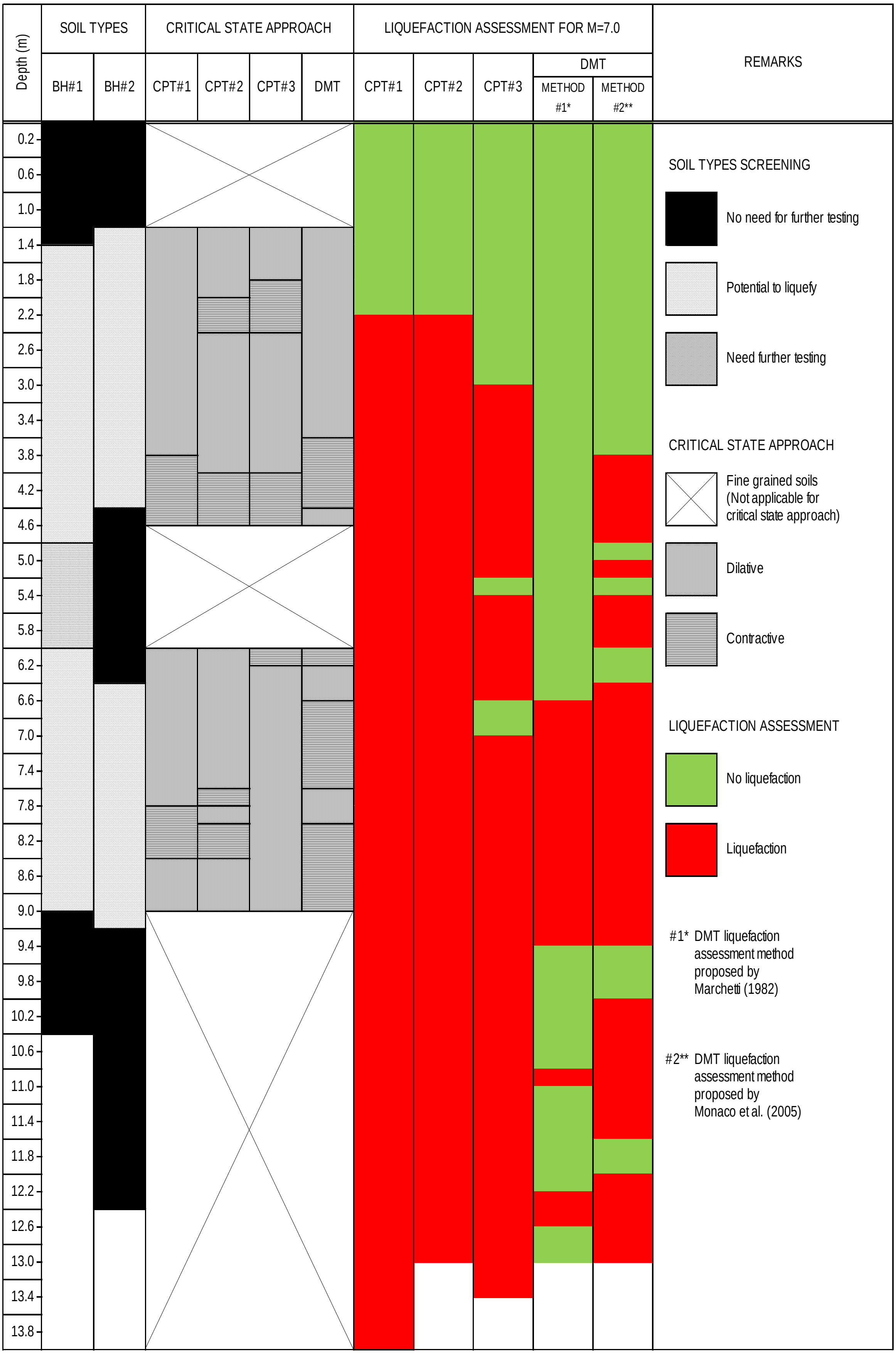
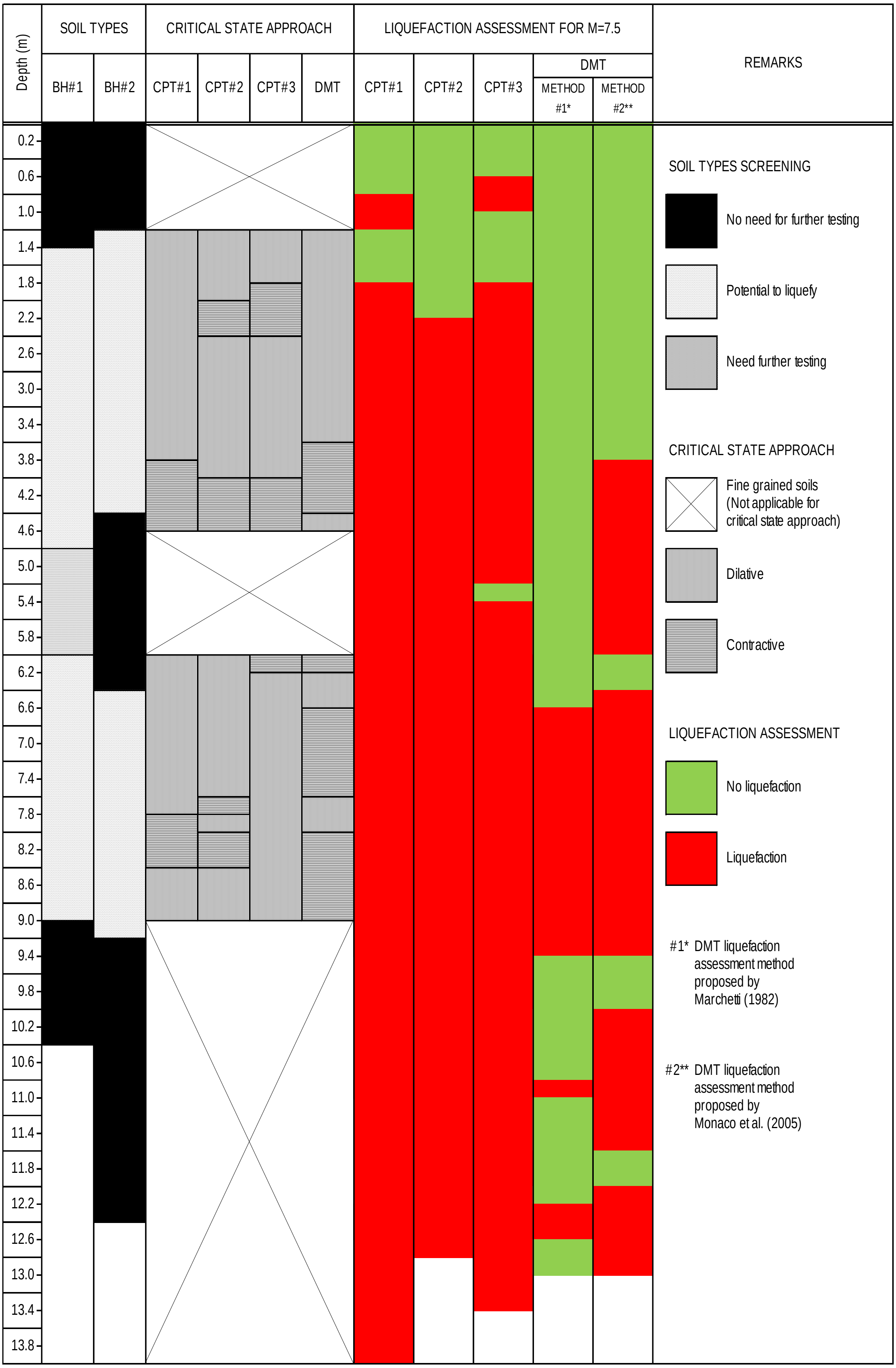


Table 6.14 Comparison of liquefaction assessment results for earthquake magnitude of 7.5



Calculating ground settlement

The suggested method requires the determination of the volumetric strain of each layer and its thickness. The settlement for each layer is the volumetric strain multiplied by the thickness of the layer and it is integrated over the entire soil profile as shown in Equation 6.3:

$$S = \sum_{i=1}^{j} \varepsilon_{vi} \Delta z_i \quad \text{..(6.3)}$$

where S is the calculated liquefaction-induced ground settlement; ε_{vi} is the post-liquefaction volumetric strain for the soil sub-layer i; Δz_i is the thickness of the sub-layer i; and j is the number of soil sub-layers.

The values of the post-liquefaction volumetric strain were obtained from a chart as shown in Figure 6.22. The chart was modified from curves by Ishihara and Yoshimine (1992) by accounting for the soil's fines content (Zhang et al., 2003). The factor of safety is the ratio of the cyclic resistance ratio (*CRR*) against the cyclic stress ratio (*CSR*) at the respective level, as mentioned previously in Chapter 2.

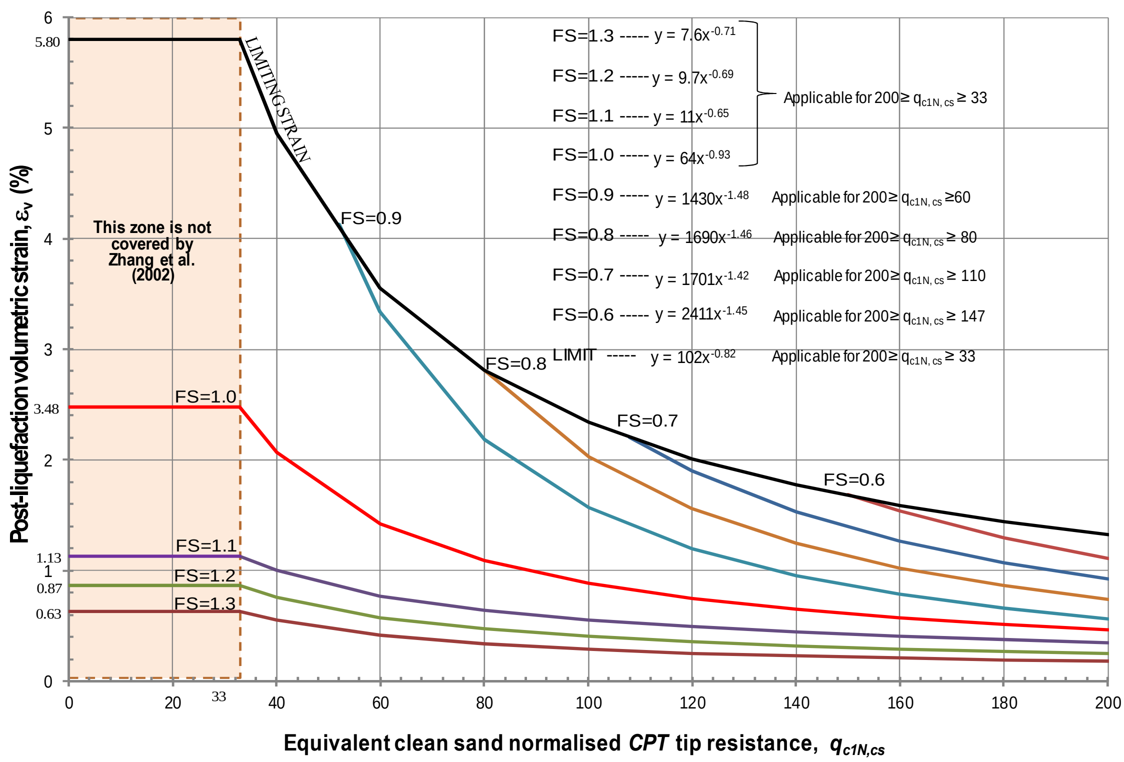


Figure 6.22 Correlation between post-liquefaction volumetric strain and equivalent clean sand normalised cone resistance for different factors of safety (modified from Zhang et al., 2002)

However, the chart provides no guidance when the equivalent clean sand normalised tip resistance, $q_{c1N,cs}$, is less than 33. As a result, for the analysis which follows, all the $q_{c1N,cs}$ values below 33 were assumed to be equal to 33. In addition, it should be noted that this settlement estimation assumes that there is no potential for lateral spreading at the study site.

Example of calculation

The estimated liquefaction-induced ground settlement assessed by the proposed *CPT*-based method can be illustrated using a *CPT* profile from the Gillman study site, as shown in Figure 6.24. The four key parameters used in the estimation are presented, namely: the profiles of equivalent clean sand normalized tip resistance, $q_{c1N,cs}$, the factor of safety, *FS*, the post-liquefaction volumetric strain, ε_{vi}, and the liquefaction induced ground settlement, *S*. The $q_{c1N,cs}$and *FS* data are derived from the liquefaction potential analysis; the ε_{vi} data are estimated from the curves proposed by Zhang et al. (2002), as shown in Figure 6.23; and the settlement, *S*, is calculated from Equation 6.3.

Results of the ground settlement estimation

Details of the liquefaction-induced ground settlement analysis using the proposed *CPT*-based method are included in Appendix L, and the results are summarised in Table 6.15. The results predict the settlement at the study site to range from 20 mm, as a consequence of a magnitude 5.0 earthquake, to 260 mm as the result of amagnitude7.5 earthquake.

Table 6.15 Estimation of ground settlements induced by liquefaction

CPT No.	Calculated ground settlement (mm)						Remarks
	M 5.0	M 5.5	M 6.0	M 6.5	M 7.0	M 7.5	
CPT#1	90	138	160	230	260	260	The ground settlement was calculated with material types identified in the continuous samplings. M is the earthquake magnitude scale.
CPT#2	40	82	150	190	210	230	
CPT#3	20	46	110	160	180	180	

However in certain cases, as shown by Ishihara (1985), settlements induced by liquefaction were not manifested at the ground level. As a consequence, the estimation of the liquefaction-induced settlement in this study included further analysis as proposed by Ishihara (1985).

Additional analysis as suggested by Ishihara (1985)

Ishihara (1985) suggested that two additional factors be incorporated into the liquefaction-induced settlement prediction, namely, the thickness of the mantle, when it is smaller than 3.0 m and the comparison between the thickness of non liquefiable surface layer, H_1, and the thickness of liquefiable layer, H_2. A schematic diagram to estimate the thickness of both layers is shown in Figure 6.24 and, in the case of stratified soil profiles, an additional diagram is shown in Figure 6.25.

To obtain both thicknesses, the results of the liquefaction assessment, as shown previously in Tables 6.9 to 6.14, were used. The findings are summarised in Table 6.16 and plotted onto the curve proposed by Ishihara, as shown in Figure 6.26.

The prediction shows that the ground settlement is manifested at the ground surface when the earthquake magnitude is at least 6.5. The increase in earthquake magnitude results in an increase in the seismically-induced settlement estimated using the Zhang et al. (2003) procedure.

Table 6.16 Results of manifestation classification based on the liquefaction assessment

In-situ testing no.	Type of layer	Thickness of the layer (m)						Remarks
		M 5.0	M 5.5	M 6.0	M 6.5	M 7.0	M 7.5	
CPT#1	H_1	9	4.6	3.4	3.2	2.2	0.8	There is no liquefaction from 9.0 m depth downward. M is the earthquake magnitude scale. H_1 is the overlying non-liquefiable layer. H_2 is the underlying liquefiable layer. [shaded] Liquefaction is manifested at the ground surface.
	H_2	0	0.8	5.6	5.8	6.8	8.2	
CPT#2	H_1	9	9	4.8	4.8	2.2	2.2	
	H_2	0	0	4.2	4.2	6.8	6.8	
CPT#3	H_1	9	9	7.8	2.6	3	0.6	
	H_2	0	0	1.2	3.4	6	8.4	
DMT Method#1	H_1	6.8	6.8	6.8	6.6	6.6	6.6	
	H_2	2.2	2.2	2.2	2.4	2.4	2.4	
DMT Method#2	H_1	6.6	6.6	6.6	5.6	3.8	3.8	
	H_2	2.4	2.4	2.4	3.4	5.2	5.2	

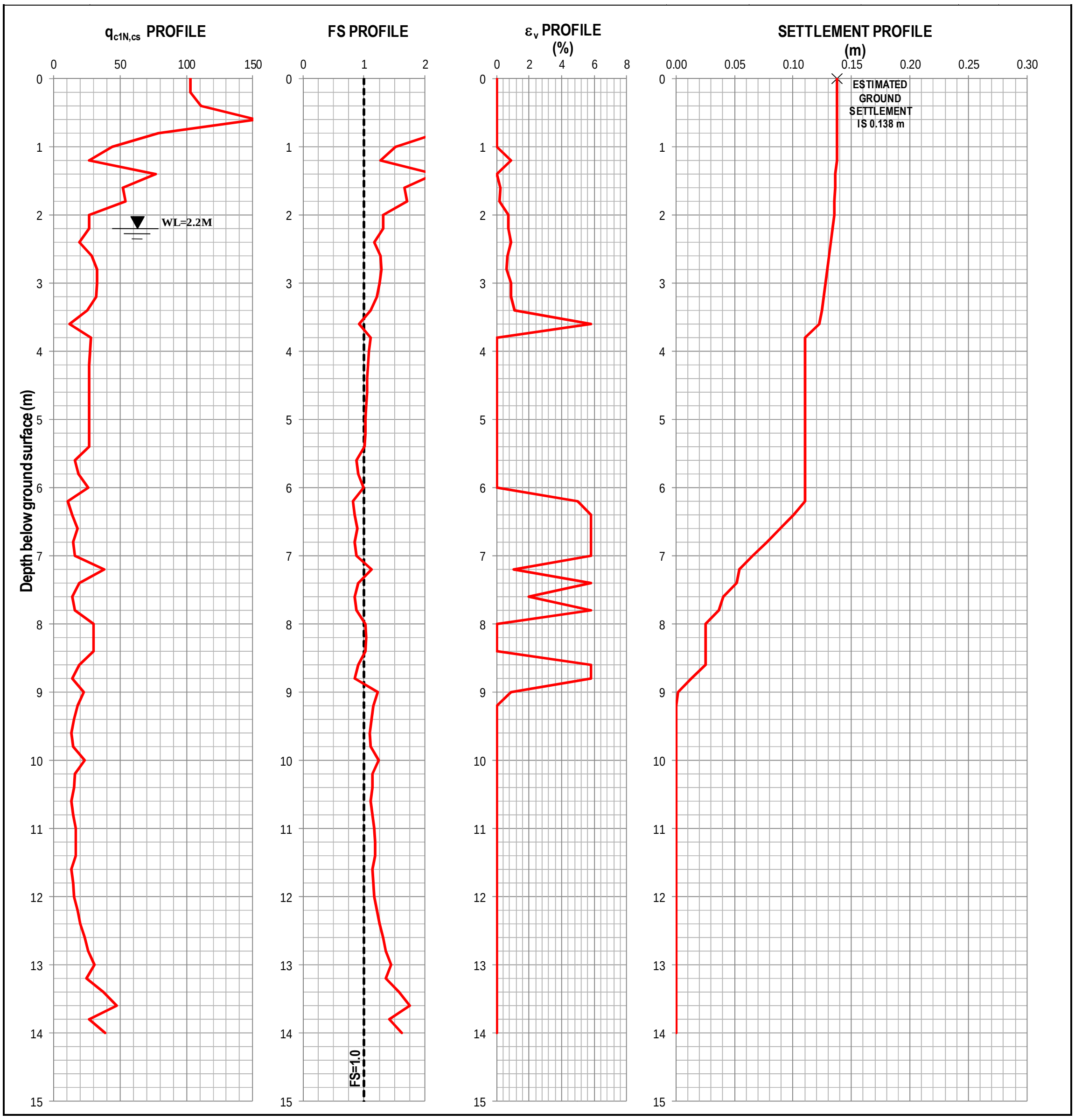


Figure 6.23 Example plots illustrating the major parameters used in estimating liquefaction-induced ground settlements from the proposed *CPT*-based method

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Figure 6.24 Schematic diagram of the surface non liquefiable layer and the underlying liquefiable layer (Ishihara, 1985)

Figure 6.25 Schematic diagram of the surface non liquefiable layer and the underlying liquefiable layer for stratified soil profiles (Ishihara, 1985)

Figure 6.26 Differentiation between surface manifestation and no surface manifestation due to liquefaction, as proposed by Ishihara (Ishihara, 1985)

A summary of the results of estimated ground settlement induced by liquefaction at the study site is tabulated in Table 6.17. The table also presents the manifestation of the settlement at the ground surface.

Table 6.17 Summary of estimated ground settlement induced by liquefaction and its manifestation at the ground surface

Earthquake magnitude scale	Estimated settlement (mm)	Is the settlement manifested at ground surface?
M=5.0	2 - 10	No
M=5.5	4.6 - 13.8	No
M=6.0	11 - 16	Yes
M=6.5	16 - 23	Yes
M=7.0	18 - 26	Yes
M=7.5	18 - 26	Yes

6.7 SUMMARY

The simplified procedure, proposed by Seed & Idriss (1971) for assessing the liquefaction potential of soil, which requires using the cyclic stress ratio (*CSR*) and the cyclic resistance ratio (*CRR*), was employed. The former variable was determined using the results of site-specific ground response analysis, examination of the literature and interpretation of the in-situ testing data. Estimates of *CRR* were obtained solely from the in-situ testing. The basic concept of the simplified procedures is as follows: if the *CSR* exceeds the *CRR*, liquefaction of the soil is highly likely to occur during an earthquake, and vice versa.

Two different in-situ testing (*CPT* and *DMT*) methods were employed in this assessment. Each of the methods was applied independently to evaluate the liquefaction potential of the study site. In the assessment using the *CPT*, the Robertson & Wride (1998) method was used for predicting liquefaction resistance of sandy soils, because it has been shown that it is reliable and convenient, with a similar degree of conservatism to the *SPT*. This method was recommended by the 1996 *NCEER* and 1998 *NCEER/NS*F Workshops. Three important parameters in this method are the soil behaviour type index (I_c), the correction factor for the grain characteristics of the soil (K_c), and the equivalent clean sand normalized *CPT* penetration resistance, $q_{c1N,cs}$. The liquefaction assessment was carried out by incorporating the ageing correction factor proposed by Hayati et al. (2008) into the Robertson and Wride (1998) method. In contrast, two correlations proposed by Marchetti (1982) and Monaco et al. (2005) were employed using the *DMT* data for liquefaction evaluation. The results were compared to those from the *CPT*-based assessment. When comparing these methods with the laboratory-based critical state approach, it was observed that the liquefaction assessment based on the method proposed by Marchetti (1982) yielded the most reliable predictions.

Subsequent to liquefaction assessment, it is desirable to evaluate the ground settlement associated with liquefaction. A *CPT*-based approach for estimating ground settlement induced by liquefaction for sites with level ground conditions was presented. To assess whether the liquefaction will or will not exert damage due to settlement at the ground surface, the criteria by Ishihara (1985) were used. It was found that a magnitude 6.0 earthquake will cause approximately 15 mm of settlement at the ground surface and a 7.5 magnitude earthquake approximately 25 mm ground settlement.

Chapter Seven

SUMMARY AND CONCLUSIONS

7.1 SUMMARY

This research has examined the recommended procedures based on the cone penetration test (*CPT*) which incorporates ageing and the flat dilatometer test (*DMT*) to assess liquefaction potential. A suite of in-situ tests has been carried out at Gillman, *SA*, in order to explore these relationships. Simple critical state parameter testing to estimate the behaviour of sandy soils has also been performed. In addition, the effect of liquefaction on the ground surface has been examined. Detailed summaries of the main chapters are given below.

In Chapter 2, the basic liquefaction mechanism and the type of the soils that is likely to liquefy during seismic loading were reviewed. A method to determine the cyclic stress ratio (*CSR*) was discussed. It consists of determining the peak ground acceleration (*PGA*), calculating the stress reduction factor and estimating the magnitude scaling factor. A review of the state-of-the-art liquefaction assessment utilising the *CPT* and the *DMT* was also presented. This included discussion of the basic, necessary equipment, the standard operation and procedure, application and data interpretation, and determination of the cyclic resistance ratio (*CRR*) value. The influence of ageing on liquefaction, such as particle cementation and re-arrangement, was also presented. In addition to this literature review, determination of the age of a soil deposit and its influence on *CRR* value was reviewed.

In Chapter 3, the existing data and conditions of the field study site, such as the soil profile and stratigraphy, geological history and geotechnical characteristics were discussed and the experimental program used in this research was developed. The general results obtained from the field and laboratory tests were presented. Of interest to this research was the identification of two potentially liquefiable soil layers at depths from 1.2 to 4.2 m and 6.0 and 8.8 m below the ground surface.

In Chapter 4, the methods to obtain the most influential parameter used in the determination of *CSR* (i.e. peak ground acceleration) were presented by performing site-specific ground response analysis using the *SHAKE91* (Schnabel, 1972) and *EERA* (Bardet & Ichi, 2000) techniques. The results of the site-specific ground response analysis were as follows:

- The analysis based on the *CPT* data showed that the study site *PGA* varies from 0.131 to 0.202 *g* with an amplification factor of between 2.23 and 3.44. Spectral accelerations with a 5% ratio of critical damping vary between 0.47 and 0.70 *g*.

- The analysis based on the *DMT* data revealed that the maximum acceleration at surface level varies from 0.182 to 0.217 *g* with an amplification factor between 2.53 to 3.84. Spectral acceleration is estimated to vary between 0.53 and 1.02 *g* by assuming a 5% damping ratio.

In Chapter 5, the simple critical state parameter test (*CS*) for six selected and applicable samples was described and carried out. In general, the results of the simple *CS* test on each specimen were very promising with a high coefficient of determination. Liquefaction assessment based on the critical state parameter, ψ, suggested that a layer at a depth of 4.0 to 4.6 m and a layer between 7.8 and 8.4 m are contractive, and potentially liquefiable, layers.

Chapter 6 described how the values of *CSR* and *CRR* at the study site were determined by using the results of the work outlined in Chapters 3 and 4. The main results were as follows:

- Soil type evaluation, based on the work of Seed et al. (2003), showed that there are two layers that have the potential to liquefy during dynamic loading at the study site. There is a layer at a depth of approximately 1.4 to 4.4 m and another at a depth of 6.4 to 9.0 m.

- Assessment of the soil behaviour based on the critical state approach from the *CPT* data indicated four contractive layers distributed from 2.0 to 8.4 m deep.

- Liquefaction assessment using the *CPT* accounting for ageing showed that the study site would have a major problem with liquefaction if the earthquake magnitude is greater than 5.5.

- The *DMT* liquefaction resistance predicted using the approach suggested by Monaco et al. (2005) very much under-predicted the liquefaction potential estimated by Marchetti (1982).

- In addition, when performing a comparison between each of the procedures *CPT* method incorporating ageing, *DMT* method using the Marchetti (1982) correlation, and *DMT* method using the Monaco et al. (2005) correlation, and assuming that the liquefaction assessment derived from the critical state approach reflects the true conditions of the study site, the correlation by Marchetti (1982) provided the most accurate prediction.

- Finally, it was concluded that vertical settlement at the ground surface at the study site is only manifested by liquefaction triggered by at least a magnitude 6.0 earthquake, and the ground settlement increases from 15 mm as the result of a magnitude 6.0 earthquake to 25 mm from a 7.5 magnitude quake.

7.2 RECOMMENDATIONS FOR FURTHER RESEARCH

The liquefaction assessment conducted for this study was limited to a cluster of in-situ tests. While the results of this study are encouraging, they are only applicable to a limited area of approximately 10 m^2. One would anticipate that somewhat more representative results would be obtained by conducting the liquefaction assessment over a much larger area incorporating the St. Kilda Formation.

The site-specific peak ground acceleration (*PGA*) is an important parameter in liquefaction assessment. The *PGA* may be estimated using the applicable attenuation of the site. However, this approach may not yield reliable results for a number of reasons, such as an incomplete seismic catalogue, uncertainty and soil amplification. Thus, site-specific ground response analysis may be a more convenient and accurate approach. However, several parameters, such as shear wave velocity, the shear modulus curve and its damping relationship are not always available from common site investigation practice in Australia. Therefore, a study to provide an empirical relationship derived from the common site investigation procedures, i.e. the *CPT,* in Australia is desirable. The main reason for selecting the *CPT* over the *DMT* is the former's ability to supply continuous rather than discrete soil data.

The ground settlement estimations presented in this thesis are based solely on the results of cone penetration testing. However, a method incorporating *DMT* data is also desirable.

The spatial variability of soil properties and the third dimension was not considered in this study. Vanmarcke (1977) stated that soil properties vary spatially in 3-dimensions (*3D*). Furthermore, the spatial distribution of natural soils is also a *3D* phenomenon. Hence, it is worthwhile to perform *3D* probabilistic liquefaction analyses considering the effects of soil variability in *3D.*

7.3 CONCLUSIONS

In general, it may be concluded from this work that in-situ testing is very useful in the evaluation of liquefaction potential provided that its limitations and range of applicability are recognised and not exceeded. From the analyses presented in this thesis, it can be concluded that the effects of soil ageing have a significant impact on the ability of soils to resist seismic loading. In addition, as mentioned above, liquefaction assessment derived from *DMT* data by the Marchetti (1982) method provided the most reliable predictions.

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APPENDIX A

ENGINEERING BORELOG

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BOREHOLE ENGINEERING LOG

BH#1

SHEET : 1 OF 3

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	DEPTH	: 0 - 5 m	REDUCE LEVEL	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	INCLINATION	: Vertical	DRILLER	: Andrew
COORDINATE	X : - Y : -	RIG MODEL	: ISUZU EZY PROBE	SUPERVISED BY	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			CHECKED BY	: Brendan Scott

PROGRESS: 11TH JUNE 2010

SUPPORT: NIL (0.0 – 2.0 m); HOLLOW AUGERS (2.0 – 5.0 m)

GROUND WATER DATA AND COMMENTS: water level at approx. 2.5 m

DEPTH (m)	FORMATION	DESCRIPTION OF STRATA (Soil type, colour, particle size, secondary and minor components, structure and other features)	Moisture Condition	Consistency or Relative Density	PROCENTAGE SAMPLE RECOVERY (%)	STANDARD PENETRATION TEST (N - VALUES) N1 N2 N3 N	Pocket Penetrometer (kPa)
0.0 – 0.5	gravelly SILT	gravelly SILT; dark brown, yellowish brown gravel is fine to coarse grained, sub-rounded to angular a trace of brickwall and rock fragment (FILL)	>PL	F			60
0.5 – 0.85	SAND	SAND; light brown, light grey sand is fine to medium grained, rounded (FILL)	D/M		100		
0.85 – 1.35	silty CLAY	silty CLAY; yellowish brown, mottled with grey & reddish brown (FILL)	>PL	VSt			330 270-300
1.35 – 1.65	silty SAND	silty SAND; dark brown sand is fine to coarse grained, sub-rounded to rounded a trace of rock fragments on gravel to pebble size (FILL)	M			6 7 5 12	
1.65 – 2.0	SAND	SAND; light grey sand is fine to medium grained, rounded (FILL)	M		88		
2.0 – 2.3	silty SAND	silty SAND; dark grey, dark brown sand is fine to medium grained, rounded a trace of rock fragments; odor (MADE GROUND)	M/W	S			30-40
2.3 – 2.6	silty CLAY	silty CLAY; dark grey, dark brown, streaked brown	W	VS			250
2.6 – 2.95	silty SAND	silty SAND; light brown, grey sand is fine grained, rounded			100		
2.95 – 4.6	clayey SAND	clayey SAND; grey, light brown sand is fine grained, rounded some sea shells	W	VS	66 100	1 1 1 2	20 20-25
4.6 – 5.0	sandy CLAY	sandy CLAY; grey sand is fine grained, rounded a trace of roots	>PL	St	95	0 1 0 1	100 120

BORING RESISTANCE:
L : LOW RESISTANCE
M : MEDIUM RESISTANCE
H : HIGH RESISTANCE
R : REFUSAL

SAMPLE CODE:
UN-DISTURBED SAMPLE
DISTURBED SAMPLE
STANDARD PENETRATION TEST (SPT)

GROUND WATER CONDITION:
WATER LEVEL ON DATE SHOWN

MOISTURE CONDITION:
D : DRY
M : MOIST
W : WET
<<PL : MUCH LESS THAN PLASTIC LIMIT
<PL : LESS THAN PLASTIC LIMIT
~PL : APPROX. PLASTIC LIMIT
>PL : GREATER THAN PLASTIC LIMIT
>>PL : MUCH GREATER THAN PLASTIC LIMIT

CONSISTENCY AND RELATIVE DENSITY INDEX:
VS : VERY SOFT (0 - 25 kPa)
S : SOFT (25 - 50 kPa)
F : FIRM (50 - 100 kPa)
St : STIFF (100 - 200 kPa)
VSt : VERY STIFF (200 - 400 kPa)
H : HARD (> 400 kPa)
Fb : FRIABLE (unable to test)
VL : VERY LOOSE
L : LOOSE
MD : MEDIUM DENSE
D : DENSE
VD : VERY DENSE

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

BOREHOLE ENGINEERING LOG

BH#1

SHEET : 2 OF 3

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 5 - 10 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**DRILLER**	: Andrew
COORDINATE	X : - Y : -	**RIG MODEL**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: Brendan Scott

PROGRESS: 11TH JUNE 2010 — SUPPORT: HOLLOW AUGERS

DEPTH (m)	FORMATION	DESCRIPTION OF STRATA (Soil type, colour, particle size, secondary and minor components, structure and other features)	Moisture Condition	Consistency or Relative Density	PERCENTAGE SAMPLE RECOVERY (%)	SPT N1	N2	N3	N	Pocket Penetrometer (kPa)
5.0 – 5.8	sandy CLAY	sandy CLAY; grey sand is fine grained, rounded a trace of roots	>PL	F	100					60
5.8 – 6.1	CLAY	CLAY; brown	>PL	St/VSt						100, 250
6.1 – 6.6	clayey SAND	clayey SAND; light brown sand is fine to medium grained, rounded a trace of gravel	W		100	1	6	5	11	
6.6 – 7.1	SAND	SAND; light brown, light grey sand is fine grained, rounded	W		100					
7.1 – 8.6	silty SAND	silty SAND; light yellow, yellow sand is fine to coarse grained, sub-rounded to rounded a trace of gravel & sea shells	W		100, 100	2	3	5	8	
8.6 – 10.0	sandy CLAY	sandy CLAY; brown, spotted grey & light brown sand is fine grained, rounded a trace of gravel	>PL	St/VSt	65, 100	4	4	5	9	140-300, 220, 220, 210

BORING RESISTANCE:
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- H : HIGH RESISTANCE
- R : REFUSAL

SAMPLE CODE:
- UN-DISTURBED SAMPLE
- DISTURBED SAMPLE
- STANDARD PENETRATION TEST (SPT)

GROUND WATER CONDITION:
- WATER LEVEL ON DATE SHOWN

MOISTURE CONDITION:
- D : DRY
- M : MOIST
- W : WET
- <<PL : MUCH LESS THAN PLASTIC LIMIT
- <PL : LESS THAN PLASTIC LIMIT
- ~PL : APPROX. PLASTIC LIMIT
- >PL : GREATER THAN PLASTIC LIMIT
- >>PL : MUCH GREATER THAN PLASTIC LIMIT

CONSISTENCY AND RELATIVE DENSITY INDEX:
- VS : VERY SOFT (0 - 25 kPa)
- S : SOFT (25 - 50 kPa)
- F : FIRM (50 - 100 kPa)
- St : STIFF (100 - 200 kPa)
- VSt : VERY STIFF (200 - 400 kPa)
- H : HARD (> 400 kPa)
- Fb : FRIABLE (unable to test)
- VL : VERY LOOSE
- L : LOOSE
- MD : MEDIUM DENSE
- D : DENSE
- VD : VERY DENSE

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Signature :

Date : 20 August 2011

BOREHOLE ENGINEERING LOG

BH#1

SHEET : 3 OF 3

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	DEPTH	: 10 - 10.5 m	REDUCE LEVEL	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	INCLINATION	: Vertical	DRILLER	: Andrew
COORDINATE	X : - Y : -	RIG MODEL	: ISUZU EZY PROBE	SUPERVISED BY	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			CHECKED BY	: Brendan Scott

PROGRESS	SUPPORT	BORING RESISTANCE (L M H R)	GROUND WATER DATA AND COMMENTS	DEPTH (m)	SAMPEL CODE	FORMATION	SOIL/ROCK SYMBOL	DESCRIPTION OF STRATA Soil type, colour, particle size, secondary and minor components, structure and other features	Moisture Condition	Consistency or Relative Density	PROCENTAGE SAMPLE RECOVERY (%) 25 50 75 100	STANDARD PENETRATION TEST (N - VALUES) 10 30 50 N1 N2 N3 N	Pocket Penetrometer (kPa)	DEPTH (m)
11TH JUNE 2010	HOLLOW AUGERS			10.5		sandy CLAY		sandy CLAY; brown, spotted grey & light brown sand is fine grained, rounded a trace of gravel	>PL	St	100		160-180	10.5
								END OF BOREHOLE AT 10.5 M						
				11.0										11.0
				11.5										11.5
				12.0										12.0
				12.5										12.5
				13.0										13.0
				13.5										13.5
				14.0										14.0
				14.5										14.5
				15.0										15.0

BORING RESISTANCE:
L : LOW RESISTANCE
M : MEDIUM RESISTANCE
H : HIGH RESISTANCE
R : REFUSAL

SAMPLE CODE:
UN-DISTURBED SAMPLE
DISTURBED SAMPLE
STANDARD PENETRATION TEST (SPT)

GROUND WATER CONDITION:
WATER LEVEL ON DATE SHOWN

MOISTURE CONDITION:
D : DRY
M : MOIST
W : WET
<<PL : MUCH LESS THAN PLASTIC LIMIT
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St : STIFF (100 - 200 kPa)
VSt : VERY STIFF (200 - 400 kPa)
H : HARD (> 400 kPa)
Fb : FRIABLE (unable to test)
VL : VERY LOOSE
L : LOOSE
MD : MEDIUM DENSE
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VD : VERY DENSE

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Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

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BOREHOLE ENGINEERING LOG

BH#2

SHEET : 1 OF 3

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	DEPTH	: 0 - 5 m	REDUCE LEVEL	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	INCLINATION	: Vertical	DRILLER	: Andrew
COORDINATE	X : - Y : -	RIG MODEL	: ISUZU EZY PROBE	SUPERVISED BY	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			CHECKED BY	: Brendan Scott

Progress: 29TH JUNE 2010. Support: NIL (0 – 3.0 m); HOLLOW AUGERS (3.0 – 5.0 m). Ground water level marked at approx. 2.2 m. Percentage sample recovery: 100 (each sampled interval).

FORMATION	DESCRIPTION OF STRATA (Colour, particle size, secondary and minor components, structure and other features)	Moisture Condition	Consistency or Relative Density	Pocket Penetrometer (kPa)	SPT (N1 N2 N3 N)
gravelly sandy SILT	gravelly sandy SILT; brown, light brown, light grey gravel is fine to coarse grained, angular sand is fine to coarse grained, angular to sub-angular (FILL)	W	F	140-160	
silty SAND	silty SAND; light brown, light grey sand is fine to medium grained, sub-rounded to rounded (FILL)	M			
gravelly CLAY	gravelly CLAY; brown, cream, grey, reddish brown gravel is fine to coarse grained, angular a trace of brickwall in gravel size (MADE GROUND)	<<PL	St	140	
silty SAND	silty SAND; black, dark grey, dark brown sand is fine to medium grained, rounded odor	M			
SAND	SAND; light brown sand is fine to medium grained, rounded	W			4 2 1 3
sandy CLAY	sandy CLAY; black, dark grey sand is fine to medium grained, rounded	W	S	40	
silty SAND	silty SAND; grey, light yellow sand is fine to medium grained, rounded	W			3 2 1 3
sandy CLAY	sandy CLAY; grey sand is fine to medium grained, rounded to sub-rounded	>>PL	VS/S	20-30; 30	
CLAY	CLAY; grey with traces of sand pockets and decay of woods slightly odor	>>PL	S/F	40-70	2 2 1 3

BORING RESISTANCE:
- L : LOW RESISTANCE
- M : MEDIUM RESISTANCE
- H : HIGH RESISTANCE
- R : REFUSAL

SAMPLE CODE:
- UN-DISTURBED SAMPLE
- DISTURBED SAMPLE
- STANDARD PENETRATION TEST (SPT)

GROUND WATER CONDITION:
- WATER LEVEL ON DATE SHOWN

MOISTURE CONDITION:
- D : DRY
- M : MOIST
- W : WET
- <<PL : MUCH LESS THAN PLASTIC LIMIT
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- VSt : VERY STIFF (200 - 400 kPa)
- H : HARD (> 400 kPa)
- Fb : FRIABLE (unable to test)
- VL : VERY LOOSE
- L : LOOSE
- MD : MEDIUM DENSE
- D : DENSE
- VD : VERY DENSE

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Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

BOREHOLE ENGINEERING LOG **BH#2** **SHEET : 2 OF 3**

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 5 - 10 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**DRILLER**	: Andrew
COORDINATE	X : - Y : -	**RIG MODEL**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: Brendan Scott

PROGRESS: 29TH JUNE 2010 — SUPPORT: HOLLOW AUGERS

DEPTH (m)	FORMATION	DESCRIPTION OF STRATA (Colour, particle size, secondary and minor components, structure and other features)	Moisture Condition	Consistency or Relative Density	PERCENTAGE SAMPLE RECOVERY (%)	STANDARD PENETRATION TEST (N-VALUES) N1 N2 N3 N	Pocket Penetrometer (kPa)
5.0 – 5.3	CLAY	CLAY; grey with traces of sand pockets and decay of woods, slightly odor					
5.3 – 6.2	CLAY	CLAY; brown	<<PL	St/VSt	100		110-250
6.2 – 6.7	sandy CLAY	sandy CLAY; grey, light brown sand is fine to medium grained, sub-rounded to rounded	>>PL	S	100	1 1 1 2	40-50
6.7 – 8.5	silty SAND	silty SAND; light yellow, cream sand is fine to coarse grained, sub-angular to angular some fine to coarse gravel	W		100, 100, 100	2 3 2 5	
8.5 – 9.1	silty CLAY	silty CLAY; light grey	>>PL	St/VSt	100		110-240
9.1 – 10.0	CLAY	CLAY; brown, light grey	>PL	F/St	65, 100	2 3 3 6	80-120

BORING RESISTANCE:
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- M : MEDIUM RESISTANCE
- H : HIGH RESISTANCE
- R : REFUSAL

SAMPLE CODE:
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- DISTURBED SAMPLE
- STANDARD PENETRATION TEST (SPT)

GROUND WATER CONDITION:
- WATER LEVEL ON DATE SHOWN

MOISTURE CONDITION:
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- L : LOOSE
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- D : DENSE
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Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

BOREHOLE ENGINEERING LOG

BH#2

SHEET : 3 OF 3

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 10 - 12.45 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**DRILLER**	: Andrew
COORDINATE	X : - Y : -	**RIG MODEL**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: Brendan Scott

Progress: 29TH JUNE 2010 — Support: HOLLOW AUGERS

DEPTH (m)	SAMPEL CODE	FORMATION	DESCRIPTION OF STRATA (Colour, particle size, secondary and minor components, structure and other features)	Moisture Condition	Consistency or Relative Density	PROCENTAGE SAMPLE RECOVERY (%)	STANDARD PENETRATION TEST (N1 N2 N3 N)	Pocket Penetrometer (kPa)
10.0 – 10.25	Disturbed	silty CLAY	silty CLAY; brown a trace of fine sand	>>PL	St	100		150-190
10.25 – 11.0	SPT	CLAY	CLAY; brown	>PL	St	67	2 4 5 **9**	150-190
11.0 – 11.8	Disturbed	sandy CLAY	sandy CLAY; brown, mottled grey sand is fine to medium grained, rounded	>>PL	St	90		110-130
11.8 – 12.45	SPT	CLAY	CLAY; brown, spotted grey	<<PL	F/St	65	4 7 10 **17**	80-160
14.5								80-120

END OF BORE HOLE AT 12.45 M

BORING RESISTANCE:
- L : LOW RESISTANCE
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- H : HIGH RESISTANCE
- R : REFUSAL

SAMPLE CODE:
- UN-DISTURBED SAMPLE
- DISTURBED SAMPLE
- STANDARD PENETRATION TEST (SPT)

GROUND WATER CONDITION:
- WATER LEVEL ON DATE SHOWN

MOISTURE CONDITION:
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- Fb : FRIABLE (unable to test)
- VL : VERY LOOSE
- L : LOOSE
- MD : MEDIUM DENSE
- D : DENSE
- VD : VERY DENSE

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Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

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APPENDIX B

FLAT DILATOMETER TEST (DMT) DATA

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FLAT DILATOMETER TEST (DMT)

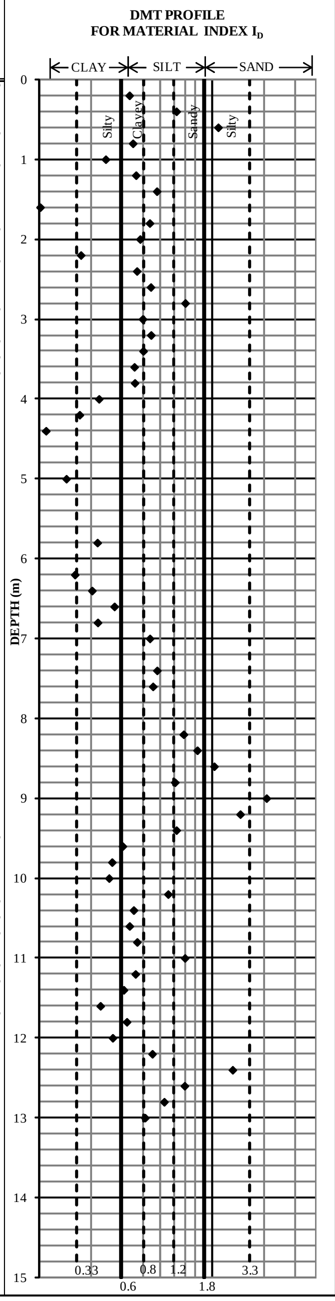
DMT#1

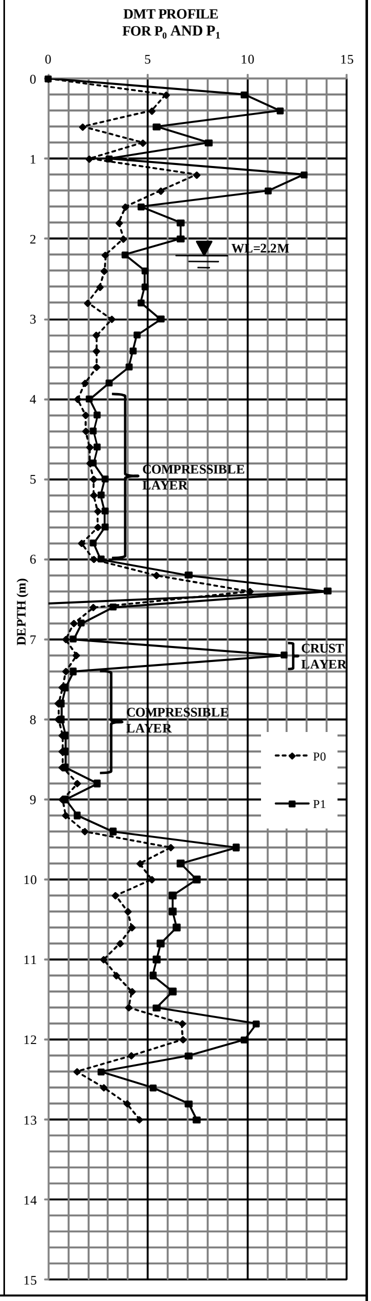
SHEET : 1 OF 4

MATERIAL INDEX & PRESSURE PROFILES

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010	TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	A Reading (Bars)	B Reading (Bars)	C Reading (Bars)	p_0	p_1	I_D	Estimated Soil Type Based-on I_D
200	6.2	10.0	0.0	5.91	9.85	0.67	Clayey SILT
400	5.6	11.8	0.0	5.19	11.65	1.24	Sandy SILT
600	2.0	5.6	0.0	1.72	5.45	2.16	Silty SAND
800	5.0	8.2	0.8	4.74	8.05	0.70	Clayey SILT
1000	2.2	3.2	1.8	2.05	3.05	0.49	Silty CLAY
1200	7.8	13.0	0.8	7.44	12.85	0.73	Clayey SILT
1400	6.0	11.2	0.0	5.64	11.05	0.96	SILT
1600	4.0	4.8	0.8	3.86	4.65	0.20	CLAY
1800	3.8	6.8	1.4	3.55	6.65	0.87	SILT
2000	4.0	6.8	0.0	3.76	6.65	0.77	Clayey SILT
2200	3.0	4.0	1.2	2.85	3.85	0.35	Silty CLAY
2400	3.0	5.0	0.4	2.80	4.85	0.74	Clayey SILT
2600	2.8	5.0	0.0	2.59	4.85	0.88	SILT
2800	2.2	4.8	0.0	1.97	4.65	1.40	Sandy SILT
3000	3.4	5.8	0.0	3.18	5.65	0.79	Clayey SILT
3200	2.6	4.6	0.0	2.40	4.45	0.89	SILT
3400	2.6	4.4	0.0	2.41	4.25	0.80	Clayey SILT
3600	2.6	4.2	0.8	2.42	4.05	0.71	Clayey SILT
3800	2.0	3.2	0.6	1.84	3.05	0.72	Clayey SILT
4000	1.6	2.2	0.8	1.47	2.05	0.44	Silty CLAY
4200	2.0	2.6	1.0	1.87	2.45	0.34	Silty CLAY
4400	2.0	2.4	1.2	1.88	2.25	0.22	CLAY
4600	2.2	2.6	1.4	2.08	2.45	0.20	CLAY
4800	2.2	2.4	1.4	2.09	2.25	0.09	CLAY
5000	2.4	3.0	2.0	2.27	2.85	0.29	CLAY
5200	2.4	2.8	1.8	2.28	2.65	0.18	CLAY
5400	2.6	3.0	1.8	2.48	2.85	0.17	CLAY
5600	2.6	3.0	2.0	2.48	2.85	0.17	CLAY
5800	1.8	2.4	0.8	1.67	2.25	0.44	Silty CLAY
6000	2.4	2.8	1.8	2.28	2.65	0.19	CLAY
6200	5.6	7.2	2.6	5.42	7.05	0.32	CLAY
6400	10.4	14.2	1.4	10.11	14.05	0.41	Silty CLAY
6600	2.4	3.4	0.0	2.25	3.25	0.55	Silty CLAY
6800	1.4	1.8	0.2	1.28	1.65	0.44	Silty CLAY
7000	1.0	1.4	0.2	0.88	1.25	0.87	SILT
7200	2.0	12.0	0.0	1.40	11.85	11.34	SAND
7400	1.0	1.4	0.0	0.88	1.25	0.96	SILT
7600	0.8	1.0	0.4	0.69	0.85	0.91	SILT
7800	0.6	0.8	0.4	0.49	0.65	-3.41	CLAY
8000	0.6	0.8	0.4	0.49	0.65	-2.41	CLAY
8200	0.8	1.0	0.5	0.69	0.85	1.37	Sandy SILT
8400	0.8	1.0	0.5	0.69	0.85	1.64	Sandy SILT
8600	0.8	1.0	0.8	0.69	0.85	2.05	Silty SAND
8800	1.6	2.6	0.8	1.45	2.45	1.22	Sandy SILT
9000	0.8	1.0	0.6	0.69	0.85	4.11	SAND
9200	1.0	1.6	0.8	0.87	1.45	2.90	Silty SAND
9400	2.0	3.4	0.4	1.83	3.25	1.24	Sandy SILT
9600	6.4	9.6	0.0	6.14	9.45	0.61	Clayey SILT
9800	4.8	6.8	0.6	4.60	6.65	0.53	Silty CLAY
10000	5.4	7.6	0.2	5.19	7.45	0.51	Silty CLAY
10200	3.6	6.4	0.4	3.36	6.25	1.11	SILT
10400	4.2	6.4	0.8	3.99	6.25	0.70	Clayey SILT
10600	4.4	6.6	0.6	4.19	6.45	0.67	Clayey SILT
10800	3.8	5.8	0.4	3.60	5.65	0.74	Clayey SILT
11000	3.0	5.6	0.4	2.77	5.45	1.39	Sandy SILT
11200	3.6	5.4	0.6	3.41	5.25	0.72	Clayey SILT
11400	4.4	6.4	1.4	4.20	6.25	0.62	Clayey SILT
11600	4.2	5.6	1.2	4.03	5.45	0.45	Silty CLAY
11800	7.0	10.6	1.8	6.72	10.45	0.64	Clayey SILT
12000	7.0	10.0	2.4	6.75	9.85	0.53	Silty CLAY
12200	4.4	7.2	0.6	4.16	7.05	0.90	SILT
12400	1.6	2.8	0.8	1.44	2.65	2.62	Silty SAND
12600	3.0	5.4	0.8	2.78	5.25	1.38	Sandy SILT
12800	4.2	7.2	0.6	3.95	7.05	1.06	SILT
13000	4.8	7.6	1.0	4.56	7.45	0.82	SILT





REMARKS:

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

THE UNIVERSITY OF ADELAIDE AUSTRALIA

FLAT DILATOMETER TEST (DMT)

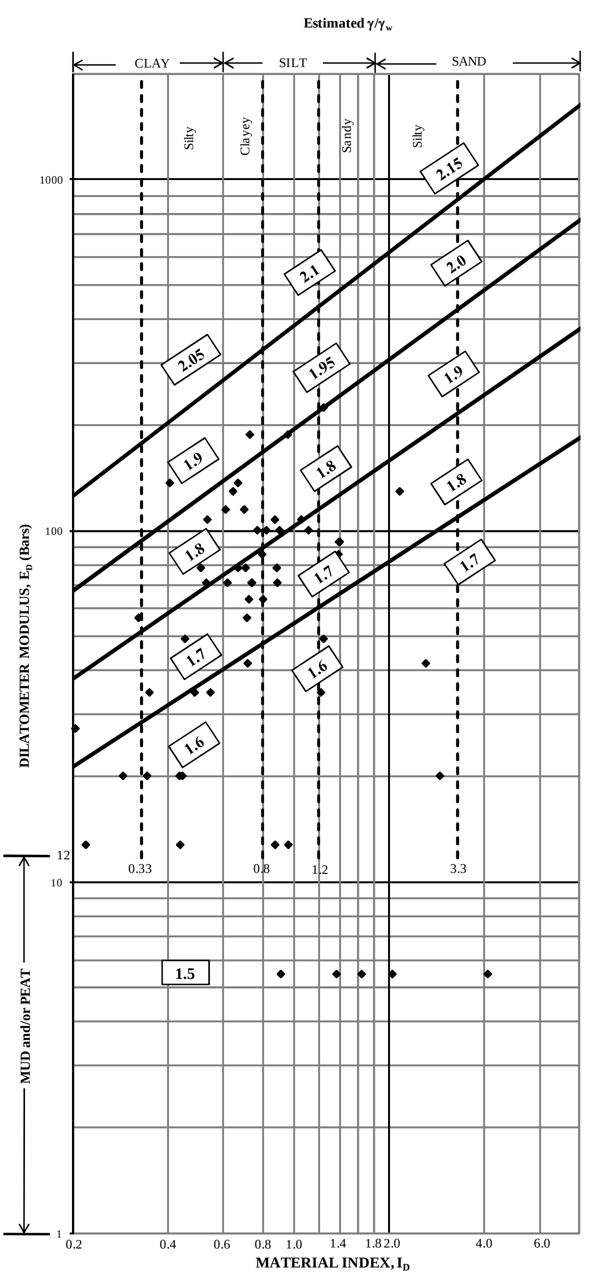
DMT#1

SHEET : 2 OF 4

DILATOMETER MODULUS & SOIL DENSITY

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	**X** : - **Y** : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	A Reading (Bars)	B Reading (Bars)	C Reading (Bars)	p_0	p_1	I_D	E_D (Bars)	Estimated γ_{Soil} (kN/m^3)
200	6.2	10.0	0.0	5.91	9.85	0.67	136.63	**14.72**
400	5.6	11.8	0.0	5.19	11.65	1.24	224.08	**19.13**
600	2.0	5.6	0.0	1.72	5.45	2.16	129.34	**17.66**
800	5.0	8.2	0.8	4.74	8.05	0.70	114.77	**17.66**
1000	2.2	3.2	1.8	2.05	3.05	0.49	34.61	**17.66**
1200	7.8	13.0	0.8	7.44	12.85	0.73	187.64	**19.13**
1400	6.0	11.2	0.0	5.64	11.05	0.96	187.64	**19.13**
1600	4.0	4.8	0.8	3.86	4.65	0.20	27.33	**17.66**
1800	3.8	6.8	1.4	3.55	6.65	0.87	107.48	**17.66**
2000	4.0	6.8	0.0	3.76	6.65	0.77	100.20	**17.66**
2200	3.0	4.0	1.2	2.85	3.85	0.35	34.61	**17.66**
2400	3.0	5.0	0.4	2.80	4.85	0.74	71.05	**17.66**
2600	2.8	5.0	0.0	2.59	4.85	0.88	78.34	**17.66**
2800	2.2	4.8	0.0	1.97	4.65	1.40	92.91	**17.66**
3000	3.4	5.8	0.0	3.18	5.65	0.79	85.62	**17.66**
3200	2.6	4.6	0.0	2.40	4.45	0.89	71.05	**17.66**
3400	2.6	4.4	0.0	2.41	4.25	0.80	63.76	**17.66**
3600	2.6	4.2	0.8	2.42	4.05	0.71	56.47	**17.66**
3800	2.0	3.2	0.6	1.84	3.05	0.72	41.90	**17.66**
4000	1.6	2.2	0.8	1.47	2.05	0.44	20.04	**15.70**
4200	2.0	2.6	1.0	1.87	2.45	0.34	20.04	**15.70**
4400	2.0	2.4	1.2	1.88	2.25	0.22	12.75	**15.70**
4600	2.2	2.6	1.4	2.08	2.45	0.20	12.75	**15.70**
4800	2.2	2.4	1.4	2.09	2.25	0.09	5.47	**14.72**
5000	2.4	3.0	2.0	2.27	2.85	0.29	20.04	**15.70**
5200	2.4	2.8	1.8	2.28	2.65	0.18	12.75	**15.70**
5400	2.6	3.0	1.8	2.48	2.85	0.17	12.75	**15.70**
5600	2.6	3.0	2.0	2.48	2.85	0.17	12.75	**15.70**
5800	1.8	2.4	0.8	1.67	2.25	0.44	20.04	**15.70**
6000	2.4	2.8	1.8	2.28	2.65	0.19	12.75	**15.70**
6200	5.6	7.2	2.6	5.42	7.05	0.32	56.47	**17.66**
6400	10.4	14.2	1.4	10.11	14.05	0.41	136.63	**18.64**
6600	2.4	3.4	0.0	2.25	3.25	0.55	34.61	**16.68**
6800	1.4	1.8	0.2	1.28	1.65	0.44	12.75	**17.66**
7000	1.0	1.4	0.2	0.88	1.25	0.87	12.75	**17.66**
7200	2.0	12.0	0.0	1.40	11.85	11.34	362.53	**17.66**
7400	1.0	1.4	0.0	0.88	1.25	0.96	12.75	**16.68**
7600	0.8	1.0	0.4	0.69	0.85	0.91	5.47	**14.72**
7800	0.6	0.8	0.4	0.49	0.65	-3.41	5.47	**14.72**
8000	0.6	0.8	0.4	0.49	0.65	-2.41	5.47	**14.72**
8200	0.8	1.0	0.5	0.69	0.85	1.37	5.47	**14.72**
8400	0.8	1.0	0.5	0.69	0.85	1.64	5.47	**14.72**
8600	0.8	1.0	0.8	0.69	0.85	2.05	5.47	**14.72**
8800	1.6	2.6	0.8	1.45	2.45	1.22	34.61	**15.70**
9000	0.8	1.0	0.6	0.69	0.85	4.11	5.47	**14.72**
9200	1.0	1.6	0.8	0.87	1.45	2.90	20.04	**16.68**
9400	2.0	3.4	0.4	1.83	3.25	1.24	49.19	**17.66**
9600	6.4	9.6	0.0	6.14	9.45	0.61	114.77	**17.66**
9800	4.8	6.8	0.6	4.60	6.65	0.53	71.05	**17.66**
10000	5.4	7.6	0.2	5.19	7.45	0.51	78.34	**17.66**
10200	3.6	6.4	0.4	3.36	6.25	1.11	100.20	**17.66**
10400	4.2	6.4	0.8	3.99	6.25	0.70	78.34	**17.66**
10600	4.4	6.6	0.6	4.19	6.45	0.67	78.34	**17.66**
10800	3.8	5.8	0.4	3.60	5.65	0.74	71.05	**17.66**
11000	3.0	5.6	0.4	2.77	5.45	1.39	92.91	**17.66**
11200	3.6	5.4	0.6	3.41	5.25	0.72	63.76	**17.66**
11400	4.4	6.4	1.4	4.20	6.25	0.62	71.05	**17.66**
11600	4.2	5.6	1.2	4.03	5.45	0.45	49.19	**17.66**
11800	7.0	10.6	1.8	6.72	10.45	0.64	129.34	**17.66**
12000	7.0	10.0	2.4	6.75	9.85	0.53	107.48	**17.66**
12200	4.4	7.2	0.6	4.16	7.05	0.90	100.20	**17.66**
12400	1.6	2.8	0.8	1.44	2.65	2.62	41.90	**17.66**
12600	3.0	5.4	0.8	2.78	5.25	1.38	85.62	**17.66**
12800	4.2	7.2	0.6	3.95	7.05	1.06	107.48	**17.66**
13000	4.8	7.6	1.0	4.56	7.45	0.82	100.20	**17.66**



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)

DMT#1

SHEET : 3 OF 4

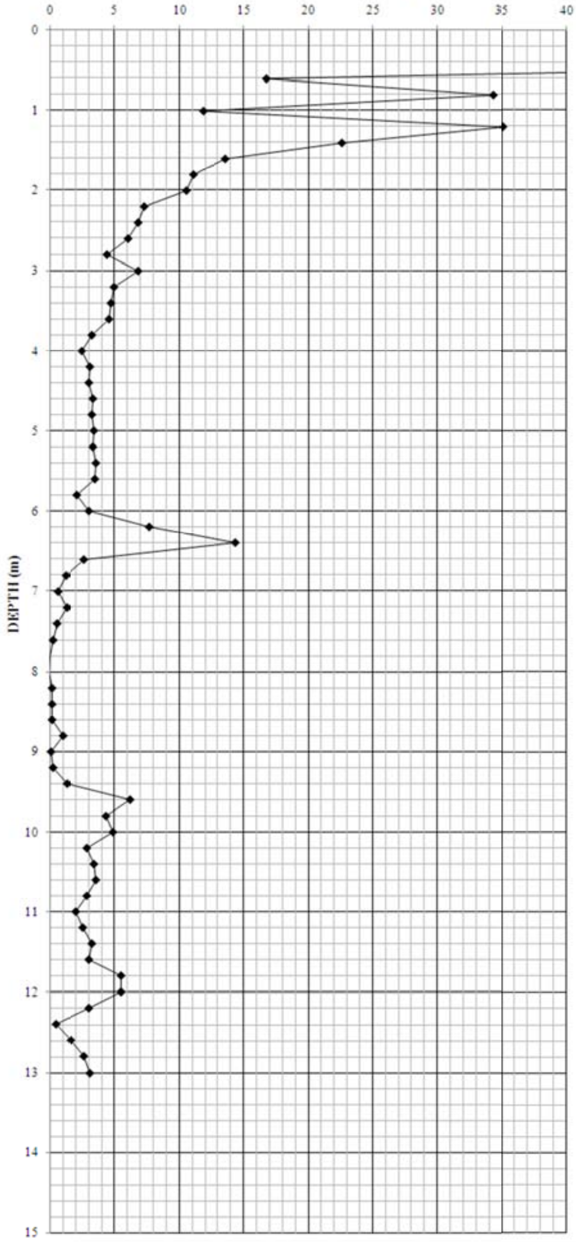
HORIZONTAL STRESS INDEX

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 28 JUNE 2010 TO 28 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Adam/Gary/Andrew
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	A Reading (Bars)	B Reading (Bars)	C Reading (Bars)	p_0 (Bars)	u_0 (Bars)	σ'_{v0} (Bars)	K_D
200	6,20	10,00	0,00	5,91	0,00	0,03	**200,90**
400	5,60	11,80	0,00	5,19	0,00	0,07	**76,71**
600	2,00	5,60	0,00	1,72	0,00	0,10	**16,72**
800	5,00	8,20	0,80	4,74	0,00	0,14	**34,29**
1000	2,20	3,20	1,80	2,05	0,00	0,17	**11,82**
1200	7,80	13,00	0,80	7,44	0,00	0,21	**35,12**
1400	6,00	11,20	0,00	5,64	0,00	0,25	**22,56**
1600	4,00	4,80	0,80	3,86	0,00	0,29	**13,53**
1800	3,80	6,80	1,40	3,55	0,00	0,32	**11,07**
2000	4,00	6,80	0,00	3,76	0,00	0,36	**10,57**
2200	3,00	4,00	1,20	2,85	0,00	0,39	**7,29**
2400	3,00	5,00	0,40	2,80	0,02	0,41	**6,84**
2600	2,80	5,00	0,00	2,59	0,04	0,42	**6,04**
2800	2,20	4,80	0,00	1,97	0,06	0,44	**4,37**
3000	3,40	5,80	0,00	3,18	0,08	0,45	**6,84**
3200	2,60	4,60	0,00	2,40	0,10	0,47	**4,91**
3400	2,60	4,40	0,00	2,41	0,12	0,49	**4,73**
3600	2,60	4,20	0,80	2,42	0,13	0,50	**4,56**
3800	2,00	3,20	0,60	1,84	0,15	0,52	**3,27**
4000	1,60	2,20	0,80	1,47	0,17	0,53	**2,46**
4200	2,00	2,60	1,00	1,87	0,19	0,54	**3,11**
4400	2,00	2,40	1,20	1,88	0,21	0,55	**3,02**
4600	2,20	2,60	1,40	2,08	0,23	0,56	**3,28**
4800	2,20	2,40	1,40	2,09	0,25	0,57	**3,21**
5000	2,40	3,00	2,00	2,27	0,27	0,59	**3,42**
5200	2,40	2,80	1,80	2,28	0,29	0,60	**3,34**
5400	2,60	3,00	1,80	2,48	0,31	0,61	**3,57**
5600	2,60	3,00	2,00	2,48	0,33	0,62	**3,47**
5800	1,80	2,40	0,80	1,67	0,35	0,63	**2,10**
6000	2,40	2,80	1,80	2,28	0,37	0,64	**2,97**
6200	5,60	7,20	2,60	5,42	0,38	0,66	**7,63**
6400	10,40	14,20	1,40	10,11	0,40	0,68	**14,32**
6600	2,40	3,40	0,00	2,25	0,42	0,69	**2,64**
6800	1,40	1,80	0,20	1,28	0,44	0,71	**1,19**
7000	1,00	1,40	0,20	0,88	0,46	0,72	**0,58**
7200	2,00	12,00	0,00	1,40	0,48	0,74	**1,25**
7400	1,00	1,40	0,00	0,88	0,50	0,75	**0,51**
7600	0,80	1,00	0,40	0,69	0,52	0,76	**0,23**
7800	0,60	0,80	0,40	0,49	0,54	0,77	**-0,06**
8000	0,60	0,80	0,40	0,49	0,56	0,78	**-0,08**
8200	0,80	1,00	0,50	0,69	0,58	0,79	**0,15**
8400	0,80	1,00	0,50	0,69	0,60	0,80	**0,12**
8600	0,80	1,00	0,80	0,69	0,62	0,81	**0,09**
8800	1,60	2,60	0,80	1,45	0,63	0,82	**0,99**
9000	0,80	1,00	0,60	0,69	0,65	0,83	**0,05**
9200	1,00	1,60	0,80	0,87	0,67	0,85	**0,24**
9400	2,00	3,40	0,40	1,83	0,69	0,86	**1,32**
9600	6,40	9,60	0,00	6,14	0,71	0,88	**6,18**
9800	4,80	6,80	0,60	4,60	0,73	0,89	**4,33**
10000	5,40	7,60	0,20	5,19	0,75	0,91	**4,88**
10200	3,60	6,40	0,40	3,36	0,77	0,93	**2,80**
10400	4,20	6,40	0,80	3,99	0,79	0,94	**3,40**
10600	4,40	6,60	0,60	4,19	0,81	0,96	**3,54**
10800	3,80	5,80	0,40	3,60	0,83	0,97	**2,85**
11000	3,00	5,60	0,40	2,77	0,85	0,99	**1,95**
11200	3,60	5,40	0,60	3,41	0,87	1,00	**2,54**
11400	4,40	6,40	1,40	4,20	0,89	1,02	**3,25**
11600	4,20	5,60	1,20	4,03	0,90	1,04	**3,02**
11800	7,00	10,60	1,80	6,72	0,92	1,05	**5,52**
12000	7,00	10,00	2,40	6,75	0,94	1,07	**5,45**
12200	4,40	7,20	0,60	4,16	0,96	1,08	**2,96**
12400	1,60	2,80	0,80	1,44	0,98	1,10	**0,42**
12600	3,00	5,40	0,80	2,78	1,00	1,11	**1,60**
12800	4,20	7,20	0,60	3,95	1,02	1,13	**2,60**
13000	4,80	7,60	1,00	4,56	1,04	1,15	**3,08**

DMT PROFILE FOR HORIZONTAL STRESS INDEX K_D



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by:		Bambang Setiawan
Signature	:	
Date	:	20 August 2011

FLAT DILATOMETER TEST (DMT)

DMT#1

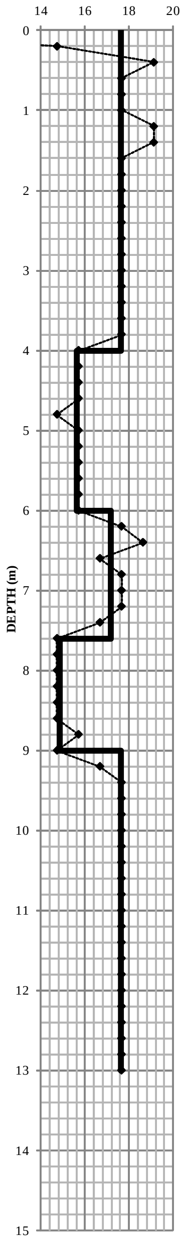
SHEET : 4 OF 4

DMT'S SHEAR WAVE VELOCITY

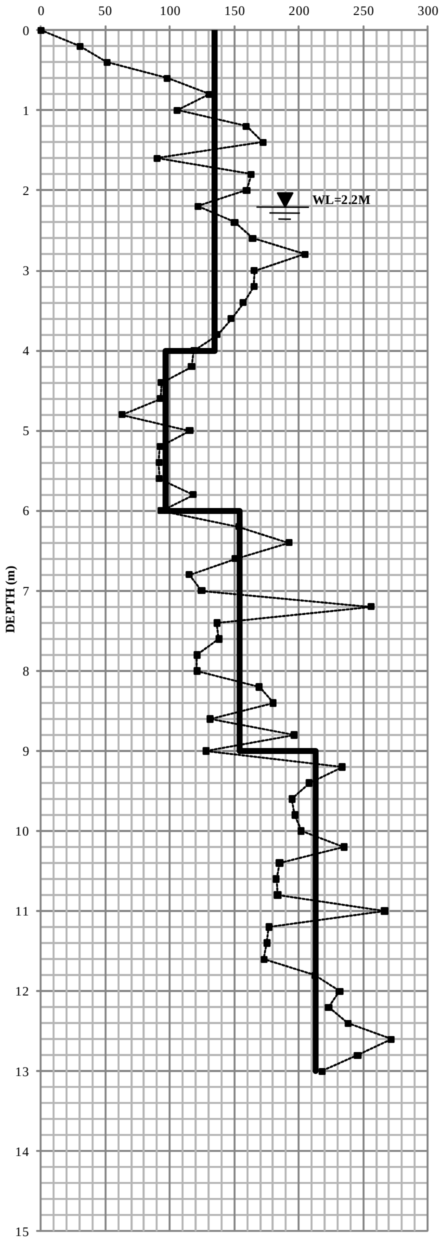
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS J		**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	**X** : -	**Y** : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010	TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	I_D	K_D	E_D (Bars)	R_{M0}	R_M	G_0	γ_{soil} (kN/m^3)	V_s (m/s)
200	0.67	200.9	136.6	5.34	0.85	13.79	14.72	30
400	1.24	76.7	224.1	4.43	0.79	51.20	19.13	51
600	2.16	16.7	129.3	1.34	2.76	172.89	17.66	98
800	0.70	34.3	114.8	-1.08	4.42	306.53	17.66	130
1000	0.49	11.8	34.6	-	2.67	201.46	17.66	106
1200	0.73	35.1	187.6	-1.09	4.46	494.99	19.13	159
1400	0.96	22.6	187.6	-0.22	3.46	577.60	19.13	172
1600	0.20	13.5	27.3	-	2.81	146.02	17.66	90
1800	0.87	11.1	107.5	0.26	2.60	478.47	17.66	163
2000	0.77	10.6	100.2	0.18	2.56	457.95	17.66	160
2200	0.35	7.3	34.6	-	2.18	266.98	17.66	122
2400	0.74	6.8	71.0	0.33	2.14	406.47	17.66	150
2600	0.88	6.0	78.3	0.53	2.07	485.00	17.66	164
2800	1.40	4.4	92.9	1.15	2.02	755.62	17.66	205
3000	0.79	6.8	85.6	0.39	2.15	492.16	17.66	165
3200	0.89	4.9	71.0	0.59	1.91	491.65	17.66	165
3400	0.80	4.7	63.8	0.51	1.85	442.67	17.66	157
3600	0.71	4.6	56.5	0.42	1.79	392.13	17.66	148
3800	0.72	3.3	41.9	0.49	1.52	336.58	17.66	137
4000	0.44	2.5	20.0	-	1.06	225.26	15.70	119
4200	0.34	3.1	20.0	-	1.30	218.16	15.70	117
4400	0.22	3.0	12.8	-	1.27	139.62	15.70	93
4600	0.20	3.3	12.8	-	1.36	137.05	15.70	93
4800	0.09	3.2	5.5	-	1.34	59.06	14.72	63
5000	0.29	3.4	20.0	-	1.40	213.05	15.70	115
5200	0.18	3.3	12.8	-	1.38	136.47	15.70	92
5400	0.17	3.6	12.8	-	1.44	133.93	15.70	91
5600	0.17	3.5	12.8	-	1.42	135.02	15.70	92
5800	0.44	2.1	20.0	-	0.90	223.76	15.70	118
6000	0.19	3.0	12.8	-	1.26	140.09	15.70	94
6200	0.32	7.6	56.5	-	2.22	424.96	17.66	154
6400	0.41	14.3	136.6	-	2.87	703.87	18.64	192
6600	0.55	2.6	34.6	-	1.14	386.98	16.68	151
6800	0.44	1.2	12.8	-	0.85	238.70	17.66	115
7000	0.87	0.6	12.8	0.79	0.85	280.00	17.66	125
7200	11.34	1.2	362.5	-	0.85	1178.90	17.66	256
7400	0.96	0.5	12.8	0.89	0.85	317.31	16.68	137
7600	0.91	0.2	5.5	0.85	0.85	285.62	14.72	138
7800	-3.41	-0.1	5.5	-	0.85	220.00	14.72	121
8000	-2.41	-0.1	5.5	-	0.85	220.00	14.72	121
8200	1.37	0.1	5.5	1.33	0.85	429.85	14.72	169
8400	1.64	0.1	5.5	1.62	0.81	487.79	14.72	180
8600	2.05	0.1	5.5	2.05	1.59	259.20	14.72	131
8800	1.22	1.0	34.6	1.13	1.13	617.37	15.70	196
9000	4.11	0.0	5.5	-	0.85	245.88	14.72	128
9200	2.90	0.2	20.0	2.94	3.21	929.40	16.68	234
9400	1.24	1.3	49.2	1.14	1.31	779.82	17.66	208
9600	0.61	6.2	114.8	0.23	2.03	681.39	17.66	195
9800	0.53	4.3	71.0	-	1.64	698.49	17.66	197
10000	0.51	4.9	78.3	-	1.77	733.58	17.66	202
10200	1.11	2.8	100.2	0.93	1.63	993.91	17.66	235
10400	0.70	3.4	78.3	0.47	1.55	616.72	17.66	185
10600	0.67	3.5	78.3	0.43	1.56	600.29	17.66	183
10800	0.74	2.9	71.0	0.53	1.43	606.52	17.66	184
11000	1.39	1.9	92.9	1.26	1.62	1279.11	17.66	267
11200	0.72	2.5	63.8	0.53	1.33	563.69	17.66	177
11400	0.62	3.3	71.0	0.39	1.47	552.71	17.66	175
11600	0.45	3.0	49.2	-	1.27	538.66	17.66	173
11800	0.64	5.5	129.3	0.30	1.93	813.13	17.66	213
12000	0.53	5.4	107.5	0.19	1.89	965.69	17.66	232
12200	0.90	3.0	100.2	0.70	1.55	896.69	17.66	223
12400	2.62	0.4	41.9	2.63	2.68	1021.55	17.66	238
12600	1.38	1.6	85.6	1.28	1.53	1329.57	17.66	272
12800	1.06	2.6	107.5	0.88	1.55	1086.83	17.66	246
13000	0.82	3.1	100.2	0.61	1.53	855.25	17.66	218

ESTIMATED γ_{SOIL}



ESTIMATED SHEAR WAVE VELOCITY (Vs) PROFILE BASED ON MONACO ET AL. (2009)



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

APPENDIX C

CONE PENETRATION TEST (CPT) DATA

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CONE PENETRATION TEST (CPT)

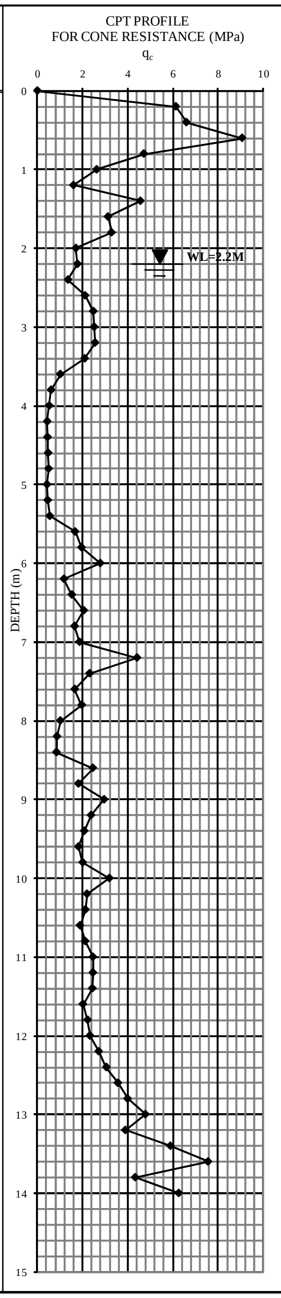
CPT#1

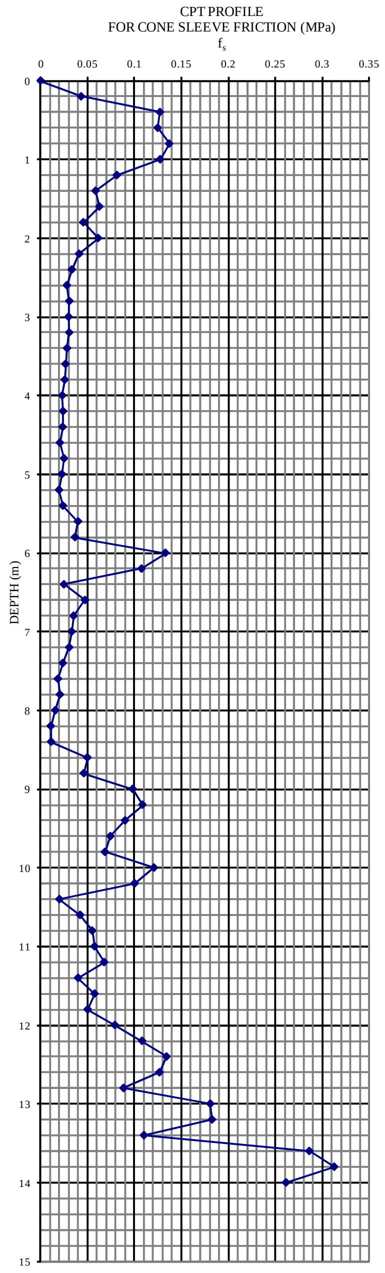
SHEET : 1 OF 4

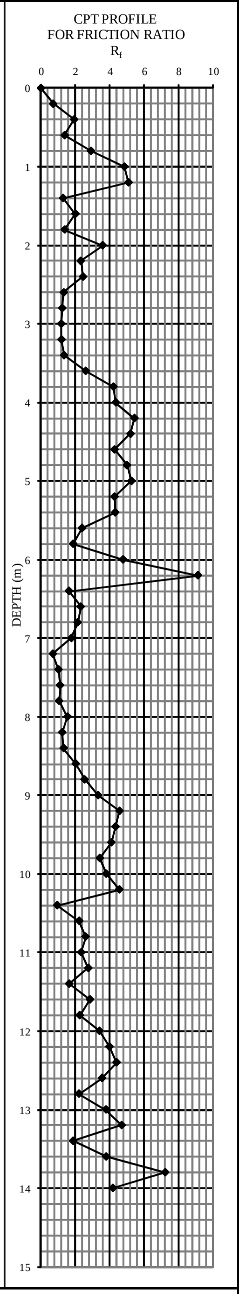
CPT GRAPHS

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (MPa)	f_s (MPa)	R_f
200	6.14	0.04	0.70
400	6.61	0.13	1.93
600	9.08	0.12	1.38
800	4.72	0.14	2.90
1000	2.63	0.13	4.85
1200	1.6	0.08	5.08
1400	4.57	0.06	1.28
1600	3.13	0.06	2.00
1800	3.29	0.05	1.38
2000	1.71	0.06	3.58
2200	1.78	0.04	2.31
2400	1.36	0.03	2.44
2600	2.11	0.03	1.32
2800	2.48	0.03	1.23
3000	2.52	0.03	1.18
3200	2.56	0.03	1.19
3400	2.1	0.03	1.34
3600	1.02	0.03	2.60
3800	0.61	0.03	4.20
4000	0.53	0.02	4.35
4200	0.44	0.02	5.43
4400	0.45	0.02	5.20
4600	0.48	0.02	4.27
4800	0.5	0.02	4.99
5000	0.43	0.02	5.26
5200	0.46	0.02	4.27
5400	0.55	0.02	4.31
5600	1.67	0.04	2.39
5800	1.96	0.04	1.87
6000	2.79	0.13	4.77
6200	1.18	0.11	9.11
6400	1.53	0.02	1.62
6600	2.06	0.05	2.30
6800	1.65	0.04	2.13
7000	1.87	0.03	1.77
7200	4.42	0.03	0.69
7400	2.32	0.02	1.02
7600	1.66	0.02	1.11
7800	1.97	0.02	1.05
8000	1.02	0.02	1.54
8200	0.87	0.01	1.23
8400	0.85	0.01	1.32
8600	2.46	0.05	2.02
8800	1.82	0.05	2.53
9000	2.96	0.10	3.32
9200	2.38	0.11	4.56
9400	2.08	0.09	4.33
9600	1.82	0.07	4.09
9800	2.01	0.07	3.41
10000	3.19	0.12	3.79
10200	2.2	0.10	4.55
10400	2.13	0.02	0.94
10600	1.89	0.04	2.22
10800	2.12	0.05	2.59
11000	2.46	0.06	2.34
11200	2.46	0.07	2.75
11400	2.44	0.04	1.64
11600	2.02	0.06	2.85
11800	2.23	0.05	2.25
12000	2.33	0.08	3.39
12200	2.72	0.11	3.98
12400	3.06	0.13	4.39
12600	3.57	0.13	3.55
12800	4	0.09	2.21
13000	4.79	0.18	3.78
13200	3.9	0.18	4.69
13400	5.9	0.11	1.87
13600	7.57	0.29	3.79
13800	4.34	0.31	7.21
14000	6.27	0.26	4.18







REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

CPT#1

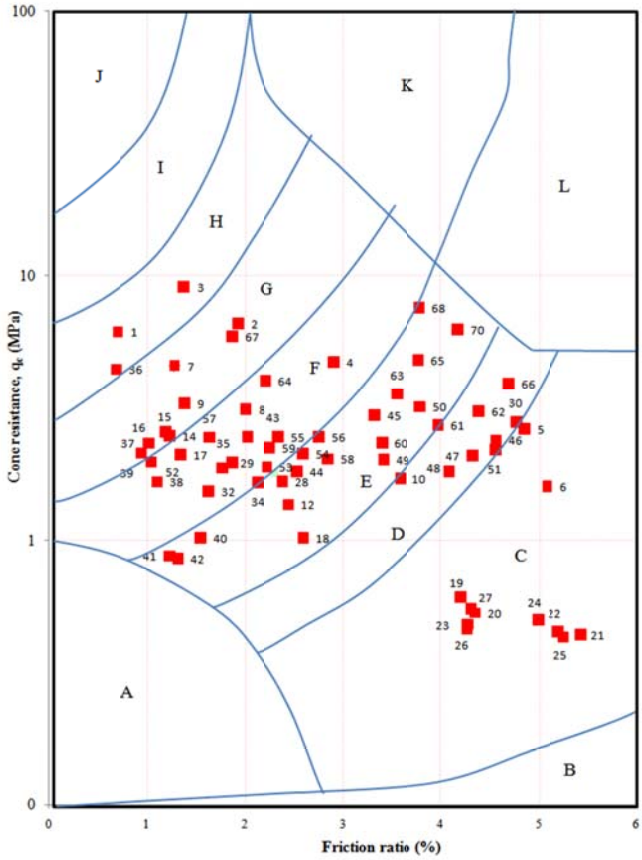
SHEET : 2 OF 4

SOIL INTERPRETATION

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

Proposed soil clasification system from CPT data (Robertson et al., 1985)

DEPTH (mm)	q_c (MPa)	f_s (kPa)	R_f	Interpretation of soil type behaviour	DEPTH (m)
200	6.14	43.15	0.70	(1) Sandy to silty sand	
400	6.61	127.25	1.93	(2) Silty sand to sandy silt	
600	9.08	124.85	1.38	(3) Sandy to silty sand	
800	4.72	137.1	2.90	(4) Sandy silt to clayey silt	
1000	2.63	127.47	4.85	(5) Silty clay	1
1200	1.6	81.35	5.08	(6) Clay	
1400	4.57	58.5	1.28	(7) Silty sand to sandy silt	
1600	3.13	62.65	2.00	(8) Sandy silt to clayey silt	
1800	3.29	45.45	1.38	(9) Silty sand to sandy silt	
2000	1.71	61.26	3.58	(10) Silty clay	2
2200	1.78	41.05	2.31	(11) Silty clay	
2400	1.36	33.25	2.44	(12) Clayey silt to silty clay	
2600	2.11	27.95	1.32	(13) Sandy silt to clayey silt	
2800	2.48	30.6	1.23	(14) Sandy silt	
3000	2.52	29.74	1.18	(15) Sandy silt	3
3200	2.56	30.53	1.19	(16) Sandy silt	
3400	2.1	28.15	1.34	(17) Sandy silt to clayey silt	
3600	1.02	26.5	2.60	(18) Clayey silt to silty clay	
3800	0.61	25.65	4.20	(19) Clay	
4000	0.53	23.05	4.35	(20) Clay	4
4200	0.44	23.89	5.43	(21) Clay	
4400	0.45	23.4	5.20	(22) Clay	
4600	0.48	20.5	4.27	(23) Clay	
4800	0.5	24.95	4.99	(24) Clay	
5000	0.43	22.6	5.26	(25) Clay	5
5200	0.46	19.63	4.27	(26) Clay	
5400	0.55	23.7	4.31	(27) Clay	
5600	1.67	39.85	2.39	(28) Clayey silt to silty clay	
5800	1.96	36.63	1.87	(29) Sandy silt to clayey silt	
6000	2.79	132.95	4.77	(30) Silty clay to clay	6
6200	1.18	107.55	9.11	(31) Clay	
6400	1.53	24.85	1.62	(32) Sandy silt to clayey silt	
6600	2.06	47.42	2.30	(33) Sandy silt to clayey silt	
6800	1.65	35.1	2.13	(34) Clayey silt to silty clay	
7000	1.87	33.05	1.77	(35) Sandy silt to clayey silt	7
7200	4.42	30.47	0.69	(36) Sandy to silty sand	
7400	2.32	23.6	1.02	(37) Silty sand to sandy silt	
7600	1.66	18.35	1.11	(38) Sandy silt to clayey silt	
7800	1.97	20.6	1.05	(39) Sandy silt to clayey silt	
8000	1.02	15.75	1.54	(40) Clayey silt to silty clay	8
8200	0.87	10.74	1.23	(41) Clayey silt to silty clay	
8400	0.85	11.2	1.32	(42) Clayey silt to silty clay	
8600	2.46	49.75	2.02	(43) Sandy silt to clayey silt	
8800	1.82	46.1	2.53	(44) Clayey silt to silty clay	
9000	2.96	98.16	3.32	(45) Clayey silt to silty clay	9
9200	2.38	108.55	4.56	(46) Clay	
9400	2.08	90	4.33	(47) Silty clay to clay	
9600	1.82	74.4	4.09	(48) Silty clay to clay	
9800	2.01	68.6	3.41	(49) Silty clay to clay	
10000	3.19	120.9	3.79	(50) Clayey silt to silty clay	10
10200	2.2	100.17	4.55	(51) Silty clay to clay	
10400	2.13	20.1	0.94	(52) Sandy silt to clayey silt	
10600	1.89	42.05	2.22	(53) Clayey silt to silty clay	
10800	2.12	54.9	2.59	(54) Clayey silt to silty clay	
11000	2.46	57.5	2.34	(55) Clayey silt to silty clay	11
11200	2.46	67.68	2.75	(56) Clayey silt to silty clay	
11400	2.44	39.95	1.64	(57) Silty sand to sandy silt	
11600	2.02	57.5	2.85	(58) Clayey silt to silty clay	
11800	2.23	50.16	2.25	(59) Clayey silt to silty clay	
12000	2.33	79.1	3.39	(60) Clayey silt to silty clay	12
12200	2.72	108.16	3.98	(61) Silty clay to clay	
12400	3.06	134.25	4.39	(62) Silty clay to clay	
12600	3.57	126.75	3.55	(63) Clayey silt to silty clay	
12800	4	88.42	2.21	(64) Sandy silt to clayey silt	
13000	4.79	180.9	3.78	(65) Clayey silt to silty clay	13
13200	3.9	182.79	4.69	(66) Silty clay to clay	
13400	5.9	110.16	1.87	(67) Silty sand to sandy silt	
13600	7.57	286.55	3.79	(68) Sandy silt to clayey silt	
13800	4.34	313.05	7.21	(69) Clay	
14000	6.27	261.8	4.18	(70) Clayey silt to silty clay	14



Note:

A- Sensitive fine grained
B- Organic material
C- Clay
D- Silty clay to clay
E- Clayey silt to silty clay
F- Sandy silt to clayey silt
G- Silty sand to sandy silt
H- Sandy to silty sand
I- Sand
J- Gravelly sand to sand
K- Very stiff fine grained
L- Sand to clayey sand

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

CPT#1

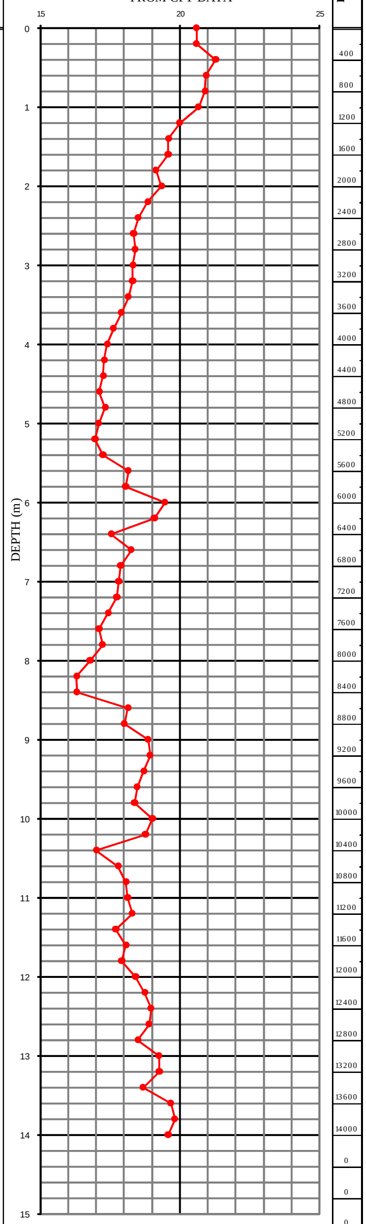
SHEET : 3 OF 4

ESTIMATING UNIT WEIGHT OF THE SOIL

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		
REDUCE LEVEL	: - m	**OPERATOR**	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan	**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (MPa)	f_s (kPa)	R_f	f_1	f_2	f_3	c	V_s (m/s) Hegazy & Mayne (1996)	γ (kN/m^3) Mayne et al. (2011)
200	6.14	43.15	0.70	0.43	-0.32	1.26	0.52	219.11	**20.60**
400	6.61	127.25	1.93	0.42	-0.32	1.27	0.37	302.44	**21.28**
600	9.08	124.85	1.38	0.38	-0.34	1.35	0.37	297.19	**20.93**
800	4.72	137.1	2.90	0.47	-0.30	1.21	0.36	311.68	**20.90**
1000	2.63	127.47	4.85	0.57	-0.26	1.12	0.39	304.91	**20.67**
1200	1.6	81.35	5.08	0.67	-0.22	1.08	0.48	262.21	**20.00**
1400	4.57	58.5	1.28	0.47	-0.30	1.20	0.46	241.52	**19.59**
1600	3.13	62.65	2.00	0.54	-0.28	1.14	0.46	246.88	**19.58**
1800	3.29	45.45	1.38	0.53	-0.28	1.15	0.50	224.28	**19.15**
2000	1.71	61.26	3.58	0.65	-0.22	1.08	0.50	241.58	**19.34**
2200	1.78	41.05	2.31	0.64	-0.23	1.09	0.54	214.61	**18.85**
2400	1.36	33.25	2.44	0.70	-0.20	1.07	0.60	198.68	**18.51**
2600	2.11	27.95	1.32	0.61	-0.24	1.10	0.58	192.41	**18.34**
2800	2.48	30.6	1.23	0.58	-0.26	1.12	0.56	198.52	**18.40**
3000	2.52	29.74	1.18	0.57	-0.26	1.12	0.57	196.89	**18.32**
3200	2.56	30.53	1.19	0.57	-0.26	1.12	0.56	198.50	**18.30**
3400	2.1	28.15	1.34	0.61	-0.24	1.10	0.58	192.80	**18.16**
3600	1.02	26.5	2.60	0.77	-0.17	1.05	0.66	181.72	**17.90**
3800	0.61	25.65	4.20	0.92	-0.11	1.03	0.79	170.00	**17.62**
4000	0.53	23.05	4.35	0.96	-0.09	1.03	0.84	161.29	**17.40**
4200	0.44	23.89	5.43	1.02	-0.06	1.02	0.92	158.06	**17.29**
4400	0.45	23.4	5.20	1.02	-0.07	1.02	0.91	157.70	**17.25**
4600	0.48	20.5	4.27	0.99	-0.08	1.02	0.89	153.25	**17.12**
4800	0.5	24.95	4.99	0.98	-0.08	1.03	0.86	163.65	**17.32**
5000	0.43	22.6	5.26	1.03	-0.06	1.02	0.93	154.80	**17.09**
5200	0.46	19.63	4.27	1.01	-0.07	1.02	0.91	150.18	**16.96**
5400	0.55	23.7	4.31	0.95	-0.10	1.03	0.83	163.56	**17.24**
5600	1.67	39.85	2.39	0.66	-0.22	1.08	0.55	212.11	**18.15**
5800	1.96	36.63	1.87	0.62	-0.24	1.09	0.55	208.17	**18.06**
6000	2.79	132.95	4.77	0.56	-0.27	1.13	0.38	309.05	**19.46**
6200	1.18	107.55	9.11	0.74	-0.19	1.06	0.49	279.86	**19.08**
6400	1.53	24.85	1.62	0.68	-0.21	1.08	0.62	183.29	**17.53**
6600	2.06	47.42	2.30	0.61	-0.24	1.10	0.51	225.31	**18.26**
6800	1.65	35.1	2.13	0.66	-0.22	1.08	0.57	204.07	**17.88**
7000	1.87	33.05	1.77	0.63	-0.23	1.09	0.57	201.50	**17.81**
7200	4.42	30.47	0.69	0.48	-0.30	1.20	0.56	198.67	**17.74**
7400	2.32	23.6	1.02	0.59	-0.25	1.11	0.60	183.36	**17.43**
7600	1.66	18.35	1.11	0.66	-0.22	1.08	0.66	168.04	**17.10**
7800	1.97	20.6	1.05	0.62	-0.24	1.10	0.63	175.19	**17.23**
8000	1.02	15.75	1.54	0.77	-0.17	1.05	0.73	155.46	**16.78**
8200	0.87	10.74	1.23	0.82	-0.15	1.04	0.80	136.56	**16.29**
8400	0.85	11.2	1.32	0.82	-0.15	1.04	0.79	137.96	**16.31**
8600	2.46	49.75	2.02	0.58	-0.26	1.12	0.50	229.64	**18.14**
8800	1.82	46.1	2.53	0.64	-0.23	1.09	0.53	222.41	**18.01**
9000	2.96	98.16	3.32	0.55	-0.27	1.14	0.41	282.36	**18.85**
9200	2.38	108.55	4.56	0.59	-0.25	1.11	0.41	289.99	**18.94**
9400	2.08	90	4.33	0.61	-0.24	1.10	0.44	273.15	**18.70**
9600	1.82	74.4	4.09	0.64	-0.23	1.09	0.47	256.76	**18.47**
9800	2.01	68.6	3.41	0.62	-0.24	1.10	0.47	251.50	**18.38**
10000	3.19	120.9	3.79	0.53	-0.28	1.15	0.38	300.74	**19.01**
10200	2.2	100.17	4.55	0.60	-0.25	1.11	0.42	282.53	**18.77**
10400	2.13	20.1	0.94	0.61	-0.24	1.10	0.63	174.34	**17.01**
10600	1.89	42.05	2.22	0.63	-0.23	1.09	0.54	216.68	**17.78**
10800	2.12	54.9	2.59	0.61	-0.24	1.10	0.49	235.64	**18.07**
11000	2.46	57.5	2.34	0.58	-0.26	1.12	0.48	239.83	**18.12**
11200	2.46	67.68	2.75	0.58	-0.26	1.12	0.46	251.85	**18.29**
11400	2.44	39.95	1.64	0.58	-0.26	1.12	0.53	214.98	**17.70**
11600	2.02	57.5	2.85	0.62	-0.24	1.10	0.49	238.57	**18.07**
11800	2.23	50.16	2.25	0.60	-0.25	1.11	0.50	229.67	**17.92**
12000	2.33	79.1	3.39	0.59	-0.25	1.11	0.45	263.60	**18.40**
12200	2.72	108.16	3.98	0.56	-0.26	1.13	0.40	290.40	**18.74**
12400	3.06	134.25	4.39	0.54	-0.27	1.14	0.37	310.25	**18.97**
12600	3.57	126.75	3.55	0.51	-0.29	1.16	0.37	305.11	**18.90**
12800	4	88.42	2.21	0.49	-0.29	1.18	0.41	273.75	**18.50**
13000	4.79	180.9	3.78	0.47	-0.31	1.21	0.33	338.63	**19.25**
13200	3.9	182.79	4.69	0.50	-0.29	1.18	0.33	340.44	**19.26**
13400	5.9	110.16	1.87	0.43	-0.32	1.25	0.38	290.56	**18.68**
13600	7.57	286.55	3.79	0.40	-0.33	1.30	0.28	384.09	**19.68**
13800	4.34	313.05	7.21	0.48	-0.30	1.19	0.28	399.72	**19.81**
14000	6.27	261.8	4.18	0.43	-0.32	1.26	0.29	376.10	**19.58**

ESTIMATED UNIT WEIGHT (γ) PROFILE FROM CPT DATA



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

CPT#1

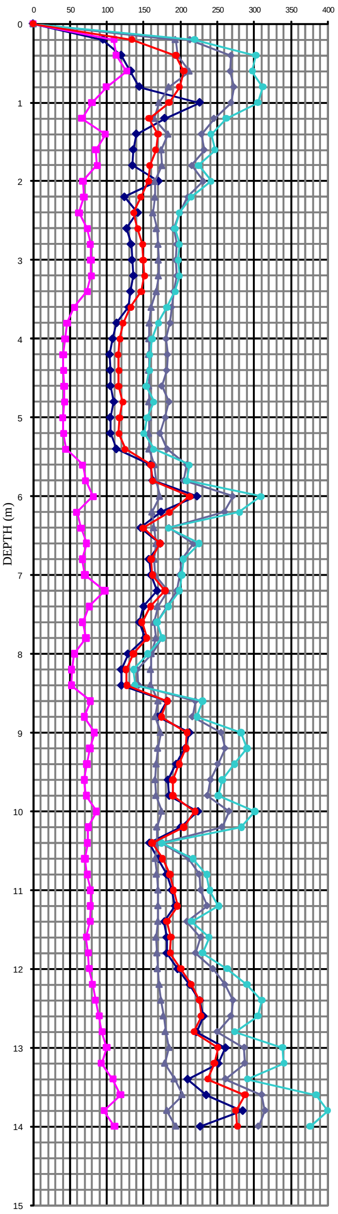
SHEET : 4 OF 4

ESTIMATING SHEAR WAVE VELOCITY

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	F	Q	I_c	V_S (m/s) Barrow & Stokoe (1983)	V_S (m/s) Hegazy & Mayne (1996)	V_S (m/s) Mayne (2003)	V_S (m/s) Lyisan (1996)	V_S (m/s) Andrus et al. (2003)	V_S (m/s) Robertson et al. (1986)
200	6140	43.15	0.70	316	1.44	**193.30**	**219.11**	**212.74**	**109.61**	**94.71**	**134.16**
400	6610	127.25	1.93	162.10	1.96	**196.30**	**302.44**	**268.53**	**112.70**	**119.30**	**193.75**
600	9080	124.85	1.38	195.44	1.80	**212.11**	**297.19**	**267.55**	**127.04**	**132.45**	**204.47**
800	4720	137.10	2.92	88.40	2.27	**184.21**	**311.68**	**272.38**	**99.27**	**143.97**	**198.58**
1000	2630	127.47	4.89	47.43	2.62	**170.83**	**304.91**	**268.62**	**79.62**	**225.71**	**184.27**
1200	1600	81.35	5.16	30.33	2.77	**164.24**	**262.21**	**245.45**	**66.02**	**178.25**	**157.32**
1400	4570	58.50	1.29	80.29	2.05	**183.25**	**241.52**	**228.44**	**98.06**	**139.89**	**169.24**
1600	3130	62.65	2.02	51.36	2.33	**174.03**	**246.88**	**231.97**	**85.02**	**135.66**	**166.43**
1800	3290	45.45	1.40	53.49	2.21	**175.06**	**224.28**	**215.42**	**86.64**	**134.68**	**158.14**
2000	1710	61.26	3.67	26.08	2.72	**164.94**	**241.58**	**230.82**	**67.70**	**169.90**	**156.50**
2200	1780	41.05	2.36	26.89	2.59	**165.39**	**214.61**	**210.16**	**68.73**	**123.87**	**146.36**
2400	1360	33.25	2.53	20.24	2.71	**162.70**	**198.68**	**199.29**	**62.10**	**141.86**	**136.58**
2600	2110	27.95	1.36	30.12	2.41	**167.50**	**192.41**	**190.33**	**73.28**	**126.81**	**141.61**
2800	2480	30.60	1.26	33.69	2.35	**169.87**	**198.52**	**195.00**	**77.88**	**132.68**	**148.38**
3000	2520	29.74	1.21	33.04	2.35	**170.13**	**196.89**	**193.53**	**78.35**	**134.12**	**149.14**
3200	2560	30.53	1.22	32.34	2.36	**170.38**	**198.50**	**194.89**	**78.82**	**136.07**	**151.33**
3400	2100	28.15	1.38	25.72	2.47	**167.44**	**192.80**	**190.70**	**73.15**	**132.04**	**146.50**
3600	1020	26.50	2.79	12.01	2.91	**160.53**	**181.72**	**187.58**	**55.71**	**129.60**	**132.18**
3800	610	25.65	4.78	6.84	3.25	**157.90**	**170.00**	**185.90**	**45.90**	**113.33**	**122.04**
4000	530	23.05	5.09	5.65	3.33	**157.39**	**161.29**	**180.39**	**43.53**	**107.86**	**117.68**
4200	440	23.89	6.64	4.40	3.49	**156.82**	**158.06**	**182.23**	**40.58**	**103.67**	**115.28**
4400	450	23.40	6.39	4.30	3.49	**156.88**	**157.70**	**181.16**	**40.92**	**104.57**	**116.24**
4600	480	20.50	5.22	4.44	3.42	**157.07**	**153.25**	**174.34**	**41.93**	**104.94**	**115.74**
4800	500	24.95	6.09	4.45	3.46	**157.20**	**163.65**	**184.47**	**42.58**	**109.54**	**121.61**
5000	430	22.60	6.73	3.56	3.57	**156.75**	**154.80**	**179.37**	**40.23**	**104.57**	**116.96**
5200	460	19.63	5.41	3.71	3.50	**156.94**	**150.18**	**172.10**	**41.27**	**104.87**	**116.26**
5400	550	23.70	5.28	4.45	3.43	**157.52**	**163.56**	**181.82**	**44.14**	**112.84**	**124.74**
5600	1670	39.85	2.55	15.19	2.81	**164.69**	**212.11**	**208.63**	**67.09**	**158.88**	**160.20**
5800	1960	36.63	1.98	17.64	2.69	**166.54**	**208.17**	**204.28**	**71.27**	**162.16**	**161.83**
6000	2790	132.95	4.96	25.45	2.82	**171.86**	**309.05**	**270.79**	**81.42**	**222.00**	**212.45**
6200	1180	107.55	10.11	9.84	3.33	**161.55**	**279.86**	**259.86**	**58.86**	**173.47**	**185.19**
6400	1530	24.85	1.76	12.58	2.79	**163.79**	**183.29**	**184.26**	**64.92**	**145.87**	**149.14**
6600	2060	47.42	2.45	17.31	2.75	**167.18**	**225.31**	**217.60**	**72.62**	**172.30**	**172.22**
6800	1650	35.10	2.30	13.25	2.83	**164.56**	**204.07**	**202.08**	**66.79**	**156.92**	**160.10**
7000	1870	33.05	1.90	14.90	2.74	**165.97**	**201.50**	**198.98**	**70.02**	**159.73**	**161.68**
7200	4420	30.47	0.71	36.20	2.19	**182.29**	**198.67**	**194.78**	**96.84**	**168.11**	**179.03**
7400	2320	23.60	1.08	17.95	2.55	**168.85**	**183.36**	**181.60**	**75.95**	**149.90**	**159.38**
7600	1660	18.35	1.21	12.10	2.72	**164.62**	**168.04**	**168.62**	**66.94**	**144.10**	**147.66**
7800	1970	20.60	1.13	14.44	2.64	**166.61**	**175.19**	**174.59**	**71.41**	**151.63**	**154.11**
8000	1020	15.75	1.80	6.57	3.04	**160.53**	**155.46**	**160.74**	**55.71**	**128.63**	**135.83**
8200	870	10.74	1.49	5.18	3.09	**159.57**	**136.56**	**140.98**	**52.47**	**119.44**	**126.19**
8400	850	11.20	1.61	4.93	3.12	**159.44**	**137.96**	**143.15**	**52.01**	**119.80**	**126.90**
8600	2460	49.75	2.16	18.25	2.70	**169.74**	**229.64**	**220.08**	**77.64**	**181.56**	**182.16**
8800	1820	46.10	2.78	12.82	2.89	**165.65**	**222.41**	**216.15**	**69.31**	**169.13**	**173.97**
9000	2960	98.16	3.51	22.62	2.76	**172.94**	**282.36**	**255.14**	**83.25**	**211.84**	**208.68**
9200	2380	108.55	4.91	17.71	2.93	**169.23**	**289.99**	**260.33**	**76.68**	**206.11**	**207.48**
9400	2080	90.00	4.72	14.91	2.98	**167.31**	**273.15**	**250.66**	**72.88**	**194.01**	**198.20**
9600	1820	74.40	4.53	12.50	3.02	**165.65**	**256.76**	**240.84**	**69.31**	**182.90**	**189.38**
9800	2010	68.60	3.75	13.78	2.94	**166.86**	**251.50**	**236.66**	**71.95**	**184.57**	**189.37**
10000	3190	120.90	4.02	23.65	2.78	**174.42**	**300.74**	**265.89**	**85.64**	**223.54**	**219.76**
10200	2200	100.17	4.98	15.31	2.98	**168.08**	**282.53**	**256.19**	**74.44**	**200.24**	**204.38**
10400	2130	20.10	1.04	12.84	2.67	**167.63**	**174.34**	**173.32**	**73.54**	**157.80**	**161.34**
10600	1890	42.05	2.48	11.81	2.89	**166.10**	**216.68**	**211.40**	**70.30**	**170.06**	**175.61**
10800	2120	54.90	2.86	13.63	2.87	**167.57**	**235.64**	**225.16**	**73.41**	**181.03**	**185.63**
11000	2460	57.50	2.55	16.03	2.79	**169.74**	**239.83**	**227.55**	**77.64**	**187.85**	**190.61**
11200	2460	67.68	3.00	16.09	2.83	**169.74**	**251.85**	**235.96**	**77.64**	**192.80**	**195.72**
11400	2440	39.95	1.79	15.05	2.72	**169.62**	**214.98**	**208.76**	**77.41**	**178.15**	**181.34**
11600	2020	57.50	3.18	12.40	2.94	**166.93**	**238.57**	**227.55**	**72.08**	**181.14**	**187.08**
11800	2230	50.16	2.49	13.60	2.84	**168.27**	**229.67**	**220.50**	**74.82**	**181.24**	**185.82**
12000	2330	79.10	3.75	14.76	2.92	**168.91**	**263.60**	**244.00**	**76.07**	**195.86**	**200.44**
12200	2720	108.16	4.33	17.94	2.89	**171.41**	**290.40**	**260.15**	**80.64**	**212.62**	**214.85**
12400	3060	134.25	4.74	20.69	2.87	**173.58**	**310.25**	**271.30**	**84.30**	**225.98**	**225.97**
12600	3570	126.75	3.80	24.24	2.75	**176.85**	**305.11**	**268.33**	**89.35**	**230.74**	**227.94**
12800	4000	88.42	2.35	26.33	2.59	**179.60**	**273.75**	**249.75**	**93.26**	**221.35**	**218.27**
13000	4790	180.90	3.97	33.91	2.66	**184.66**	**338.63**	**286.68**	**99.82**	**260.63**	**250.83**
13200	3900	182.79	5.00	27.01	2.80	**178.96**	**340.44**	**287.22**	**92.38**	**250.91**	**245.78**
13400	5900	110.16	1.95	39.76	2.40	**191.76**	**290.56**	**261.09**	**107.98**	**209.39**	**237.19**
13600	7570	286.55	3.91	56.07	2.50	**202.45**	**384.09**	**310.42**	**118.62**	**234.57**	**287.61**
13800	4340	313.05	7.66	31.16	2.89	**181.78**	**399.72**	**314.98**	**96.17**	**283.99**	**274.92**
14000	6270	261.80	4.35	45.27	2.60	**194.13**	**376.10**	**305.75**	**110.48**	**226.41**	**277.27**

ESTIMATED SHEAR WAVE VELOCITY (Vs) PROFILE BASED ON VARIOUS PREVIOUS RESEARCHERS



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA	Reported by: Bambang Setiawan Signature : Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

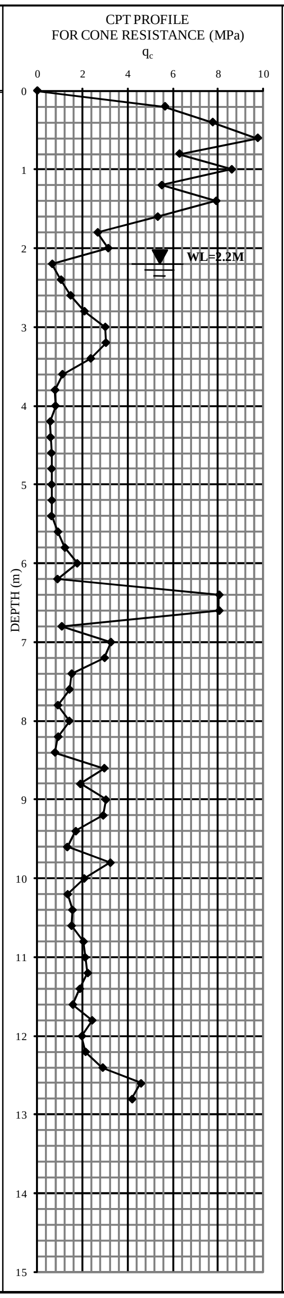
CPT#2

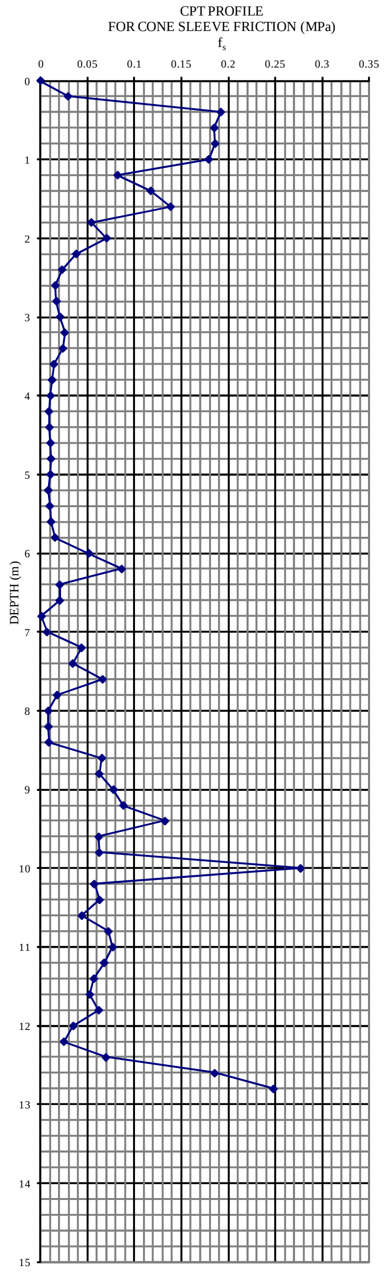
SHEET : 1 OF 4

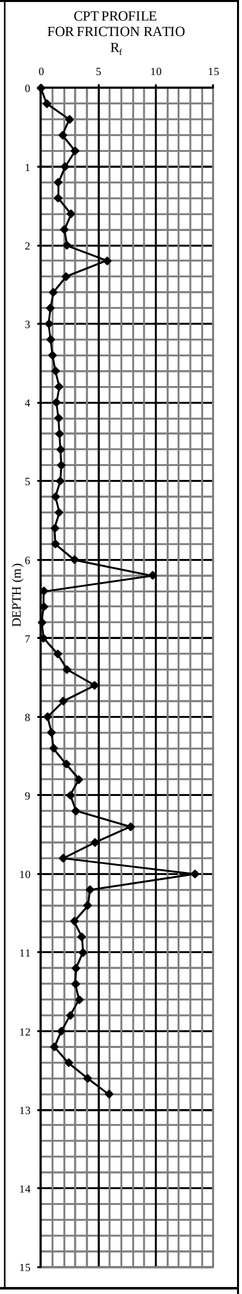
CPT GRAPHS

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (MPa)	f_s (MPa)	R_f
200	5.64	0.03	0.52
400	7.75	0.19	2.48
600	9.74	0.18	1.90
800	6.28	0.19	2.96
1000	8.59	0.18	2.08
1200	5.5	0.08	1.49
1400	7.9	0.12	1.49
1600	5.32	0.14	2.60
1800	2.67	0.05	2.02
2000	3.13	0.07	2.25
2200	0.66	0.04	5.75
2400	1.05	0.02	2.17
2600	1.47	0.02	1.06
2800	2.08	0.02	0.81
3000	3	0.02	0.69
3200	3.03	0.03	0.84
3400	2.36	0.02	1.00
3600	1.11	0.01	1.27
3800	0.78	0.01	1.57
4000	0.8	0.01	1.33
4200	0.57	0.01	1.54
4400	0.58	0.01	1.61
4600	0.62	0.01	1.71
4800	0.63	0.01	1.76
5000	0.63	0.01	1.67
5200	0.64	0.01	1.27
5400	0.62	0.01	1.56
5600	0.91	0.01	1.21
5800	1.22	0.02	1.25
6000	1.76	0.05	2.92
6200	0.89	0.09	9.70
6400	8.04	0.02	0.25
6600	8.04	0.02	0.25
6800	1.08	0.00	0.09
7000	3.25	0.01	0.21
7200	2.97	0.04	1.46
7400	1.52	0.03	2.25
7600	1.42	0.07	4.65
7800	0.91	0.02	1.93
8000	1.41	0.01	0.58
8200	0.92	0.01	0.90
8400	0.78	0.01	1.11
8600	2.96	0.07	2.21
8800	1.9	0.06	3.28
9000	3.03	0.08	2.56
9200	2.91	0.09	3.03
9400	1.7	0.13	7.79
9600	1.32	0.06	4.69
9800	3.23	0.06	1.93
10000	2.07	0.28	13.37
10200	1.34	0.06	4.25
10400	1.55	0.06	4.05
10600	1.51	0.04	2.91
10800	2.04	0.07	3.53
11000	2.11	0.08	3.64
11200	2.23	0.07	3.03
11400	1.88	0.06	3.01
11600	1.57	0.05	3.33
11800	2.42	0.06	2.56
12000	1.97	0.03	1.77
12200	2.13	0.02	1.16
12400	2.89	0.07	2.41
12600	4.58	0.19	4.05
12800	4.19	0.25	5.92







REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

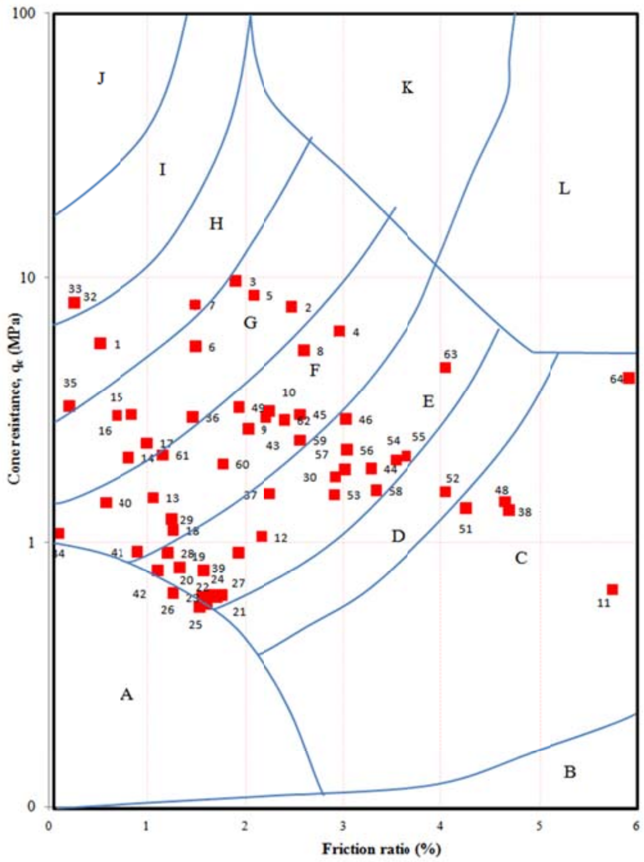
CPT#2

SHEET : 2 OF 4

SOIL INTERPRETATION

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

Proposed soil clasification system from CPT data (Robertson et al., 1985)



Note:

A- Sensitive fine grained
B- Organic material
C- Clay
D- Silty clay to clay
E- Clayey silt to silty clay
F- Sandy silt to clayey silt
G- Silty sand to sandy silt
H- Sandy to silty sand
I- Sand
J- Gravelly sand to sand
K- Very stiff fine grained
L- Sand to clayey sand

DEPTH (mm)	q_c (MPa)	f_s (kPa)	R_f	Interpretation of soil type behaviour	DEPTH (m)
200	5.64	29.2	0.52	(1) Sandy to silty sand	
400	7.75	191.9	2.48	(2) Silty sand to sandy silt	
600	9.74	184.95	1.90	(3) Silty sand to sandy silt	
800	6.28	185.9	2.96	(4) Sandy silt to clayey silt	
1000	8.59	179	2.08	(5) Silty sand to sandy silt	1
1200	5.5	82	1.49	(6) Silty sand to sandy silt	
1400	7.9	117.33	1.49	(7) Silty sand to sandy silt	
1600	5.32	138.4	2.60	(8) Clayey silt to silty clay	
1800	2.67	54.05	2.02	(9) Clayey silt to silty clay	
2000	3.13	70.32	2.25	(10) Sand	2
2200	0.66	37.95	5.75	(11) Clay	
2400	1.05	22.8	2.17	(12) Sandy silt to clayey silt	
2600	1.47	15.65	1.06	(13) Sandy silt to clayey silt	
2800	2.08	16.89	0.81	(14) Silty sand to sandy silt	
3000	3	20.8	0.69	(15) Silty sand to sandy silt	3
3200	3.03	25.6	0.84	(16) Silty sand to sandy silt	
3400	2.36	23.65	1.00	(17) Silty sand to sandy silt	
3600	1.11	14.05	1.27	(18) Sandy silt to clayey silt	
3800	0.78	12.25	1.57	(19) Clayey silt to silty clay	
4000	0.8	10.65	1.33	(20) Clayey silt to silty clay	4
4200	0.57	8.75	1.54	(21) Clayey silt to silty clay	
4400	0.58	9.32	1.61	(22) Clayey silt to silty clay	
4600	0.62	10.6	1.71	(23) Clayey silt to silty clay	
4800	0.63	11.1	1.76	(24) Clayey silt to silty clay	
5000	0.63	10.5	1.67	(25) Clayey silt to silty clay	5
5200	0.64	8.1	1.27	(26) Clayey silt to silty clay	
5400	0.62	9.68	1.56	(27) Clayey silt to silty clay	
5600	0.91	11.05	1.21	(28) Clayey silt to silty clay	
5800	1.22	15.3	1.25	(29) Sandy silt to clayey silt	
6000	1.76	51.37	2.92	(30) Clayey silt to silty clay	6
6200	0.89	86.3	9.70	(31) Clay	
6400	8.04	20.33	0.25	(32) Sand	
6600	8.04	20.3	0.25	(33) Sand	
6800	1.08	1	0.09	(34) Sandy silt to clayey silt	
7000	3.25	6.7	0.21	(35) Silty sand to sandy silt	7
7200	2.97	43.45	1.46	(36) Silty sand to sandy silt	
7400	1.52	34.2	2.25	(37) Clayey silt to silty clay	
7600	1.42	66	4.65	(38) Clay	
7800	0.91	17.55	1.93	(39) Clayey silt to silty clay	
8000	1.41	8.15	0.58	(40) Sandy silt to clayey silt	8
8200	0.92	8.32	0.90	(41) Sandy silt to clayey silt	
8400	0.78	8.65	1.11	(42) Clayey silt to silty clay	
8600	2.96	65.3	2.21	(43) Sandy silt to clayey silt	
8800	1.9	62.32	3.28	(44) Clayey silt to silty clay	
9000	3.03	77.7	2.56	(45) Sandy silt to clayey silt	9
9200	2.91	88.11	3.03	(46) Clayey silt to silty clay	
9400	1.7	132.4	7.79	(47) Clay	
9600	1.32	61.9	4.69	(48) Clay	
9800	3.23	62.37	1.93	(49) Sandy silt to clayey silt	
10000	2.07	276.84	13.37	(50) Clay	10
10200	1.34	57	4.25	(51) Clay	
10400	1.55	62.75	4.05	(52) Clay	
10600	1.51	43.9	2.91	(53) Clayey silt to silty clay	
10800	2.04	72.11	3.53	(54) Clayey silt to silty clay	
11000	2.11	76.9	3.64	(55) Clayey silt to silty clay	11
11200	2.23	67.65	3.03	(56) Clayey silt to silty clay	
11400	1.88	56.65	3.01	(57) Clayey silt to silty clay	
11600	1.57	52.3	3.33	(58) Clayey silt to silty clay	
11800	2.42	61.95	2.56	(59) Sandy silt to clayey silt	
12000	1.97	34.85	1.77	(60) Sandy silt to clayey silt	12
12200	2.13	24.75	1.16	(61) Sandy silt to clayey silt	
12400	2.89	69.55	2.41	(62) Sandy silt to clayey silt	
12600	4.58	185.35	4.05	(63) Clayey silt to silty clay	
12800	4.19	247.94	5.92	(64) Clay	12.8

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

SHEET : 3 OF 4

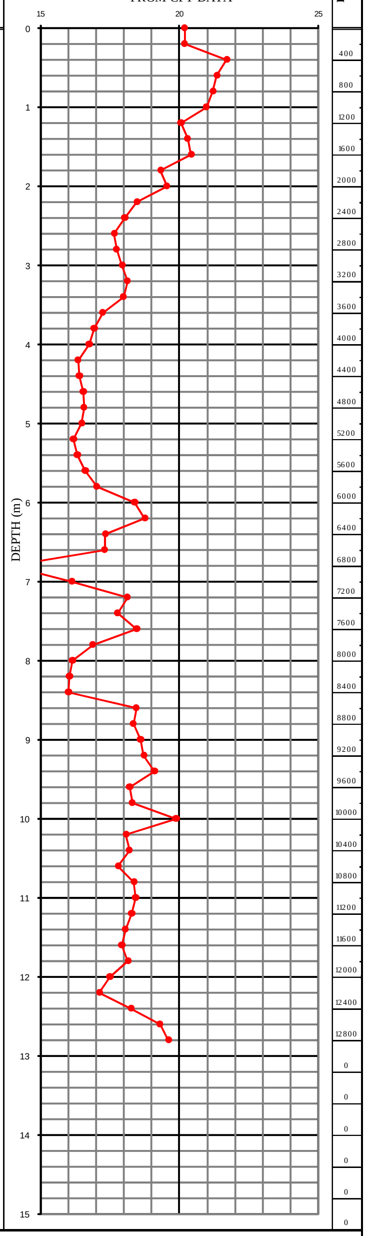
ESTIMATING UNIT WEIGHT OF THE SOIL

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	**q_c (MPa)**	**f_s (kPa)**	**R_f**	**f_1**	**f_2**	**f_3**	**c**	**V_s (m/s) Hegazy & Mayne (1996)**	**γ (kN/m^3) Mayne et al. (2011)**
200	5.64	29.2	0.52	0.44	-0.32	1.24	0.58	195.31	**20.18**
400	7.75	191.9	2.48	0.40	-0.33	1.31	0.32	340.27	**21.71**
600	9.74	184.95	1.90	0.37	-0.35	1.37	0.33	333.32	**21.35**
800	6.28	185.9	2.96	0.43	-0.32	1.26	0.32	339.38	**21.21**
1000	8.59	179	2.08	0.38	-0.34	1.33	0.33	331.89	**20.97**
1200	5.5	82	1.49	0.44	-0.31	1.23	0.42	266.38	**20.05**
1400	7.9	117.33	1.49	0.39	-0.33	1.31	0.38	293.36	**20.29**
1600	5.32	138.4	2.60	0.45	-0.31	1.23	0.36	311.89	**20.42**
1800	2.67	54.05	2.02	0.56	-0.26	1.13	0.48	235.77	**19.33**
2000	3.13	70.32	2.25	0.54	-0.28	1.14	0.44	255.59	**19.55**
2200	0.66	37.95	5.75	0.89	-0.12	1.03	0.73	193.22	**18.47**
2400	1.05	22.8	2.17	0.77	-0.18	1.05	0.68	174.13	**18.03**
2600	1.47	15.65	1.06	0.69	-0.21	1.07	0.69	159.21	**17.65**
2800	2.08	16.89	0.81	0.61	-0.24	1.10	0.66	165.35	**17.74**
3000	3	20.8	0.69	0.54	-0.27	1.14	0.62	177.29	**17.94**
3200	3.03	25.6	0.84	0.54	-0.27	1.14	0.59	188.70	**18.12**
3400	2.36	23.65	1.00	0.59	-0.25	1.11	0.60	183.55	**17.98**
3600	1.11	14.05	1.27	0.75	-0.18	1.06	0.73	151.27	**17.24**
3800	0.78	12.25	1.57	0.85	-0.14	1.04	0.80	140.42	**16.93**
4000	0.8	10.65	1.33	0.84	-0.14	1.04	0.81	135.02	**16.76**
4200	0.57	8.75	1.54	0.94	-0.10	1.03	0.90	121.94	**16.35**
4400	0.58	9.32	1.61	0.93	-0.10	1.03	0.89	124.58	**16.40**
4600	0.62	10.6	1.71	0.91	-0.11	1.03	0.86	130.70	**16.54**
4800	0.63	11.1	1.76	0.91	-0.11	1.03	0.85	132.81	**16.57**
5000	0.63	10.5	1.67	0.91	-0.11	1.03	0.86	130.61	**16.48**
5200	0.64	8.1	1.27	0.90	-0.12	1.03	0.88	121.08	**16.18**
5400	0.62	9.68	1.56	0.91	-0.11	1.03	0.87	127.19	**16.33**
5600	0.91	11.05	1.21	0.80	-0.16	1.05	0.79	138.34	**16.61**
5800	1.22	15.3	1.25	0.73	-0.19	1.06	0.71	156.28	**17.02**
6000	1.76	51.37	2.92	0.65	-0.23	1.09	0.52	229.44	**18.39**
6200	0.89	86.3	9.70	0.81	-0.16	1.04	0.57	255.74	**18.76**
6400	8.04	20.33	0.25	0.39	-0.34	1.32	0.68	173.27	**17.33**
6600	8.04	20.3	0.25	0.39	-0.34	1.32	0.68	173.20	**17.31**
6800	1.08	1	0.09	0.76	-0.18	1.05	1.17	68.31	**13.92**
7000	3.25	6.7	0.21	0.53	-0.28	1.15	0.85	126.28	**16.12**
7200	2.97	43.45	1.46	0.54	-0.27	1.14	0.51	221.12	**18.13**
7400	1.52	34.2	2.25	0.68	-0.21	1.07	0.58	201.65	**17.77**
7600	1.42	66	4.65	0.69	-0.21	1.07	0.51	244.69	**18.46**
7800	0.91	17.55	1.93	0.80	-0.16	1.05	0.73	158.93	**16.88**
8000	1.41	8.15	0.58	0.70	-0.21	1.07	0.79	130.59	**16.15**
8200	0.92	8.32	0.90	0.80	-0.16	1.05	0.82	127.18	**16.04**
8400	0.78	8.65	1.11	0.85	-0.14	1.04	0.84	126.50	**16.00**
8600	2.96	65.3	2.21	0.55	-0.27	1.14	0.46	249.86	**18.44**
8800	1.9	62.32	3.28	0.63	-0.23	1.09	0.49	243.87	**18.34**
9000	3.03	77.7	2.56	0.54	-0.27	1.14	0.43	263.29	**18.60**
9200	2.91	88.11	3.03	0.55	-0.27	1.14	0.42	273.31	**18.72**
9400	1.7	132.4	7.79	0.65	-0.22	1.08	0.42	304.34	**19.09**
9600	1.32	61.9	4.69	0.71	-0.20	1.07	0.53	238.95	**18.21**
9800	3.23	62.37	1.93	0.53	-0.28	1.15	0.46	246.59	**18.31**
10000	2.07	276.84	13.37	0.61	-0.24	1.10	0.34	382.58	**19.88**
10200	1.34	57	4.25	0.71	-0.20	1.07	0.54	233.34	**18.08**
10400	1.55	62.75	4.05	0.67	-0.22	1.08	0.51	242.17	**18.20**
10600	1.51	43.9	2.91	0.68	-0.21	1.07	0.55	217.26	**17.79**
10800	2.04	72.11	3.53	0.62	-0.24	1.10	0.47	255.42	**18.36**
11000	2.11	76.9	3.64	0.61	-0.24	1.10	0.46	260.67	**18.43**
11200	2.23	67.65	3.03	0.60	-0.25	1.11	0.47	251.24	**18.28**
11400	1.88	56.65	3.01	0.63	-0.23	1.09	0.50	236.90	**18.05**
11600	1.57	52.3	3.33	0.67	-0.22	1.08	0.53	229.45	**17.93**
11800	2.42	61.95	2.56	0.58	-0.26	1.11	0.47	245.17	**18.15**
12000	1.97	34.85	1.77	0.62	-0.24	1.10	0.56	205.12	**17.50**
12200	2.13	24.75	1.16	0.61	-0.24	1.10	0.60	185.57	**17.12**
12400	2.89	69.55	2.41	0.55	-0.27	1.13	0.45	254.57	**18.26**
12600	4.58	185.35	4.05	0.47	-0.30	1.20	0.33	341.34	**19.30**
12800	4.19	247.94	5.92	0.49	-0.30	1.19	0.30	372.85	**19.61**

ESTIMATED UNIT WEIGHT (γ) PROFILE FROM CPT DATA



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

SHEET : 4 OF 4

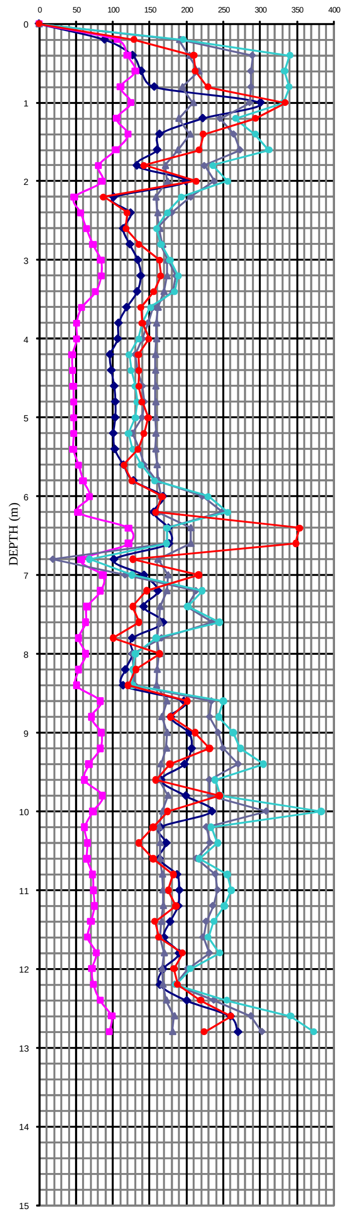
ESTIMATING SHEAR WAVE VELOCITY

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	F	Q	I_c	V_S (m/s) Barrow & Stokoe (1983)	V_S (m/s) Hegazy & Mayne (1996)	V_S (m/s) Mayne (2003)	V_S (m/s) Lyisan (1996)	V_S (m/s) Andrus et al. (2003)	V_S (m/s) Robertson et al. (1986)
200	5640	29.20	0.52	361	1.31	190.10	195.31	192.59	106.16	88.80	128.57
400	7750	191.90	2.48	169.98	2.04	203.60	340.27	289.73	119.67	126.68	209.81
600	9740	184.95	1.90	190.19	1.91	216.34	333.32	287.83	130.44	138.58	211.78
800	6280	185.90	2.97	110.31	2.21	194.19	339.38	288.09	110.55	155.97	229.16
1000	8590	179.00	2.09	141.92	2.03	208.98	331.89	286.14	124.41	299.88	333.94
1200	5500	82.00	1.50	96.95	2.04	189.20	266.38	245.86	105.16	221.68	293.31
1400	7900	117.33	1.49	124.47	1.96	204.56	293.36	264.35	120.54	163.20	222.80
1600	5320	138.40	2.62	77.55	2.28	188.05	311.89	272.87	103.85	160.09	217.43
1800	2670	54.05	2.05	42.23	2.40	171.09	235.77	224.36	80.08	132.51	142.26
2000	3130	70.32	2.28	45.57	2.40	174.03	255.59	237.93	85.02	198.82	212.87
2200	660	37.95	6.17	11.02	3.15	158.22	193.22	206.11	47.28	101.02	87.14
2400	1050	22.80	2.28	16.31	2.75	160.72	174.13	179.82	56.33	123.93	119.33
2600	1470	15.65	1.10	22.19	2.47	163.41	159.21	160.41	63.94	114.09	117.54
2800	2080	16.89	0.83	29.75	2.30	167.31	165.35	164.34	72.88	123.12	135.59
3000	3000	20.80	0.71	40.63	2.15	173.20	177.29	175.09	83.68	133.94	163.04
3200	3030	25.60	0.86	38.86	2.21	173.39	188.70	185.80	83.99	137.81	164.95
3400	2360	23.65	1.03	29.27	2.35	169.10	183.55	181.71	76.44	132.94	155.58
3600	1110	14.05	1.35	13.50	2.70	161.10	151.27	154.84	57.52	118.58	138.30
3800	780	12.25	1.73	9.06	2.91	158.99	140.42	147.77	50.36	107.55	140.07
4000	800	10.65	1.47	8.98	2.87	159.12	135.02	140.55	50.84	106.51	148.69
4200	570	8.75	1.78	6.01	3.07	157.65	121.94	130.41	44.74	96.10	134.58
4400	580	9.32	1.88	5.87	3.09	157.71	124.58	133.67	45.03	97.91	135.40
4600	620	10.60	1.99	6.05	3.09	157.97	130.70	140.31	46.18	101.79	134.90
4800	630	11.10	2.05	5.93	3.10	158.03	132.81	142.68	46.46	103.36	139.71
5000	630	10.50	1.95	5.71	3.11	158.03	130.61	139.82	46.46	103.11	147.87
5200	640	8.10	1.49	5.63	3.06	158.10	121.08	126.43	46.74	100.59	142.39
5400	620	9.68	1.86	5.23	3.13	157.97	127.19	135.62	46.18	102.66	134.30
5600	910	11.05	1.37	7.89	2.91	159.82	138.34	142.45	53.37	114.33	115.04
5800	1220	15.30	1.37	10.64	2.79	161.81	156.28	159.24	59.61	127.84	125.51
6000	1760	51.37	3.11	15.63	2.85	165.26	229.44	221.73	68.44	167.88	166.77
6200	890	86.30	11.11	7.18	3.46	159.70	255.74	248.50	52.92	155.18	158.18
6400	8040	20.33	0.26	70.89	1.74	205.46	173.27	173.91	121.34	175.07	353.44
6600	8040	20.30	0.26	69.46	1.75	205.46	173.20	173.83	121.34	176.05	348.22
6800	1080	1.00	0.10	7.51	2.61	160.91	68.31	18.50	56.93	101.49	126.87
7000	3250	6.70	0.21	25.52	2.14	174.80	126.28	116.64	86.24	142.20	216.63
7200	2970	43.45	1.53	24.68	2.51	173.01	221.12	213.09	83.36	161.01	145.73
7400	1520	34.20	2.47	11.65	2.89	163.73	201.65	200.74	64.76	141.67	127.01
7600	1420	66.00	5.15	10.83	3.11	163.09	244.69	234.66	63.12	167.97	135.67
7800	910	17.55	2.28	5.97	3.12	159.82	158.93	166.32	53.37	126.26	100.03
8000	1410	8.15	0.64	9.47	2.70	163.02	130.59	126.75	62.95	126.85	163.61
8200	920	8.32	1.08	5.62	2.99	159.89	127.18	127.81	53.59	116.83	130.79
8400	780	8.65	1.37	4.46	3.13	158.99	126.50	129.82	50.36	113.82	120.69
8600	2960	65.30	2.33	22.88	2.64	172.94	249.86	234.11	83.25	196.24	201.10
8800	1900	62.32	3.58	13.86	2.93	166.16	243.87	231.70	70.44	178.31	178.29
9000	3030	77.70	2.71	23.13	2.68	173.39	263.29	243.08	83.99	203.54	211.40
9200	2910	88.11	3.21	22.06	2.74	172.62	273.31	249.57	82.72	206.63	231.16
9400	1700	132.40	8.65	12.19	3.22	164.88	304.34	270.58	67.55	196.97	177.56
9600	1320	61.90	5.39	8.54	3.20	162.45	238.95	231.35	61.40	165.29	158.22
9800	3230	62.37	2.04	23.38	2.60	174.67	246.59	231.74	86.04	198.79	244.61
10000	2070	276.84	14.65	15.38	3.30	167.25	382.58	308.64	72.75	234.23	174.23
10200	1340	57.00	4.93	8.29	3.19	162.58	233.34	227.10	61.75	164.52	154.90
10400	1550	62.75	4.61	9.84	3.11	163.92	242.17	232.06	65.23	172.31	135.23
10600	1510	43.90	3.33	9.18	3.05	163.66	217.26	213.62	64.60	163.02	154.88
10800	2040	72.11	3.91	13.44	2.96	167.06	255.42	239.23	72.35	186.79	181.88
11000	2110	76.90	4.02	13.89	2.96	167.50	260.67	242.55	73.28	190.13	175.36
11200	2230	67.65	3.34	14.51	2.89	168.27	251.24	235.94	74.82	188.63	185.61
11400	1880	56.65	3.38	11.60	2.97	166.03	236.90	226.78	70.16	177.58	157.08
11600	1570	52.30	3.84	9.17	3.09	164.05	229.45	222.66	65.55	169.41	162.32
11800	2420	61.95	2.81	15.35	2.83	169.49	245.17	231.39	77.17	189.55	194.52
12000	1970	34.85	1.99	11.35	2.85	166.61	205.12	201.71	71.41	168.13	182.71
12200	2130	24.75	1.30	11.85	2.74	167.63	185.57	184.06	73.54	163.76	187.93
12400	2890	69.55	2.61	18.45	2.75	172.50	254.57	237.36	82.51	200.00	219.24
12600	4580	185.35	4.26	32.98	2.69	183.31	341.34	287.94	98.15	259.33	260.24
12800	4190	247.94	6.26	30.45	2.83	180.82	372.85	302.95	94.91	269.50	223.80

ESTIMATED SHEAR WAVE VELOCITY (Vs) PROFILE BASED ON VARIOUS PREVIOUS RESEARCHERS



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

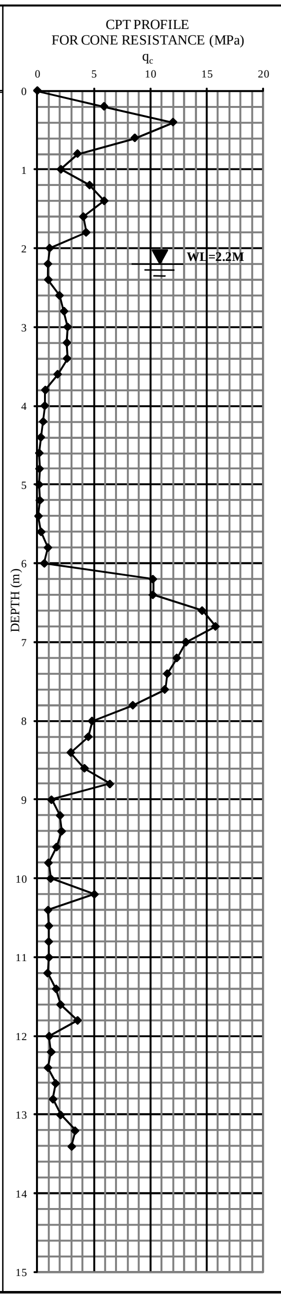
CPT#3

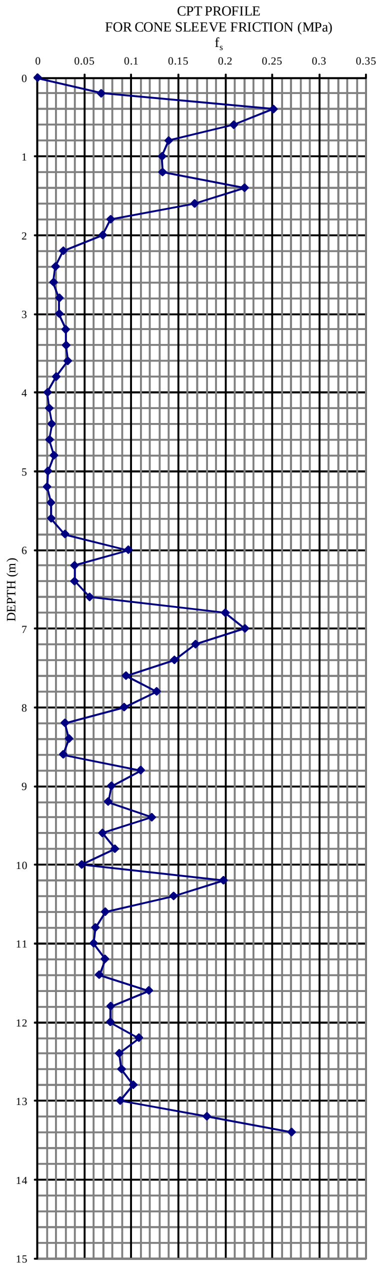
SHEET : 1 OF 4

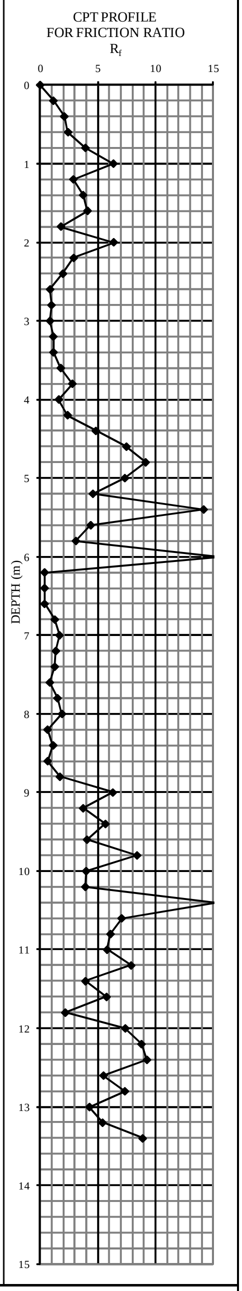
CPT GRAPHS

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (MPa)	f_s (MPa)	R_f
200	5.92	0.07	1.14
400	12.04	0.25	2.09
600	8.65	0.21	2.42
800	3.56	0.14	3.92
1000	2.09	0.13	6.35
1200	4.63	0.13	2.87
1400	5.93	0.22	3.72
1600	4.08	0.17	4.10
1800	4.32	0.08	1.80
2000	1.09	0.07	6.37
2200	0.94	0.03	2.91
2400	0.97	0.02	1.97
2600	1.96	0.02	0.86
2800	2.37	0.02	0.98
3000	2.69	0.02	0.86
3200	2.625	0.03	1.14
3400	2.64	0.03	1.15
3600	1.8	0.03	1.78
3800	0.71	0.02	2.79
4000	0.66	0.01	1.62
4200	0.52	0.01	2.38
4400	0.31	0.01	4.82
4600	0.17	0.01	7.47
4800	0.19	0.02	9.13
5000	0.15	0.01	7.33
5200	0.22	0.01	4.57
5400	0.1	0.01	14.16
5600	0.33	0.01	4.38
5800	0.94	0.03	3.10
6000	0.62	0.10	15.58
6200	10.25	0.04	0.38
6400	10.25	0.04	0.38
6600	14.62	0.06	0.38
6800	15.8	0.20	1.27
7000	13.18	0.22	1.68
7200	12.37	0.17	1.36
7400	11.53	0.15	1.26
7600	11.3	0.09	0.83
7800	8.47	0.13	1.50
8000	4.85	0.09	1.90
8200	4.52	0.03	0.64
8400	2.97	0.03	1.13
8600	4.18	0.03	0.65
8800	6.43	0.11	1.71
9000	1.25	0.08	6.29
9200	2.02	0.08	3.72
9400	2.15	0.12	5.65
9600	1.7	0.07	4.06
9800	0.98	0.08	8.39
10000	1.18	0.05	3.98
10200	5.06	0.20	3.91
10400	0.95	0.14	15.24
10600	1.02	0.07	7.06
10800	1.01	0.06	6.09
11000	1.03	0.06	5.80
11200	0.91	0.07	7.88
11400	1.67	0.07	3.92
11600	2.06	0.12	5.75
11800	3.57	0.08	2.18
12000	1.05	0.08	7.38
12200	1.23	0.11	8.77
12400	0.94	0.09	9.25
12600	1.63	0.09	5.48
12800	1.39	0.10	7.33
13000	2.06	0.09	4.27
13200	3.34	0.18	5.40
13400	3.05	0.27	8.87







REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

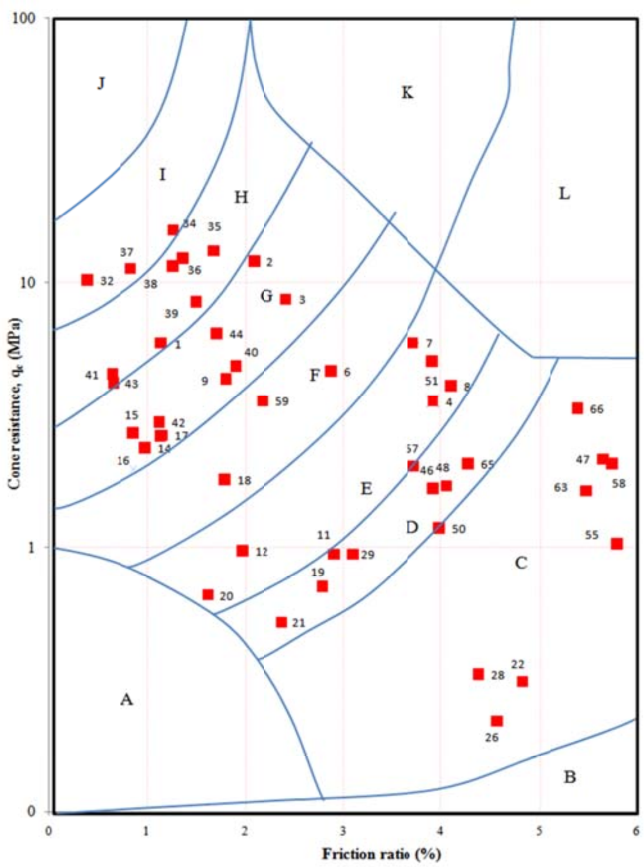
SHEET : 2 OF 4

SOIL INTERPRETATION

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (MPa)	f_s (kPa)	R_f	Interpretation of soil type behaviour	DEPTH (m)
200	5.92	67.7	1.14	(1) Silty sand to sandy silt	
400	12.04	251.25	2.09	(2) Silty sand to sandy silt	
600	8.65	209	2.42	(3) Silty sand to sandy silt	
800	3.56	139.6	3.92	(4) Clayey silt to silty clay	
1000	2.09	132.63	6.35	(5) Clay	1
1200	4.63	133.05	2.87	(6) Sandy silt to clayey silt	
1400	5.93	220.42	3.72	(7) Clayey silt to silty clay	
1600	4.08	167.3	4.10	(8) Clayey silt to silty clay	
1800	4.32	77.85	1.80	(9) Silty sand to sandy silt	
2000	1.09	69.4	6.37	(10) Clay	2
2200	0.94	27.32	2.91	(11) Silty clay to clay	
2400	0.97	19.1	1.97	(12) Clayey silt to silty clay	
2600	1.96	16.95	0.86	(13) Silty sand to sandy silt	
2800	2.37	23.2	0.98	(14) Silty sand to sandy silt	
3000	2.69	23.05	0.86	(15) Silty sand to sandy silt	3
3200	2.625	29.85	1.14	(16) Silty sand to sandy silt	
3400	2.64	30.37	1.15	(17) Silty sand to sandy silt	
3600	1.8	32.1	1.78	(18) Sandy silt to clayey silt	
3800	0.71	19.8	2.79	(19) Silty clay to clay	
4000	0.66	10.68	1.62	(20) Clayey silt to silty clay	4
4200	0.52	12.35	2.38	(21) Silty clay to clay	
4400	0.31	14.95	4.82	(22) Clay	
4600	0.17	12.7	7.47	(23) Clay	
4800	0.19	17.35	9.13	(24) Clay	
5000	0.15	11	7.33	(25) Clay	5
5200	0.22	10.05	4.57	(26) Clay	
5400	0.1	14.16	14.16	(27) Clay	
5600	0.33	14.45	4.38	(28) Clay	
5800	0.94	29.1	3.10	(29) Silty clay to clay	
6000	0.62	96.6	15.58	(30) Clay	6
6200	10.25	39.28	0.38	(31) Sand	
6400	10.25	39.28	0.38	(32) Sand	
6600	14.62	55.4	0.38	(33) Sand	
6800	15.8	199.9	1.27	(34) Sandy to silty sand	
7000	13.18	220.85	1.68	(35) Sandy to silty sand	7
7200	12.37	168.21	1.36	(36) Sandy to silty sand	
7400	11.53	145.65	1.26	(37) Sand	
7600	11.3	94.1	0.83	(38) Sandy to silty sand	
7800	8.47	126.79	1.50	(39) Sandy to silty sand	
8000	4.85	92.15	1.90	(40) Silty sand to sandy silt	8
8200	4.52	29.05	0.64	(41) Sandy to silty sand	
8400	2.97	33.42	1.13	(42) Silty sand to sandy silt	
8600	4.18	27.3	0.65	(43) Sandy to silty sand	
8800	6.43	109.79	1.71	(44) Silty sand to sandy silt	
9000	1.25	78.58	6.29	(45) Clay	9
9200	2.02	75.1	3.72	(46) Silty clay to clay	
9400	2.15	121.58	5.65	(47) Clay	
9600	1.7	69	4.06	(48) Silty clay to clay	
9800	0.98	82.25	8.39	(49) Clay	
10000	1.18	47	3.98	(50) Clay	10
10200	5.06	198	3.91	(51) Clayey	
10400	0.95	144.8	15.24	(52) Clay	
10600	1.02	72	7.06	(53) Clay	
10800	1.01	61.54	6.09	(54) Clay	
11000	1.03	59.7	5.80	(55) Clay	11
11200	0.91	71.7	7.88	(56) Clay	
11400	1.67	65.53	3.92	(57) Silty clay to clay	
11600	2.06	118.4	5.75	(58) Clay	
11800	3.57	77.8	2.18	(59) Sandy silt to clayey silt	
12000	1.05	77.45	7.38	(60) Clay	12
12200	1.23	107.85	8.77	(61) Clay	
12400	0.94	86.95	9.25	(62) Clay	
12600	1.63	89.4	5.48	(63) Clay	
12800	1.39	101.95	7.33	(64) Clay	
13000	2.06	88	4.27	(65) Silty clay to clay	13
13200	3.34	180.3	5.40	(66) Clay	
13400	3.05	270.64	8.87	(67) Clay	13.4

Proposed soil clasification system from CPT data (Robertson et al., 1985)



Note:

A- Sensitive fine grained
B- Organic material
C- Clay
D- Silty clay to clay
E- Clayey silt to silty clay
F- Sandy silt to clayey silt
G- Silty sand to sandy silt
H- Sandy to silty sand
I- Sand
J- Gravelly sand to sand
K- Very stiff fine grained
L- Sand to clayey sand

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

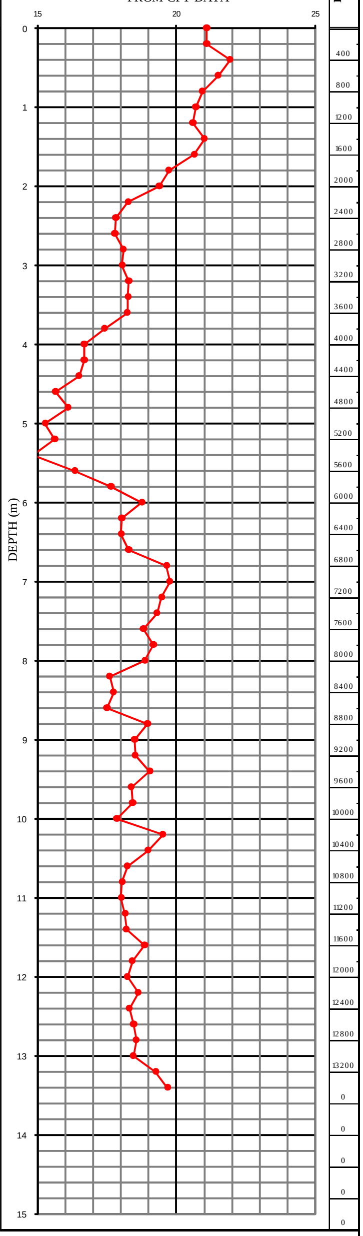
SHEET : 3 OF 4

ESTIMATING UNIT WEIGHT OF THE SOIL

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		
REDUCE LEVEL	: - m	**OPERATOR**	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan	**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (MPa)	f_s (kPa)	R_f	f_1	f_2	f_3	c	V_s (m/s) Hegazy & Mayne (1996)	γ (kN/m³) Mayne et al. (2011)
200	5.92	67.7	1.14	0.43	-0.32	1.25	0.45	251.05	21.09
400	12.04	251.25	2.09	0.34	-0.36	1.43	0.30	361.52	21.92
600	8.65	209	2.42	0.38	-0.34	1.34	0.31	347.58	21.50
800	3.56	139.6	3.92	0.51	-0.28	1.16	0.36	314.08	20.93
1000	2.09	132.63	6.35	0.61	-0.24	1.10	0.40	306.89	20.69
1200	4.63	133.05	2.87	0.47	-0.30	1.20	0.36	308.98	20.59
1400	5.93	220.42	3.72	0.43	-0.32	1.25	0.31	357.72	21.01
1600	4.08	167.3	4.10	0.49	-0.29	1.18	0.34	331.41	20.64
1800	4.32	77.85	1.80	0.48	-0.30	1.19	0.43	263.31	19.73
2000	1.09	69.4	6.37	0.76	-0.18	1.05	0.55	243.91	19.38
2200	0.94	27.32	2.91	0.80	-0.16	1.05	0.67	182.06	18.25
2400	0.97	19.1	1.97	0.79	-0.17	1.05	0.71	163.99	17.82
2600	1.96	16.95	0.86	0.62	-0.24	1.09	0.66	165.20	17.79
2800	2.37	23.2	0.98	0.59	-0.25	1.11	0.61	182.52	18.09
3000	2.69	23.05	0.86	0.56	-0.26	1.13	0.60	182.60	18.05
3200	2.625	29.85	1.14	0.57	-0.26	1.12	0.57	197.25	18.28
3400	2.64	30.37	1.15	0.57	-0.26	1.12	0.56	198.29	18.26
3600	1.8	32.1	1.78	0.64	-0.23	1.09	0.57	199.44	18.24
3800	0.71	19.8	2.79	0.87	-0.13	1.04	0.77	160.41	17.41
4000	0.66	10.68	1.62	0.89	-0.12	1.03	0.85	132.08	16.68
4200	0.52	12.35	2.38	0.97	-0.09	1.03	0.90	133.36	16.68
4400	0.31	14.95	4.82	1.15	-0.01	1.02	1.13	127.83	16.49
4600	0.17	12.7	7.47	1.40	0.10	1.01	1.73	102.21	15.65
4800	0.19	17.35	9.13	1.35	0.08	1.01	1.62	116.62	16.10
5000	0.15	11	7.33	1.46	0.13	1.01	1.89	93.41	15.27
5200	0.22	10.05	4.57	1.29	0.05	1.01	1.39	103.66	15.62
5400	0.1	14.16	14.16	1.67	0.23	1.01	3.04	83.68	14.82
5600	0.33	14.45	4.38	1.12	-0.02	1.02	1.09	128.34	16.34
5800	0.94	29.1	3.10	0.80	-0.16	1.05	0.67	185.54	17.64
6000	0.62	96.6	15.58	0.91	-0.11	1.03	0.67	253.62	18.75
6200	10.25	39.28	0.38	0.36	-0.35	1.38	0.57	208.90	18.03
6400	10.25	39.28	0.38	0.36	-0.35	1.38	0.57	208.90	18.00
6600	14.62	55.4	0.38	0.32	-0.36	1.49	0.53	227.14	18.28
6800	15.8	199.9	1.27	0.31	-0.37	1.52	0.34	332.18	19.64
7000	13.18	220.85	1.68	0.33	-0.36	1.46	0.32	346.05	19.76
7200	12.37	168.21	1.36	0.34	-0.36	1.44	0.35	320.05	19.46
7400	11.53	145.65	1.26	0.35	-0.35	1.42	0.36	307.68	19.30
7600	11.3	94.1	0.83	0.35	-0.35	1.41	0.42	270.17	18.81
7800	8.47	126.79	1.50	0.39	-0.34	1.33	0.37	299.44	19.17
8000	4.85	92.15	1.90	0.46	-0.31	1.21	0.40	276.54	18.86
8200	4.52	29.05	0.64	0.47	-0.30	1.20	0.57	195.80	17.60
8400	2.97	33.42	1.13	0.54	-0.27	1.14	0.55	204.38	17.73
8600	4.18	27.3	0.65	0.49	-0.30	1.19	0.58	192.35	17.50
8800	6.43	109.79	1.71	0.42	-0.32	1.27	0.38	289.58	18.96
9000	1.25	78.58	6.29	0.72	-0.19	1.06	0.51	255.76	18.50
9200	2.02	75.1	3.72	0.62	-0.24	1.10	0.46	258.47	18.52
9400	2.15	121.58	5.65	0.61	-0.25	1.10	0.41	299.24	19.03
9600	1.7	69	4.06	0.65	-0.22	1.08	0.49	250.29	18.37
9800	0.98	82.25	8.39	0.79	-0.17	1.05	0.55	254.36	18.42
10000	1.18	47	3.98	0.74	-0.19	1.06	0.58	218.32	17.85
10200	5.06	198	3.91	0.46	-0.31	1.22	0.32	347.61	19.52
10400	0.95	144.8	15.24	0.79	-0.16	1.05	0.51	300.55	18.98
10600	1.02	72	7.06	0.77	-0.17	1.05	0.56	245.27	18.23
10800	1.01	61.54	6.09	0.78	-0.17	1.05	0.58	233.78	18.04
11000	1.03	59.7	5.80	0.77	-0.17	1.05	0.57	232.05	18.01
11200	0.91	71.7	7.88	0.80	-0.16	1.05	0.58	242.43	18.15
11400	1.67	65.53	3.92	0.66	-0.22	1.08	0.49	246.24	18.19
11600	2.06	118.4	5.75	0.61	-0.24	1.10	0.41	296.48	18.85
11800	3.57	77.8	2.18	0.51	-0.29	1.16	0.43	263.55	18.42
12000	1.05	77.45	7.38	0.77	-0.18	1.05	0.55	251.31	18.23
12200	1.23	107.85	8.77	0.73	-0.19	1.06	0.49	280.93	18.62
12400	0.94	86.95	9.25	0.80	-0.16	1.05	0.56	257.66	18.30
12600	1.63	89.4	5.48	0.66	-0.22	1.08	0.46	269.98	18.46
12800	1.39	101.95	7.33	0.70	-0.20	1.07	0.47	278.43	18.56
13000	2.06	88	4.27	0.61	-0.24	1.10	0.44	271.23	18.45
13200	3.34	180.3	5.40	0.52	-0.28	1.15	0.34	339.11	19.25
13400	3.05	270.64	8.87	0.54	-0.27	1.14	0.31	382.87	19.68

ESTIMATED UNIT WEIGHT (γ) PROFILE FROM CPT DATA



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

SHEET : 4 OF 4

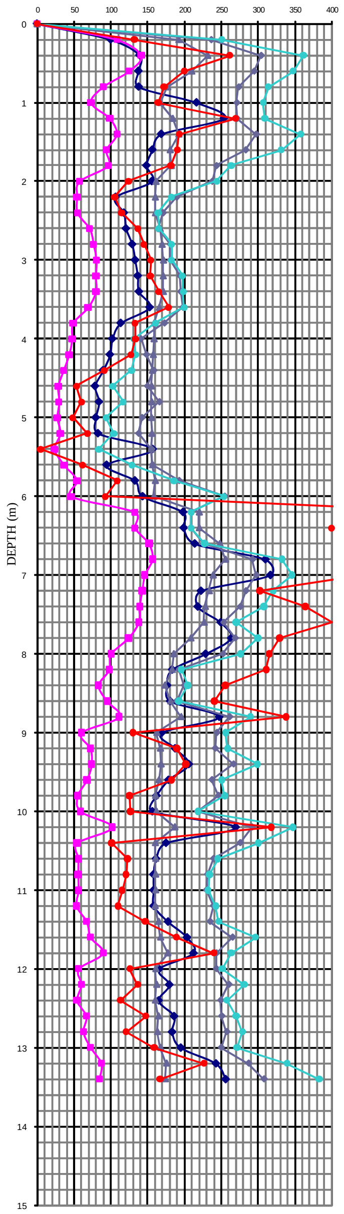
ESTIMATING SHEAR WAVE VELOCITY

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	F	Q	I_c	V_S (m/s) Barrow & Stokoe (1983)	V_S (m/s) Hegazy & Mayne (1996)	V_S (m/s) Mayne (2003)	V_S (m/s) Lyisan (1996)	V_S (m/s) Andrus et al. (2003)	V_S (m/s) Robertson et al. (1986)
200	5920	67.70	1.14	241	1.68	191.89	251.05	235.97	108.12	99.70	131.73
400	12040	251.25	2.09	248.76	1.88	231.06	361.52	303.63	141.29	139.00	261.56
600	8650	209.00	2.42	162.47	2.04	209.36	347.58	294.13	124.73	137.44	199.55
800	3560	139.60	3.94	66.70	2.45	176.78	314.08	273.31	89.25	137.74	172.35
1000	2090	132.63	6.41	38.13	2.77	167.38	306.89	270.67	73.02	216.13	164.08
1200	4630	133.05	2.89	74.98	2.32	183.63	308.98	270.83	98.55	253.44	268.99
1400	5930	220.42	3.74	84.95	2.36	191.95	357.72	296.88	108.18	168.44	192.91
1600	4080	167.30	4.13	58.08	2.51	180.11	331.41	282.65	93.96	156.23	190.22
1800	4320	77.85	1.82	64.42	2.22	181.65	263.31	243.18	96.01	148.35	181.43
2000	1090	69.40	6.62	16.89	3.03	160.98	243.91	237.25	57.13	155.64	124.02
2200	940	27.32	3.05	15.23	2.85	160.02	182.06	189.15	54.02	106.44	105.08
2400	970	19.10	2.07	15.29	2.75	160.21	163.99	170.69	54.67	117.69	114.45
2600	1960	16.95	0.89	29.16	2.32	166.54	165.20	164.53	71.27	120.58	136.33
2800	2370	23.20	1.00	32.76	2.30	169.17	182.52	180.72	76.56	128.94	144.96
3000	2690	23.05	0.88	35.82	2.24	171.22	182.60	180.39	80.30	132.91	154.19
3200	2625	29.85	1.17	33.03	2.34	170.80	197.25	193.72	79.57	136.47	153.26
3400	2640	30.37	1.18	32.11	2.35	170.90	198.29	194.61	79.74	138.04	164.79
3600	1800	32.10	1.86	21.03	2.61	165.52	199.44	197.47	69.02	152.61	178.32
3800	710	19.80	3.11	8.00	3.09	158.54	160.41	172.54	48.60	113.49	132.86
4000	660	10.68	1.83	7.24	3.00	158.22	132.08	140.69	47.28	102.09	133.43
4200	520	12.35	2.81	5.33	3.21	157.33	133.36	148.19	43.22	98.80	127.40
4400	310	14.95	6.61	2.76	3.65	155.98	127.83	158.05	35.56	89.59	91.32
4600	170	12.70	15.31	1.06	4.20	155.09	102.21	149.63	28.35	78.62	53.19
4800	190	17.35	17.39	1.19	4.19	155.22	116.62	165.73	29.57	83.92	60.02
5000	150	11.00	19.40	0.65	4.43	154.96	93.41	142.22	27.05	79.57	48.04
5200	220	10.05	8.13	1.31	3.97	155.41	103.66	137.56	31.25	82.61	67.87
5400	100	14.16	2334.46	0.01	7.29	154.64	83.68	155.25	23.21	156.67	4.58
5600	330	14.45	6.36	2.21	3.72	156.11	128.34	156.29	36.41	94.36	61.05
5800	940	29.10	3.49	7.98	3.12	160.02	185.54	192.41	54.02	132.60	108.59
6000	620	96.60	18.94	4.76	3.75	157.97	253.62	254.32	46.18	143.14	92.72
6200	10250	39.28	0.39	93.80	1.70	219.60	208.90	207.89	132.97	197.98	571.53
6400	10250	39.28	0.39	92.12	1.71	219.60	208.90	207.89	132.97	198.85	399.70
6600	14620	55.40	0.38	130.35	1.57	247.57	227.14	225.63	152.02	213.79	471.16
6800	15800	199.90	1.28	144.29	1.86	255.12	332.18	291.84	156.54	309.55	513.53
7000	13180	220.85	1.69	119.42	2.01	238.35	346.05	296.98	146.20	316.33	442.80
7200	12370	168.21	1.37	110.02	1.97	233.17	320.05	282.93	142.74	222.23	302.50
7400	11530	145.65	1.28	100.95	1.98	227.79	307.68	275.50	139.01	217.95	364.11
7600	11300	94.10	0.84	96.03	1.88	226.32	270.17	252.96	137.95	249.06	400.17
7800	8470	126.79	1.52	72.14	2.14	208.21	299.44	268.35	123.75	263.25	329.08
8000	4850	92.15	1.96	39.85	2.40	185.04	276.54	251.88	100.29	228.45	315.30
8200	4520	29.05	0.66	34.27	2.20	182.93	195.80	192.32	97.66	183.30	310.96
8400	2970	33.42	1.19	22.04	2.49	173.01	204.38	199.55	83.36	176.24	255.19
8600	4180	27.30	0.68	30.63	2.25	180.75	192.35	189.12	94.82	180.46	240.75
8800	6430	109.79	1.75	51.66	2.29	195.15	289.58	260.92	111.54	246.98	338.16
9000	1250	78.58	7.25	8.31	3.29	162.00	255.76	243.66	60.15	169.25	129.96
9200	2020	75.10	4.06	14.40	2.95	166.93	258.47	241.33	72.08	187.19	189.80
9400	2150	121.58	6.15	15.69	3.03	167.76	299.24	266.18	73.80	205.69	201.75
9600	1700	69.00	4.53	11.45	3.06	164.88	250.29	236.96	67.55	178.26	182.28
9800	980	82.25	10.29	5.72	3.51	160.27	254.36	246.02	54.88	161.99	125.14
10000	1180	47.00	4.72	6.96	3.24	161.55	218.32	217.15	58.86	156.27	126.47
10200	5060	198.00	4.06	39.47	2.62	186.38	347.61	291.34	101.90	269.22	317.98
10400	950	144.80	19.10	5.40	3.71	160.08	300.55	275.20	54.24	174.90	100.87
10600	1020	72.00	8.73	5.63	3.47	160.53	245.27	239.15	55.71	161.36	122.44
10800	1010	61.54	7.59	5.42	3.45	160.46	233.78	231.05	55.51	157.87	120.56
11000	1030	59.70	7.22	5.48	3.43	160.59	232.05	229.49	55.92	158.10	115.35
11200	910	71.70	10.19	4.58	3.59	159.82	242.43	238.94	53.37	158.16	109.32
11400	1670	65.53	4.49	10.05	3.10	164.69	246.24	234.29	67.09	177.61	146.68
11600	2060	118.40	6.41	13.39	3.10	167.18	296.48	264.81	72.62	203.43	189.06
11800	3570	77.80	2.32	23.85	2.63	176.85	263.55	243.15	89.35	212.05	239.73
12000	1050	77.45	9.35	5.34	3.51	160.72	251.31	242.92	56.33	165.52	125.61
12200	1230	107.85	10.73	6.74	3.47	161.87	280.93	260.00	59.79	179.33	136.32
12400	940	86.95	12.22	4.46	3.64	160.02	257.66	248.89	54.02	164.84	113.24
12600	1630	89.40	6.40	9.39	3.22	164.43	269.98	250.32	66.48	185.76	147.47
12800	1390	101.95	8.83	7.64	3.37	162.90	278.43	257.10	62.61	183.13	120.83
13000	2060	88.00	4.83	12.27	3.05	167.18	271.23	249.50	72.62	194.88	158.62
13200	3340	180.30	5.82	22.68	2.90	175.38	339.11	286.51	87.13	242.56	226.14
13400	3050	270.64	9.66	21.00	3.08	173.52	382.87	307.47	84.20	255.65	166.99

ESTIMATED SHEAR WAVE VELOCITY (Vs) PROFILE BASED ON VARIOUS PREVIOUS RESEARCHERS



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

APPENDIX D

LABORATORY TESTING RESULTS FOR SOIL CLASSIFICATION

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-01/#1.1	Date of Testing	: 16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Brown; Gravelly sandy SILT	Depth of sample	: 0.0 - 1.35 m

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.443	50.4722
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.052	165.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.443	50.472
Wt. of dish + dry soil	Wds	(g)	43.066	74.380
Wt. of dry soil	Ws	(g)	13.623	23.908
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.63	2.63

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.63 / 2.63 = 1.00025 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.63

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Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: GILL/BH-01/#1.1		Date of Testing	: 17-Aug-10
Tested By	: BAMBANG SETIAWAN		Eq/Device/Method	: ***
Visual Description	: Brown; Gravelly sandy SILT		Depth of sample	: 0.0 - 1.35 m

Moisture content Calculations

Can no.		40
Wt. of wet soil + can	(g)	128.30
Wt. of dry soil + can	(g)	121.95
Wt. of can	(g)	40.96
Wt. of dry soil	(g)	80.99
Wt. of water	(g)	6.35
Moisture content, w	(%)	7.84

Can no.		5a
Wt. of wet soil + can	(g)	104.23
Wt. of dry soil + can	(g)	99.54
Wt. of can	(g)	40.31
Wt. of dry soil	(g)	59.23
Wt. of water	(g)	4.69
Moisture content, w	(%)	7.92

Average moisture content	(%)	7.88

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 7.88 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 22.38 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 23.77 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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SUB CRUCE LUMEN

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Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.1 Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown; Gravelly sandy SILT Depth of sample : 0.0 - 1.35 m

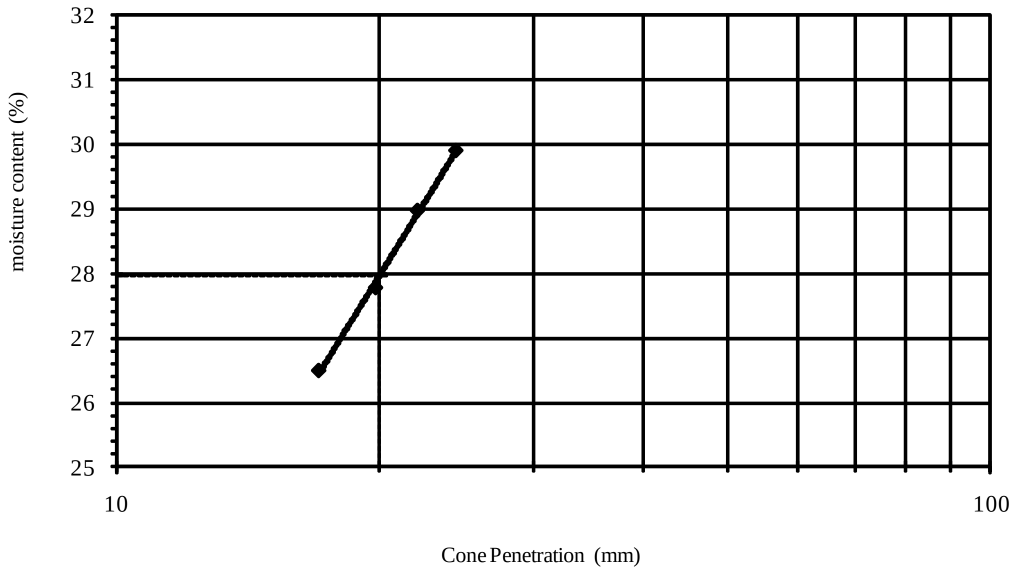
Liquid Limit Calculations

Can no.	7	Q	C	2
Wt. of wet soil + can (g)	51.84	53.65	48.52	52.91
Wt. of dry soil + can (g)	47.92	49.19	44.63	48.42
Wt. of can (g)	33.12	33.13	31.20	33.40
Wt. of dry soil (g)	14.80	16.06	13.43	15.02
Wt. of water (g)	3.92	4.46	3.89	4.49
Moisture content, w (%)	26.49	27.77	28.97	29.89
Cone penetration (mm)	17.03	19.79	22.1	24.46

Plastic Limit Calculations

Can no.	21	23
Wt. of wet soil + can (g)	54.70	63.11
Wt. of dry soil + can (g)	53.26	60.49
Wt. of can (g)	42.53	42.72
Wt. of dry soil (g)	10.73	17.77
Wt. of water (g)	1.44	2.62
Moisture content, w (%)	13.42	14.74

Liquid Limit (LL) (%) = **27.97** Plasticity Indeks, Ip (%) **13.89**
Plastic Limit (PL) (%) = **14.08**



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Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.1 Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown; Gravelly sandy SILT Depth of sample : 0.0 - 1.35 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	600	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	600.00		
Total	600.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	33.61	5.60	94.40
PAN#2	566.39		
Total	600.00	100.00	0.00
1.190	11.72	7.56	92.45
0.602	15.91	10.21	89.79
0.315	0.61	10.31	89.69
0.211	78.01	23.31	76.69
0.075	159.92	49.96	50.04
PAN#3	300.22		
Total	600.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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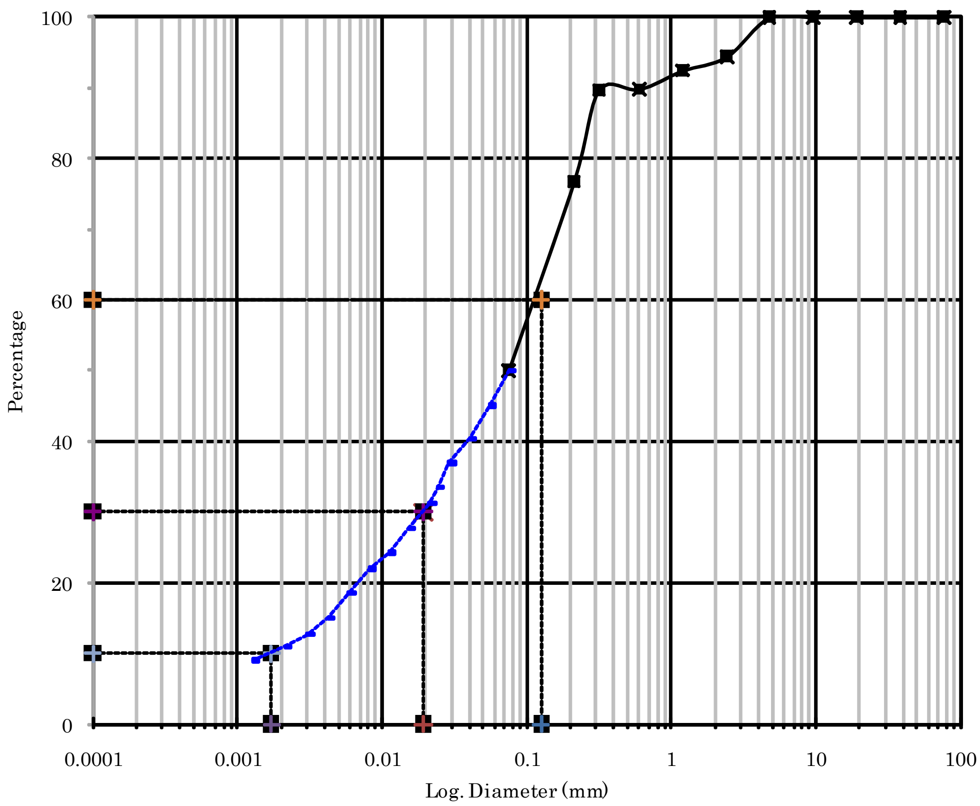
Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.1 Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown; Gravelly sandy SILT Depth of sample : 0.0 - 1.35 m



		Percentage		
			D60 =	0.126 mm
Gravel (> 2 mm) & (< 4 mm)	=	6.26 %	D30 =	0.019 mm
Sand (> 0.075 mm) & (< 2 mm)	=	43.71 %	D10 =	0.002 mm
Fine (< 0.075 mm)	=	50.04 %	Cu =	73.46
			Cc =	1.72

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Date: 20 August 2011

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	:	Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	:	Gillman, SA		
Sample Code	:	GILL/BH-01/#1.2	Date of Testing	: 16-Feb-11
Tested By	:	BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	:	Grey, dark brown; Gravelly Silty SAND	Depth of sample	: 1.35 - 2.70 m

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.443	50.4722
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.052	165.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.443	50.472
Wt. of dish + dry soil	Wds	(g)	43.066	74.380
Wt. of dry soil	Ws	(g)	13.623	23.908
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.63	2.63

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.63 / 2.63 = 1.00025 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.63

THE UNIVERSITY OF ADELAIDE AUSTRALIA	Reported by : B. Setiawan Signature: Date: 20 August 2011

Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	:	Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	:	Gillman, SA		
Sample Code	:	GILL/BH-01/#1.2	Date of Testing	: 17-Aug-10
Tested By	:	BAMBANG SETIAWAN	Eq/Device/Method :	***
Visual Description	:	Grey, dark brown; Gravelly Silty SAND	Depth of sample :	1.35 - 2.70 m

Moisture content Calculations

Can no.		42
Wt. of wet soil + can	(g)	140.03
Wt. of dry soil + can	(g)	112.12
Wt. of can	(g)	40.62
Wt. of dry soil	(g)	71.50
Wt. of water	(g)	27.91
Moisture content, w	(%)	39.03

Can no.		3
Wt. of wet soil + can	(g)	133.54
Wt. of dry soil + can	(g)	105.22
Wt. of can	(g)	33.12
Wt. of dry soil	(g)	72.10
Wt. of water	(g)	28.32
Moisture content, w	(%)	39.28

Average moisture content	(%)	39.16

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 39.16 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 18.68 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 19.84 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Reported by : B. Setiawan

Signature:

Date: 20 August 2011

Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-01/#1.2	Date of Testing	: 16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Grey, dark brown; Gravelly Silty SAND	Depth of sample	: 1.35 - 2.70 m

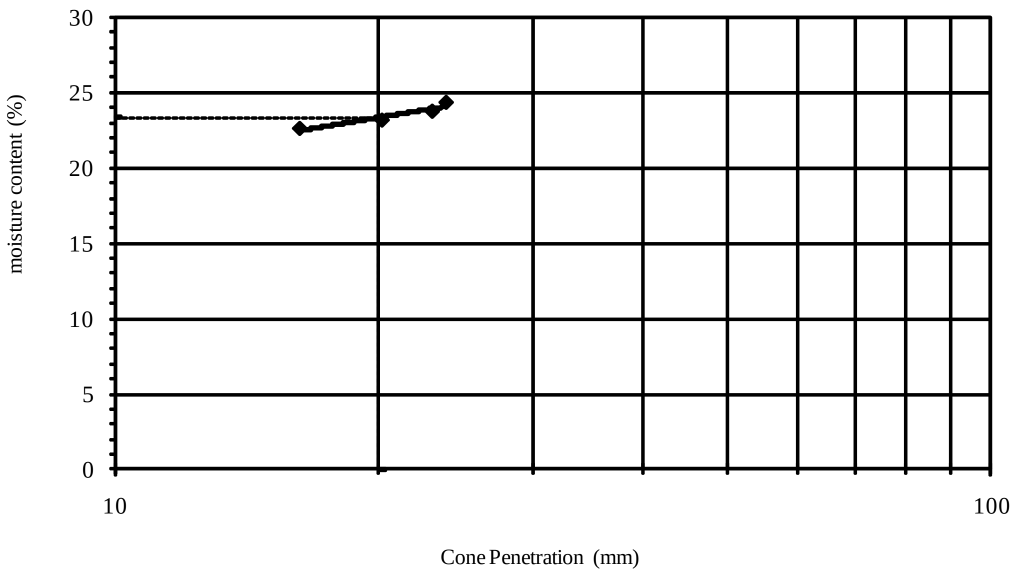
Liquid Limit Calculations

Can no.	48	42	43	45
Wt. of wet soil + can (g)	73.26	62.63	69.48	78.90
Wt. of dry soil + can (g)	67.24	58.49	63.94	71.40
Wt. of can (g)	40.59	40.61	40.62	40.62
Wt. of dry soil (g)	26.65	17.88	23.32	30.78
Wt. of water (g)	6.02	4.14	5.54	7.50
Moisture content, w (%)	22.59	23.15	23.76	24.37
Cone penetration (mm)	16.22	20.16	23.02	23.88

Plastic Limit Calculations

Can no.	2b	5a
Wt. of wet soil + can (g)	53.45	56.91
Wt. of dry soil + can (g)	51.60	54.19
Wt. of can (g)	42.10	40.31
Wt. of dry soil (g)	9.5	13.88
Wt. of water (g)	1.85	2.72
Moisture content, w (%)	19.47	19.60

Liquid Limit (LL) (%) =	**23.35**	Plasticity Indeks, Ip (%)	**3.81**
Plastic Limit (PL) (%) =	**19.54**		



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Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.2 — Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description : Grey, dark brown; Gravelly Silty SAND — Depth of sample : 1.35 - 2.70 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	600	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	600.00		
Total	600.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	38.12	6.35	93.65
PAN#2	561.88		
Total	600.00	100.00	0.00
1.190	17.12	9.21	90.79
0.602	21.91	12.86	87.14
0.315	0.92	13.01	86.99
0.211	130.80	34.81	65.19
0.075	220.21	71.51	28.49
PAN#3	170.92		
Total	600.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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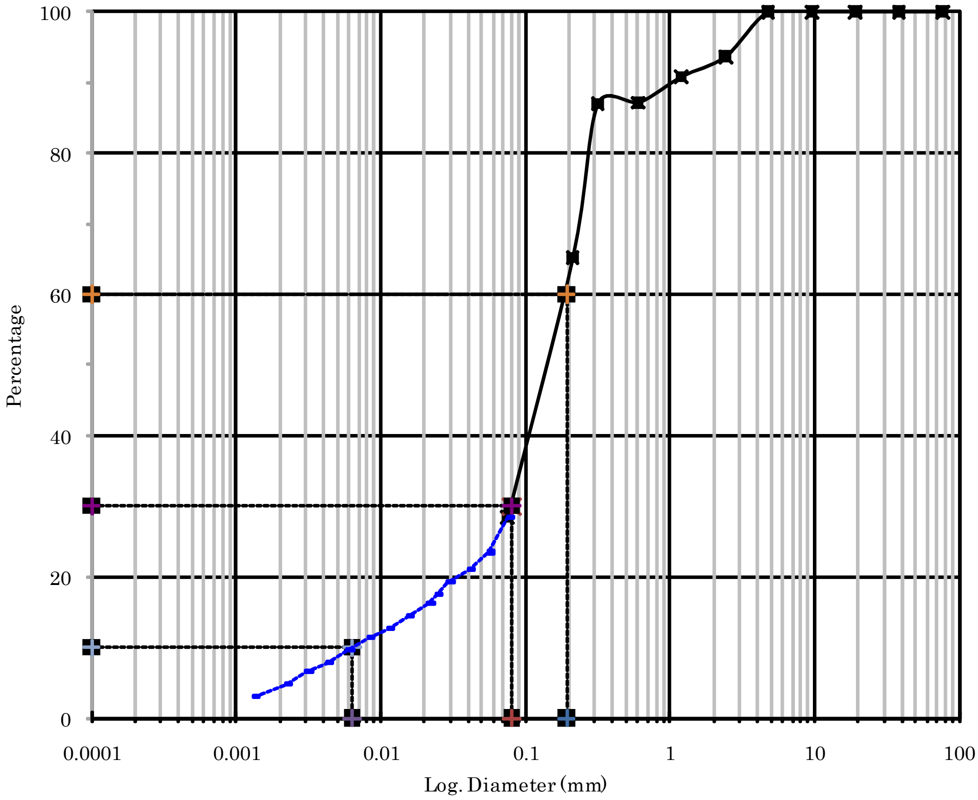
Reported by: B. Setiawan

Signature: ____________
Date: 20 August 2011

Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-01/#1.2	Date of Testing	: 16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Grey, dark brown; Gravelly Silty SAND	Depth of sample	: 1.35 - 2.70 m



		Percentage		
			D60 =	0.192 mm
Gravel (> 2 mm) & (< 4 mm)	=	7.31 %	D30 =	0.081 mm
Sand (> 0.075 mm) & (< 2 mm)	=	64.20 %	D10 =	0.006 mm
Fine (< 0.075 mm)	=	28.49 %	Cu =	30.19
			Cc =	5.33

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Reported by: B. Setiawan

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Date: 20 August 2011

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.3 Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey, light grey; Silty SAND Depth of sample : 2.70 - 4.70 m

[A] Calibration of pycnometer

Pycnometer No.			G2	G27
Wt. of dry, clean pycnometer	Wp	(g)	30.841	50.8624
Wt. of pycnometer + water	Wpw	(g)	80.096	150.563
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.949	167.942
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.096	150.563
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	30.841	50.862
Wt. of dish + dry soil	Wds	(g)	46.552	78.610
Wt. of dry soil	Ws	(g)	15.712	27.748
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.68	2.68

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.68 / 2.68 = 1.00218 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.68

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Date: 20 August 2011

Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.3 Date of Testing : 17-Aug-10
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey, light grey; Silty SAND Depth of sample : 2.70 - 4.70 m

Moisture content Calculations

Can no.		43
Wt. of wet soil + can	(g)	160.34
Wt. of dry soil + can	(g)	120.10
Wt. of can	(g)	40.63
Wt. of dry soil	(g)	79.47
Wt. of water	(g)	40.24
Moisture content, w	(%)	50.64

Can no.		Aa
Wt. of wet soil + can	(g)	168.08
Wt. of dry soil + can	(g)	122.57
Wt. of can	(g)	32.01
Wt. of dry soil	(g)	90.56
Wt. of water	(g)	45.51
Moisture content, w	(%)	50.25

Average moisture content	(%)	50.44

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 50.44 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 28.18 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 29.95 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.3 — Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description : Grey, light grey; Silty SAND — Depth of sample : 2.70 - 4.70 m

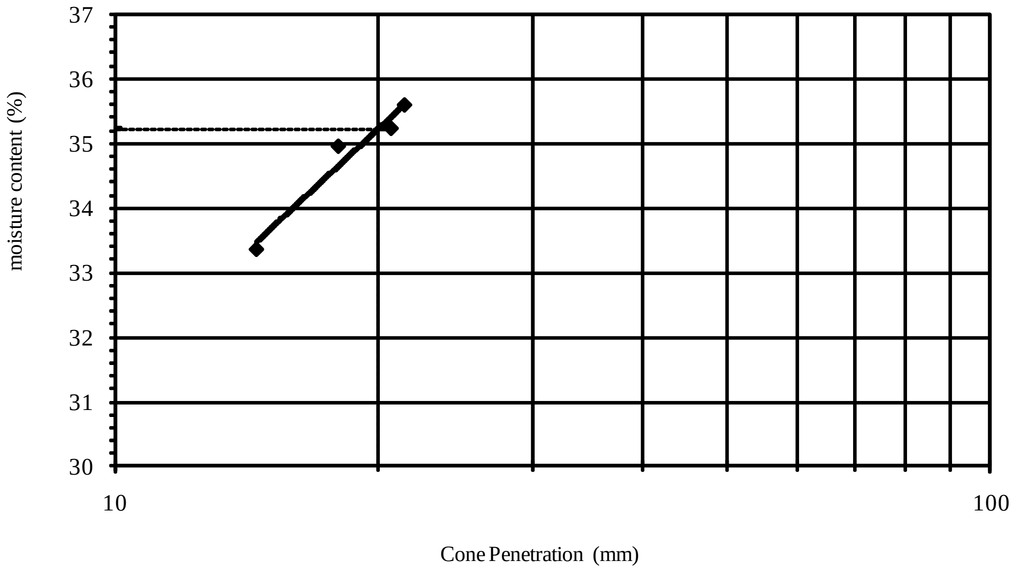
Liquid Limit Calculations

Can no.	D	4b	A	3b
Wt. of wet soil + can (g)	59.07	53.42	53.91	60.36
Wt. of dry soil + can (g)	52.60	48.08	48.51	53.10
Wt. of can (g)	33.20	32.80	33.18	32.70
Wt. of dry soil (g)	19.40	15.28	15.33	20.40
Wt. of water (g)	6.47	5.34	5.40	7.26
Moisture content, w (%)	33.35	34.95	35.23	35.59
Cone penetration (mm)	14.49	17.97	20.64	21.38

Plastic Limit Calculations

Can no.	33	7
Wt. of wet soil + can (g)	60.94	55.59
Wt. of dry soil + can (g)	57.24	52.21
Wt. of can (g)	45.78	41.77
Wt. of dry soil (g)	11.46	10.44
Wt. of water (g)	3.7	3.38
Moisture content, w (%)	32.29	32.38

Liquid Limit (LL) (%) = **35.23** — Plasticity Indeks, Ip (%) **2.90**
Plastic Limit (PL) (%) = **32.33**



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Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.3 — Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description : Grey, light grey; Silty SAND — Depth of sample : 2.70 - 4.70 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	9.51	1.90	98.10
PAN#2	490.49		
Total	500.00	100.00	0.00
1.190	19.25	5.75	94.25
0.602	13.25	8.40	91.60
0.315	0.52	8.51	91.49
0.211	40.51	16.61	83.39
0.075	295.02	75.61	24.39
PAN#3	121.94		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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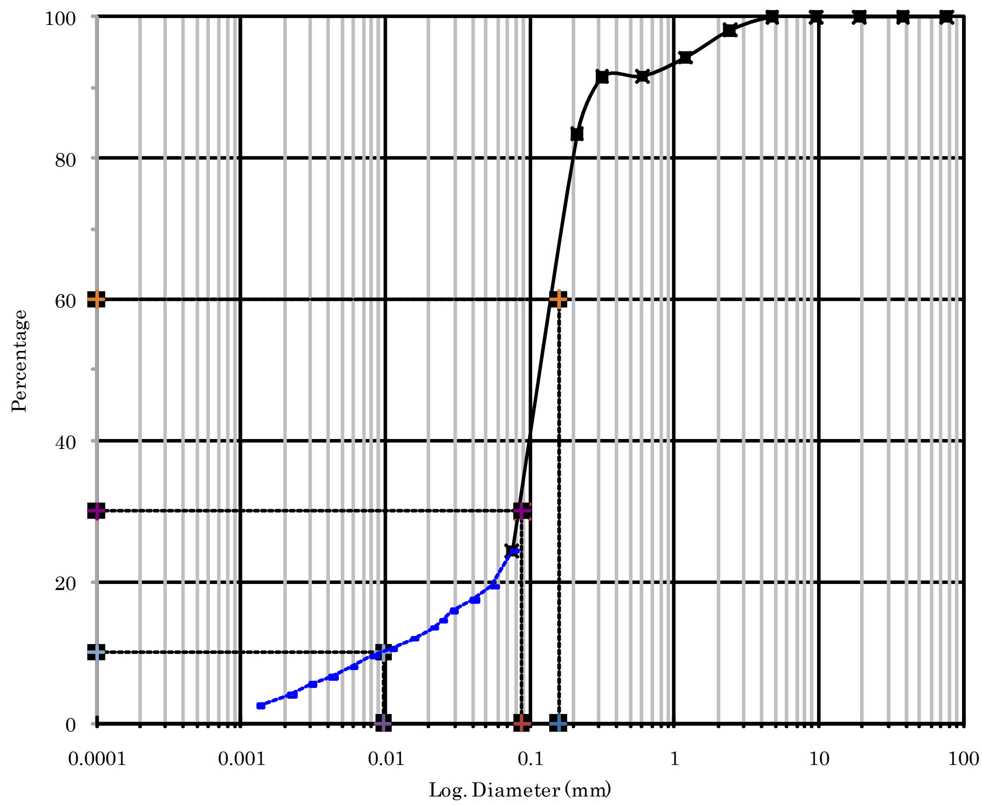
Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-01/#1.3	Date of Testing	: 16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Grey, light grey; Silty SAND	Depth of sample	: 2.70 - 4.70 m



		Percentage		
			D60 =	0.157 mm
Gravel (> 2 mm) & (< 4 mm)	=	3.20 %	D30 =	0.088 mm
Sand (> 0.075 mm) & (< 2 mm)	=	72.42 %	D10 =	0.010 mm
Fine (< 0.075 mm)	=	24.39 %	Cu =	16.27
			Cc =	5.10

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10

Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-01/#1.4	Date of Testing	: 16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Grey; Silty CLAY	Depth of sample	: 4.70 - 6.00 m

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.443	50.4722
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.052	165.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.443	50.472
Wt. of dish + dry soil	Wds	(g)	43.066	74.380
Wt. of dry soil	Ws	(g)	13.623	23.908
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.63	2.63

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.63 / 2.63 = 1.00025 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.63

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Date: 20 August 2011

Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: GILL/BH-01/#1.4		Date of Testing	: 17-Aug-10
Tested By	: BAMBANG SETIAWAN		Eq/Device/Method	: ***
Visual Description	: Grey; Silty CLAY		Depth of sample	: 4.70 - 6.00 m

Moisture content Calculations

Can no.		44
Wt. of wet soil + can	(g)	143.04
Wt. of dry soil + can	(g)	108.28
Wt. of can	(g)	41.03
Wt. of dry soil	(g)	67.25
Wt. of water	(g)	34.76
Moisture content, w	(%)	51.69

Can no.		J
Wt. of wet soil + can	(g)	133.29
Wt. of dry soil + can	(g)	98.76
Wt. of can	(g)	32.54
Wt. of dry soil	(g)	66.22
Wt. of water	(g)	34.53
Moisture content, w	(%)	52.14

Average moisture content	(%)	51.92

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC):	51.92 %
Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA):	24.30 %
Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB):	25.82 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Date: 20 August 2011

Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.4 Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty CLAY Depth of sample : 4.70 - 6.00 m

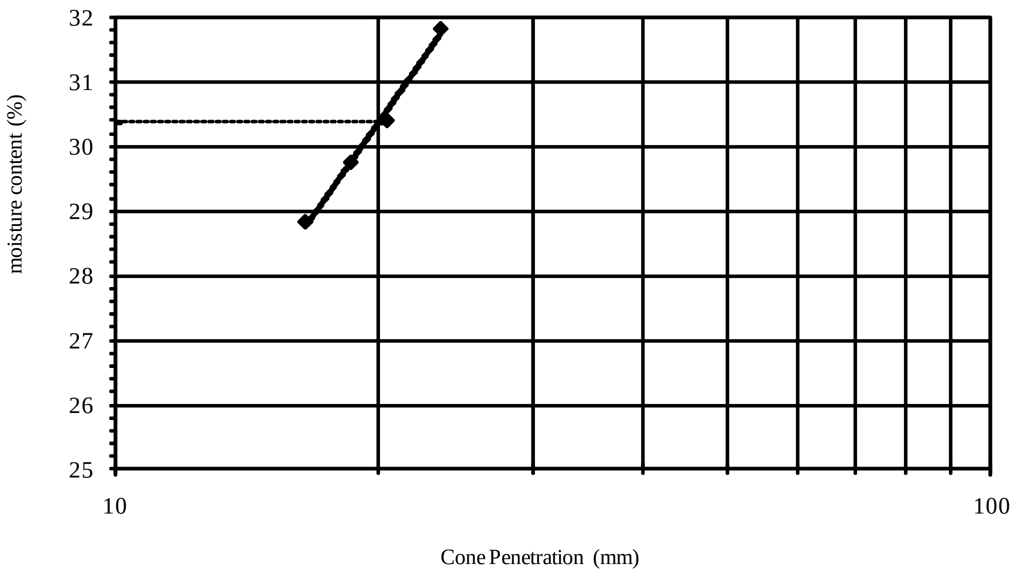
Liquid Limit Calculations

Can no.	J	K	Aa	3
Wt. of wet soil + can (g)	57.30	58.72	53.33	60.42
Wt. of dry soil + can (g)	51.76	52.58	48.36	53.83
Wt. of can (g)	32.54	31.94	32.01	33.12
Wt. of dry soil (g)	19.22	20.64	16.35	20.71
Wt. of water (g)	5.54	6.14	4.97	6.59
Moisture content, w (%)	28.82	29.75	30.40	31.82
Cone penetration (mm)	16.5	18.58	20.42	23.48

Plastic Limit Calculations

Can no.	14	8
Wt. of wet soil + can (g)	54.24	41.13
Wt. of dry soil + can (g)	52.51	39.67
Wt. of can (g)	43.05	31.43
Wt. of dry soil (g)	9.46	8.24
Wt. of water (g)	1.73	1.46
Moisture content, w (%)	18.29	17.72

Liquid Limit (LL) (%) = **30.38** Plasticity Indeks, Ip (%) **12.37**
Plastic Limit (PL) (%) = **18.00**



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Reported by: B. Setiawan
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Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.4 — Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description : Grey; Silty CLAY — Depth of sample : 4.70 - 6.00 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	4.02	0.80	99.20
PAN#2	495.98		
Total	500.00	100.00	0.00
1.190	14.50	3.70	96.30
0.602	17.01	7.11	92.89
0.315	0.25	7.16	92.84
0.211	52.02	17.56	82.44
0.075	144.01	46.36	53.64
PAN#3	268.19		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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Reported by: B. Setiawan

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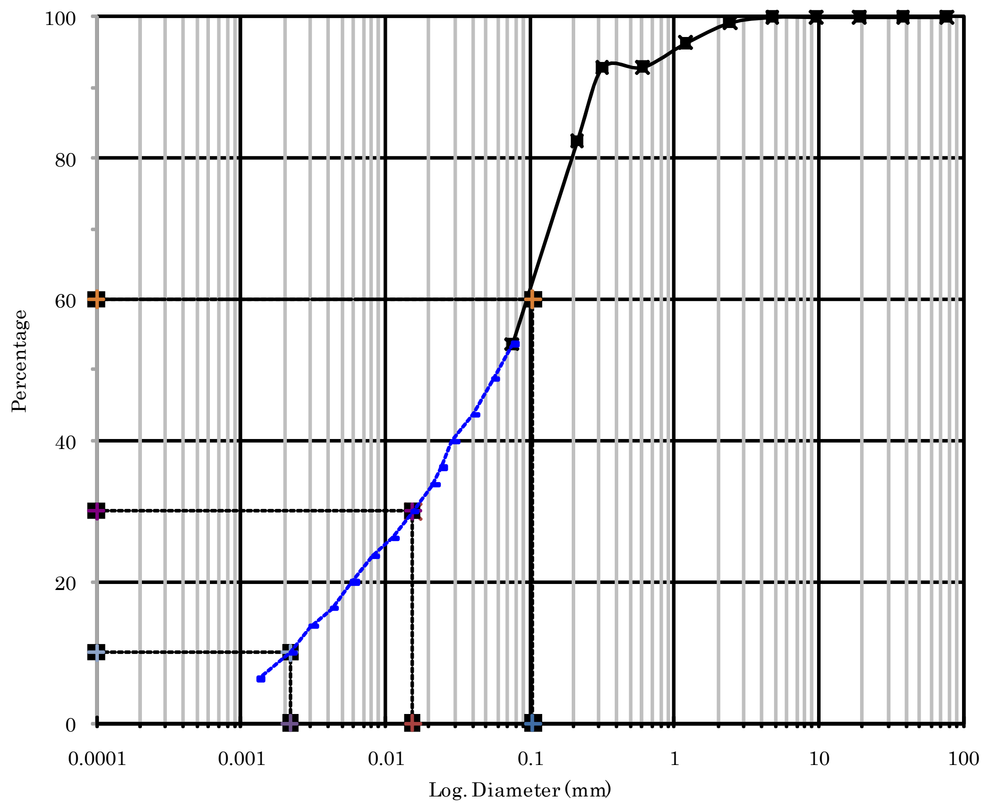
Date: 20 August 2011

Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.4 Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty CLAY Depth of sample : 4.70 - 6.00 m



		Percentage		
			D60 =	0.105 mm
Gravel (> 2 mm) & (< 4 mm)	=	1.78 %	D30 =	0.015 mm
Sand (> 0.075 mm) & (< 2 mm)	=	44.58 %	D10 =	0.002 mm
Fine (< 0.075 mm)	=	53.64 %	Cu =	48.04
			Cc =	1.04

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Reported by: B. Setiawan

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Date: 20 August 2011

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-01/#1.5	Date of Testing	: 16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method :	***
Visual Description	: Yellowish brown; Gravelly silty SAND	Depth of sample :	6.00 - 9.00 m

[A] Calibration of pycnometer

Pycnometer No.			G3	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.987	49.1969
Wt. of pycnometer + water	Wpw	(g)	79.871	149.924
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	88.424	167.630
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	79.871	149.924
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.987	49.197
Wt. of dish + dry soil	Wds	(g)	43.641	77.428
Wt. of dry soil	Ws	(g)	13.654	28.231
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.68	2.68

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.68 / 2.68 = 1.00204 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.68

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Reported by : B. Setiawan

Signature:

Date: 20 August 2011

Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	:	Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	:	Gillman, SA		
Sample Code	:	GILL/BH-01/#1.5	Date of Testing	: 17-Aug-10
Tested By	:	BAMBANG SETIAWAN	Eq/Device/Method :	***
Visual Description	:	Yellowish brown; Gravelly silty SAND	Depth of sample :	6.00 - 9.00 m

Moisture content Calculations

Can no.		45
Wt. of wet soil + can	(g)	190.80
Wt. of dry soil + can	(g)	152.74
Wt. of can	(g)	40.60
Wt. of dry soil	(g)	112.14
Wt. of water	(g)	38.06
Moisture content, w	(%)	33.94

Can no.		K
Wt. of wet soil + can	(g)	192.23
Wt. of dry soil + can	(g)	153.23
Wt. of can	(g)	31.94
Wt. of dry soil	(g)	121.29
Wt. of water	(g)	39.00
Moisture content, w	(%)	32.15

Average moisture content	(%)	33.05

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 33.05 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 23.44 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 24.91 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Reported by : B. Setiawan

Signature:

Date: 20 August 2011

Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.5 — Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description : Yellowish brown; Gravelly silty SAND — Depth of sample : 6.00 - 9.00 m

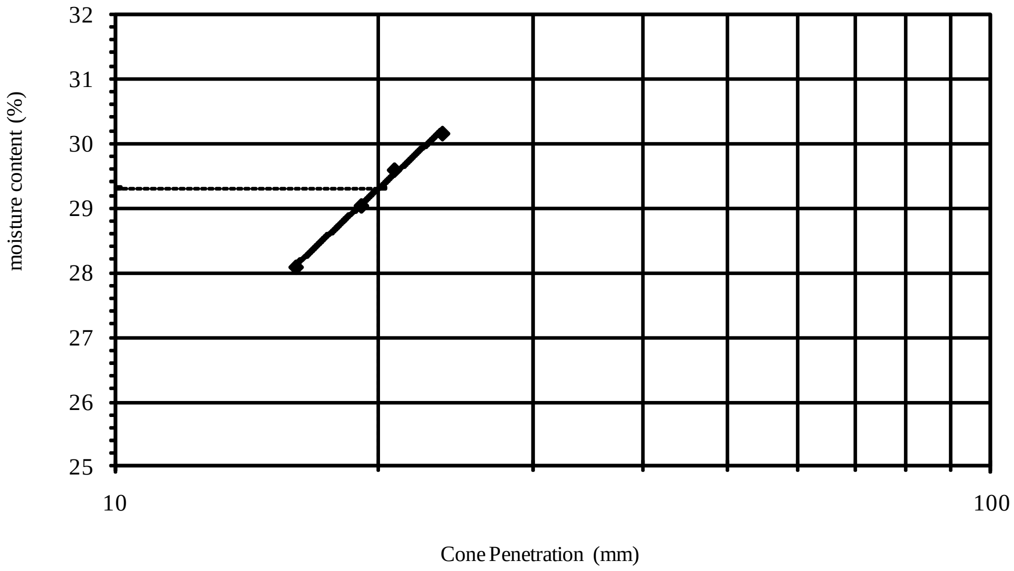
Liquid Limit Calculations

Can no.	40	46	44	H
Wt. of wet soil + can (g)	63.68	65.80	66.60	55.87
Wt. of dry soil + can (g)	58.69	60.20	60.76	50.51
Wt. of can (g)	40.93	40.92	41.03	32.74
Wt. of dry soil (g)	17.76	19.28	19.73	17.77
Wt. of water (g)	4.99	5.60	5.84	5.36
Moisture content, w (%)	28.10	29.05	29.60	30.16
Cone penetration (mm)	16.08	19.09	20.83	23.63

Plastic Limit Calculations

Can no.	36	6
Wt. of wet soil + can (g)	61.41	42.05
Wt. of dry soil + can (g)	58.23	40.22
Wt. of can (g)	46.04	32.99
Wt. of dry soil (g)	12.19	7.23
Wt. of water (g)	3.18	1.83
Moisture content, w (%)	26.09	25.31

Liquid Limit (LL) (%) = **29.30** — Plasticity Indeks, Ip (%) **3.61**
Plastic Limit (PL) (%) = **25.70**



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Signature:
Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.5 Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Yellowish brown; Gravelly silty SAND Depth of sample : 6.00 - 9.00 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	600	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	600.00		
Total	600.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	30.02	5.00	95.00
PAN#2	569.98		
Total	600.00	100.00	0.00
1.190	25.21	9.21	90.80
0.602	27.92	13.86	86.14
0.315	0.00	13.86	86.14
0.211	52.52	22.61	77.39
0.075	357.61	82.21	17.79
PAN#3	106.72		
Total	600.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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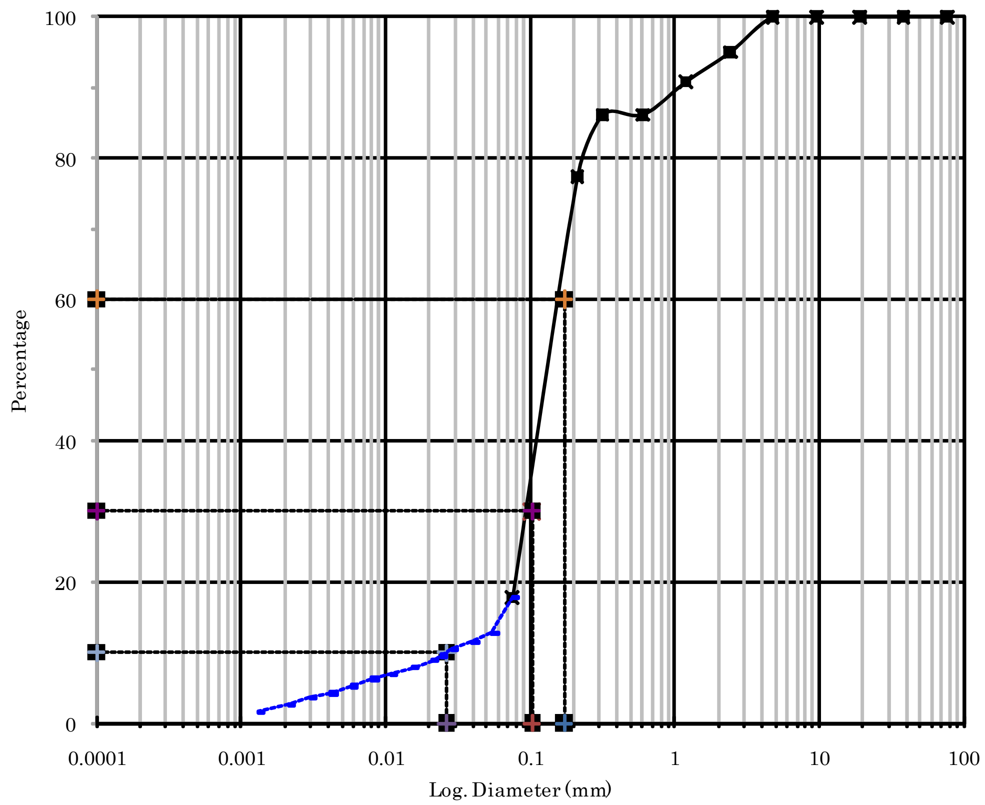
Date: 20 August 2011

Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.5 Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Yellowish brown; Gravelly silty SAND Depth of sample : 6.00 - 9.00 m



		Percentage		
			D60 =	0.171 mm
Gravel (> 2 mm) & (< 4 mm)	=	6.42 %	D30 =	0.103 mm
Sand (> 0.075 mm) & (< 2 mm)	=	75.80 %	D10 =	0.026 mm
Fine (< 0.075 mm)	=	17.79 %	Cu =	6.52
			Cc =	2.35

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-01/#1.6	Date of Testing	: 16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Brown; Silty CLAY	Depth of sample	: 9.00 - 10.50 m

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.443	50.4722
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.052	165.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.443	50.472
Wt. of dish + dry soil	Wds	(g)	43.066	74.380
Wt. of dry soil	Ws	(g)	13.623	23.908
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.63	2.63

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.63 / 2.63 = 1.00025 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.63

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Date: 20 August 2011

Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	:	Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	:	Gillman, SA			
Sample Code	:	GILL/BH-01/#1.6	Date of Testing	:	17-Aug-10
Tested By	:	BAMBANG SETIAWAN	Eq/Device/Method	:	***
Visual Description	:	Brown; Silty CLAY	Depth of sample	:	9.00 - 10.50 m

Moisture content Calculations

Can no.		46
Wt. of wet soil + can	(g)	193.71
Wt. of dry soil + can	(g)	165.62
Wt. of can	(g)	40.92
Wt. of dry soil	(g)	124.70
Wt. of water	(g)	28.09
Moisture content, w	(%)	22.53

Can no.		33
Wt. of wet soil + can	(g)	188.08
Wt. of dry soil + can	(g)	161.87
Wt. of can	(g)	45.78
Wt. of dry soil	(g)	116.09
Wt. of water	(g)	26.21
Moisture content, w	(%)	22.58

Average moisture content	(%)	22.55

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 22.55 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 29.99 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 31.87 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project	:	Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	:	Gillman, SA		
Sample Code	:	GILL/BH-01/#1.6	Date of Testing	: 16-Feb-11
Tested By	:	BAMBANG SETIAWAN	Eq/Device/Method :	***
Visual Description	:	Brown; Silty CLAY	Depth of sample :	9.00 - 10.50 m

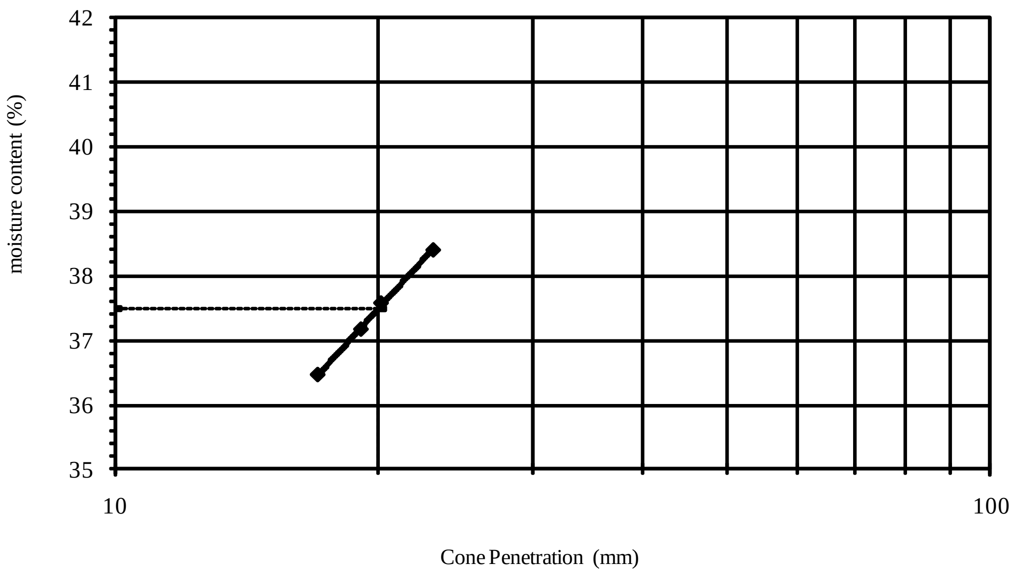
Liquid Limit Calculations

Can no.	32	5a	39	49
Wt. of wet soil + can (g)	72.02	60.72	70.03	77.40
Wt. of dry soil + can (g)	65.07	55.16	63.47	67.23
Wt. of can (g)	46.01	40.20	46.01	40.74
Wt. of dry soil (g)	19.06	14.96	17.46	26.49
Wt. of water (g)	6.95	5.56	6.56	10.17
Moisture content, w (%)	36.46	37.17	37.57	38.39
Cone penetration (mm)	17.07	19.1	20.12	23.04

Plastic Limit Calculations

Can no.	35	G
Wt. of wet soil + can (g)	56.45	41.00
Wt. of dry soil + can (g)	54.87	39.50
Wt. of can (g)	46.04	31.25
Wt. of dry soil (g)	8.83	8.25
Wt. of water (g)	1.58	1.5
Moisture content, w (%)	17.89	18.18

Liquid Limit (LL) (%) =	**37.49**	Plasticity Indeks, Ip (%)	**19.45**
Plastic Limit (PL) (%) =	**18.04**		



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Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.6 — Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description : Brown; Silty CLAY — Depth of sample : 9.00 - 10.50 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	10.25	2.05	97.95
PAN#2	489.75		
Total	500.00	100.00	0.00
1.190	1.75	2.40	97.60
0.602	0.75	2.55	97.45
0.315	0.00	2.55	97.45
0.211	3.75	3.30	96.70
0.075	11.52	5.60	94.40
PAN#3	471.98		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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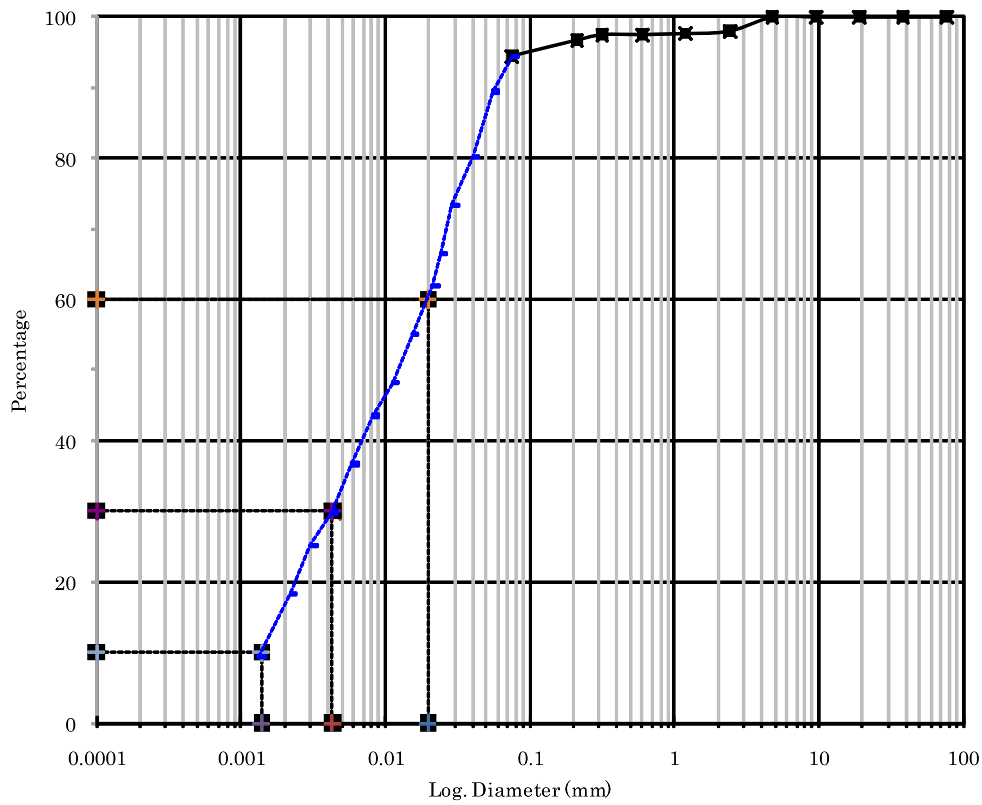
Date: 20 August 2011

Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.6 Date of Testing : 16-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown; Silty CLAY Depth of sample : 9.00 - 10.50 m



		Percentage		
			D60 =	0.020 mm
Gravel (> 2 mm) & (< 4 mm)	=	2.17 %	D30 =	0.004 mm
Sand (> 0.075 mm) & (< 2 mm)	=	3.44 %	D10 =	0.001 mm
Fine (< 0.075 mm)	=	94.40 %	Cu =	14.17
			Cc =	0.67

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Date: 20 August 2011

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-02/#2.1	Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Grey; Silty SAND	Depth of sample	: 0.00 - 0.70 m

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.443	50.4722
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.052	165.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.443	50.472
Wt. of dish + dry soil	Wds	(g)	43.066	74.380
Wt. of dry soil	Ws	(g)	13.623	23.908
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.63	2.63

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.63 / 2.63 = 1.00025 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.63

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Date: 20 August 2011

Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: GILL/BH-02/#2.1		Date of Testing	: 17-Aug-10
Tested By	: BAMBANG SETIAWAN		Eq/Device/Method	: ***
Visual Description	: Grey; Silty SAND		Depth of sample	: 0.00 - 0.70 m

Moisture content Calculations

Can no.		I
Wt. of wet soil + can	(g)	58.32
Wt. of dry soil + can	(g)	56.33
Wt. of can	(g)	32.73
Wt. of dry soil	(g)	23.60
Wt. of water	(g)	1.99
Moisture content, w	(%)	8.43

Can no.		21
Wt. of wet soil + can	(g)	88.08
Wt. of dry soil + can	(g)	84.42
Wt. of can	(g)	42.53
Wt. of dry soil	(g)	41.89
Wt. of water	(g)	3.66
Moisture content, w	(%)	8.74

Average moisture content	(%)	8.58

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 8.58 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 18.43 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 19.58 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Date: 20 August 2011

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LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.1 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty SAND Depth of sample : 0.00 - 0.70 m

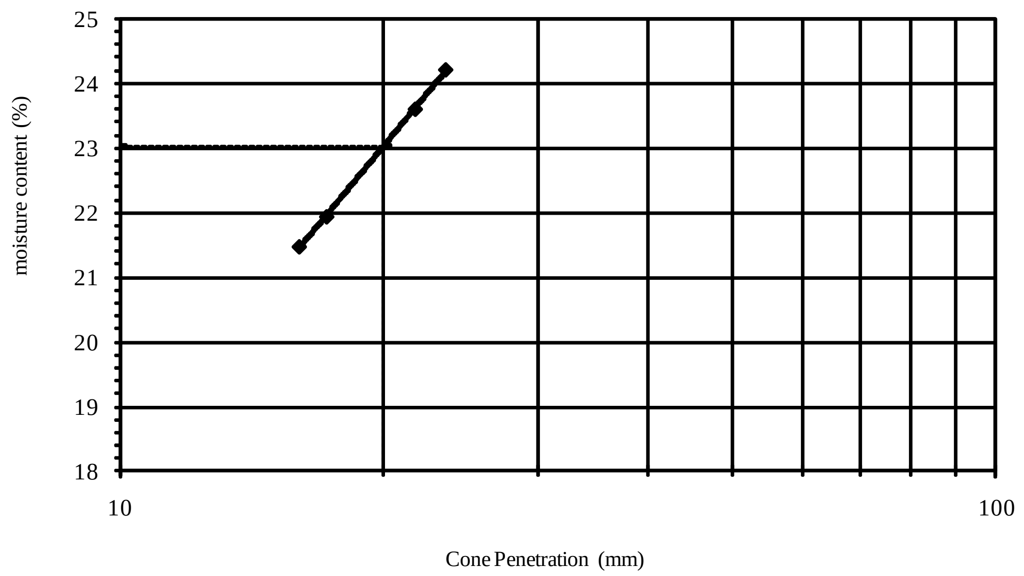
Liquid Limit Calculations

Can no.	14	35	36	2
Wt. of wet soil + can (g)	70.16	78.29	73.08	62.45
Wt. of dry soil + can (g)	65.37	72.49	67.81	56.90
Wt. of can (g)	43.06	46.05	46.05	33.39
Wt. of dry soil (g)	22.31	26.44	21.76	23.51
Wt. of water (g)	4.79	5.80	5.27	5.55
Moisture content, w (%)	21.47	21.94	24.22	23.61
Cone penetration (mm)	16	17.2	23.55	21.73

Plastic Limit Calculations

Can no.	44	48
Wt. of wet soil + can (g)	80.25	91.33
Wt. of dry soil + can (g)	72.95	81.91
Wt. of can (g)	41.03	40.60
Wt. of dry soil (g)	31.92	41.31
Wt. of water (g)	7.3	9.42
Moisture content, w (%)	22.87	22.80

Liquid Limit (LL) (%) = **23.04** Plasticity Indeks, Ip (%) **0.20**
Plastic Limit (PL) (%) = **22.84**



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Reported by: B. Setiawan

Signature:
Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.1 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty SAND Depth of sample : 0.00 - 0.70 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	43.75	8.75	91.25
PAN#2	456.25		
Total	500.00	100.00	0.00
1.190	9.75	10.70	89.30
0.602	10.25	12.75	87.25
0.315	0.52	12.85	87.15
0.211	199.03	52.66	47.34
0.075	151.75	83.01	16.99
PAN#3	84.95		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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Reported by: B. Setiawan

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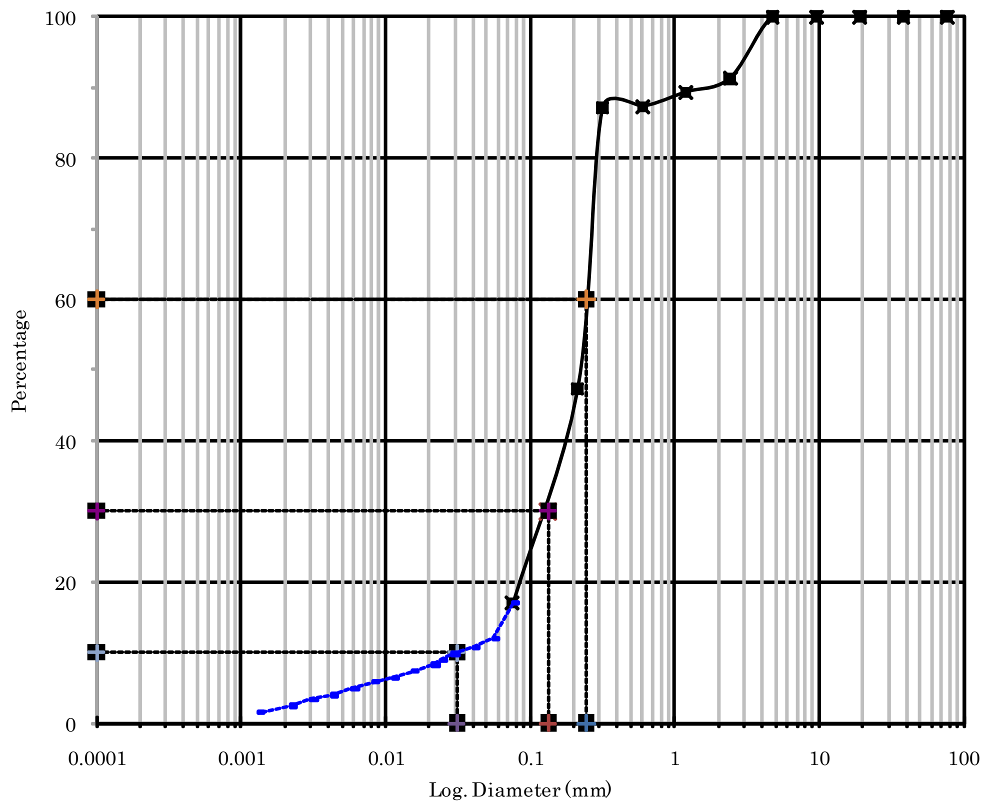
Date: 20 August 2011

Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.1 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty SAND Depth of sample : 0.00 - 0.70 m



		Percentage		
Gravel (> 2 mm) & (< 4 mm)	=	9.41 %	D60 =	0.244 mm
Sand (> 0.075 mm) & (< 2 mm)	=	73.60 %	D30 =	0.133 mm
Fine (< 0.075 mm)	=	16.99 %	D10 =	0.031 mm
			Cu =	7.86
			Cc =	2.34

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Reported by: B. Setiawan

Signature: ____________
Date: 20 August 2011

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.2 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown, reddish brown; Gravelly sandy SILT Depth of sample : 0.70 - 1.20 m

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.443	50.4722
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.052	165.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.443	50.472
Wt. of dish + dry soil	Wds	(g)	43.066	74.380
Wt. of dry soil	Ws	(g)	13.623	23.908
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.63	2.63

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.63 / 2.63 = 1.00025 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.63

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Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: GILL/BH-02/#2.2		Date of Testing	: 17-Aug-10
Tested By	: BAMBANG SETIAWAN		Eq/Device/Method	: ***
Visual Description	: Brown, reddish brown; Gravelly sandy SILT		Depth of sample	: 0.70 - 1.20 m

Moisture content Calculations

Can no.		D
Wt. of wet soil + can	(g)	62.08
Wt. of dry soil + can	(g)	59.43
Wt. of can	(g)	33.20
Wt. of dry soil	(g)	26.23
Wt. of water	(g)	2.65
Moisture content, w	(%)	10.10

Can no.		48
Wt. of wet soil + can	(g)	66.04
Wt. of dry soil + can	(g)	63.68
Wt. of can	(g)	40.59
Wt. of dry soil	(g)	23.09
Wt. of water	(g)	2.36
Moisture content, w	(%)	10.22

Average moisture content	(%)	10.16

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 10.16 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 22.11 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 23.49 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:

a) Fine Content ≥ 20% if Plasticity Index >12%

b) Fine Content ≥ 35% if Plasticity Index <12%

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Date: 20 August 2011

Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.2 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown, reddish brown; Gravelly sandy SILT Depth of sample : 0.70 - 1.20 m

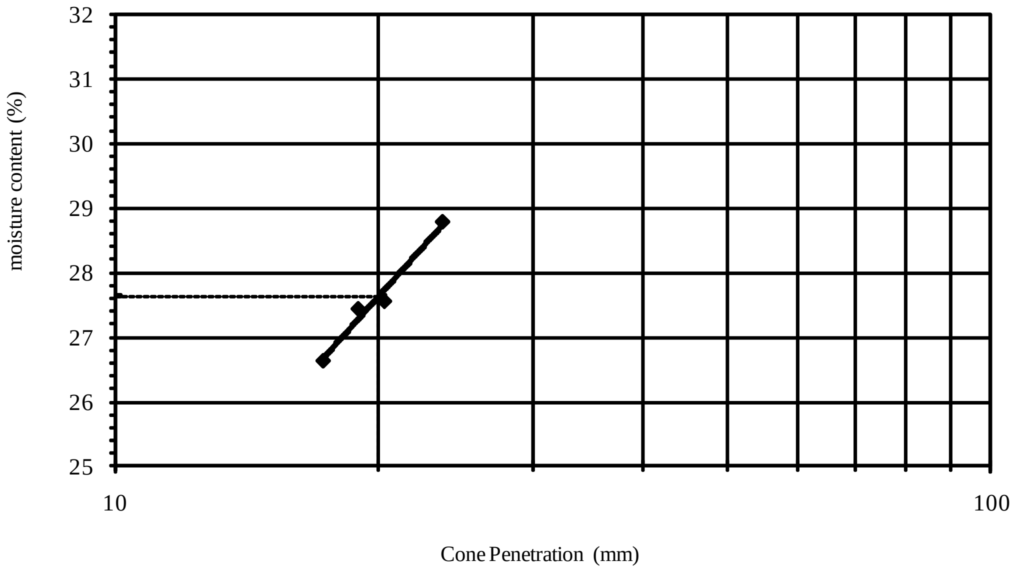
Liquid Limit Calculations

Can no.	33	32	48	42
Wt. of wet soil + can (g)	73.40	70.45	61.94	56.63
Wt. of dry soil + can (g)	67.59	65.19	57.33	53.05
Wt. of can (g)	45.78	46.02	40.60	40.61
Wt. of dry soil (g)	21.81	19.17	16.73	12.44
Wt. of water (g)	5.81	5.26	4.61	3.58
Moisture content, w (%)	26.64	27.44	27.56	28.78
Cone penetration (mm)	17.27	18.94	20.29	23.64

Plastic Limit Calculations

Can no.	4b	4
Wt. of wet soil + can (g)	42.98	44.53
Wt. of dry soil + can (g)	41.73	43.09
Wt. of can (g)	32.80	33.12
Wt. of dry soil (g)	8.93	9.97
Wt. of water (g)	1.25	1.44
Moisture content, w (%)	14.00	14.44

Liquid Limit (LL) (%) = **27.64** Plasticity Indeks, Ip (%) **13.41**
Plastic Limit (PL) (%) = **14.22**



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Reported by: B. Setiawan

Signature:
Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.2 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown, reddish brown; Gravelly sandy SILT Depth of sample : 0.70 - 1.20 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	600	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	600.00		
Total	600.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	57.92	9.65	90.35
PAN#2	542.08		
Total	600.00	100.00	0.00
1.190	11.73	11.61	88.39
0.602	15.90	14.26	85.74
0.315	0.00	14.26	85.74
0.211	81.91	27.91	72.09
0.075	11.92	29.90	70.10
PAN#3	420.62		
Total	600.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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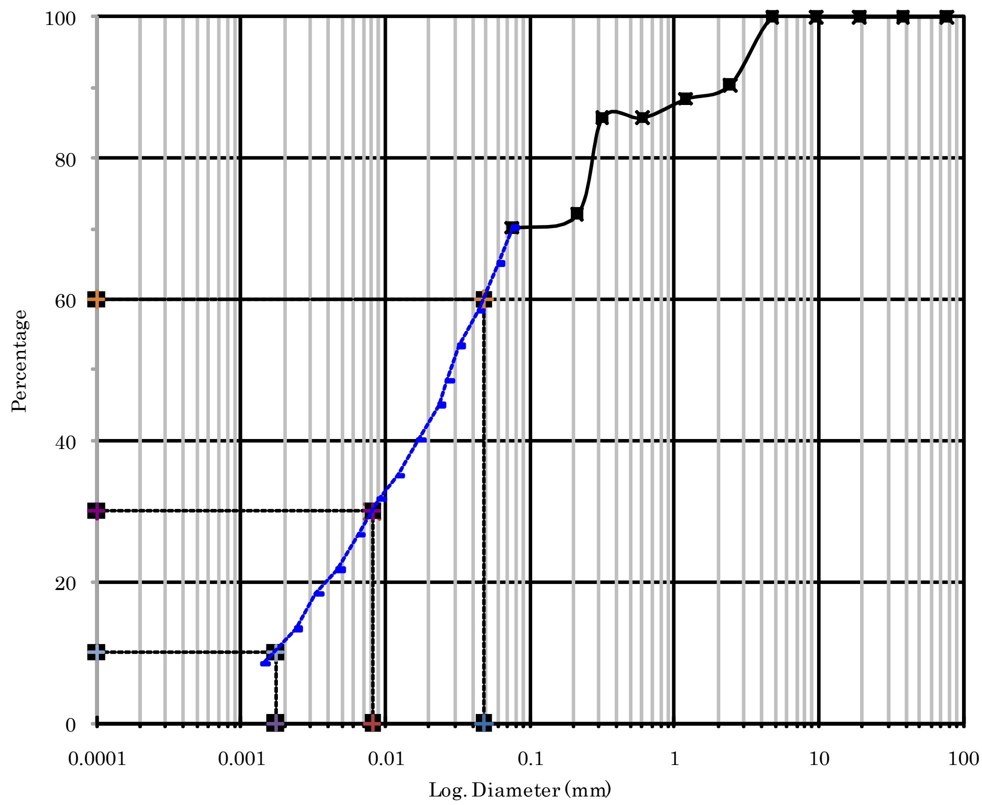
Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.2 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown, reddish brown; Gravelly sandy SILT Depth of sample : 0.70 - 1.20 m



		Percentage		
Gravel (> 2 mm) & (< 4 mm)	=	10.31 %	D60 =	0.048 mm
Sand (> 0.075 mm) & (< 2 mm)	=	19.59 %	D30 =	0.008 mm
Fine (< 0.075 mm)	=	70.10 %	D10 =	0.002 mm
			Cu =	27.75
			Cc =	0.79

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-02/#2.3	Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Brown; Sandy SILT	Depth of sample	: 1.20 - 2.20 m

[A] Calibration of pycnometer

Pycnometer No.			G79	G26
Wt. of dry, clean pycnometer	Wp	(g)	48.712	49.0601
Wt. of pycnometer + water	Wpw	(g)	150.069	151.574
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	167.873	166.247
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	150.069	151.574
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	48.712	49.060
Wt. of dish + dry soil	Wds	(g)	77.562	72.791
Wt. of dry soil	Ws	(g)	28.850	23.731
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.61	2.62

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.62 / 2.61 = 1.00317 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.62

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Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	:	Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	:	Gillman, SA		
Sample Code	:	GILL/BH-02/#2.3	Date of Testing	: 17-Aug-10
Tested By	:	BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	:	Brown; Sandy SILT	Depth of sample	: 1.20 - 2.20 m

Moisture content Calculations

Can no.		2
Wt. of wet soil + can	(g)	127.26
Wt. of dry soil + can	(g)	102.32
Wt. of can	(g)	33.40
Wt. of dry soil	(g)	68.92
Wt. of water	(g)	24.94
Moisture content, w	(%)	36.19

Can no.		23
Wt. of wet soil + can	(g)	135.77
Wt. of dry soil + can	(g)	111.21
Wt. of can	(g)	42.72
Wt. of dry soil	(g)	68.49
Wt. of water	(g)	24.56
Moisture content, w	(%)	35.86

Average moisture content	(%)	36.02

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 36.02 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 18.76 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 19.93 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Signature:

Date: 20 August 2011

Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.3 — Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description : Brown; Sandy SILT — Depth of sample : 1.20 - 2.20 m

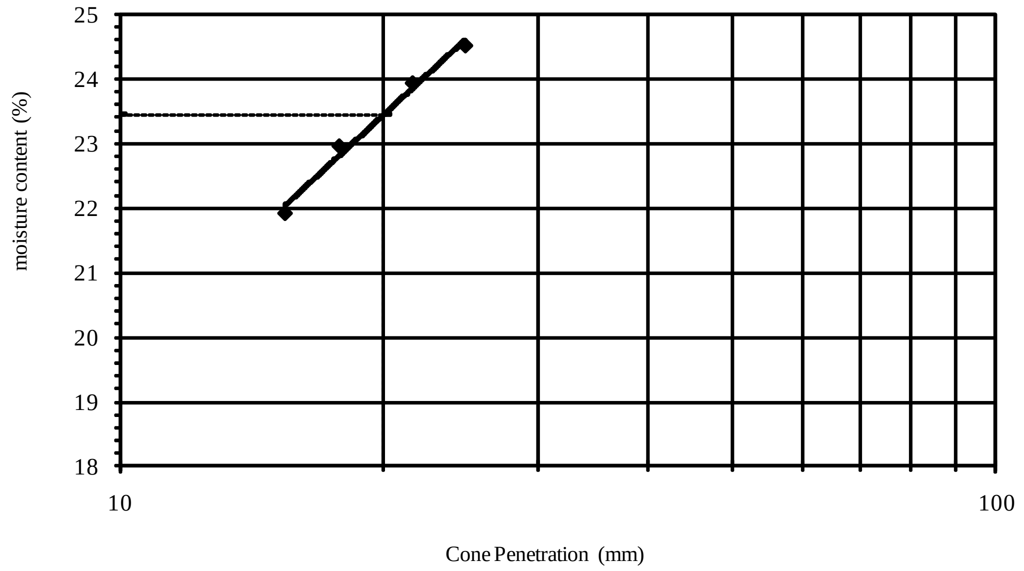
Liquid Limit Calculations

Can no.	7	21	2b	23
Wt. of wet soil + can (g)	70.41	67.06	77.01	78.40
Wt. of dry soil + can (g)	65.26	62.48	70.27	71.38
Wt. of can (g)	41.77	42.53	42.10	42.73
Wt. of dry soil (g)	23.49	19.95	28.17	28.65
Wt. of water (g)	5.15	4.58	6.74	7.02
Moisture content, w (%)	21.92	22.96	23.93	24.50
Cone penetration (mm)	15.45	17.8	21.55	24.74

Plastic Limit Calculations

Can no.	49	42
Wt. of wet soil + can (g)	52.71	51.11
Wt. of dry soil + can (g)	50.75	49.44
Wt. of can (g)	40.74	40.61
Wt. of dry soil (g)	10.01	8.83
Wt. of water (g)	1.96	1.67
Moisture content, w (%)	19.58	18.91

Liquid Limit (LL) (%) = **23.45** — Plasticity Indeks, Ip (%) **4.20**
Plastic Limit (PL) (%) = **19.25**



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Signature:
Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.3 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown; Sandy SILT Depth of sample : 1.20 - 2.20 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	26.25	5.25	94.75
PAN#2	473.75		
Total	500.00	100.00	0.00
1.190	18.25	8.90	91.10
0.602	23.75	13.65	86.35
0.315	0.52	13.75	86.25
0.211	131.53	40.06	59.94
0.075	165.25	73.11	26.89
PAN#3	134.45		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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Reported by: B. Setiawan

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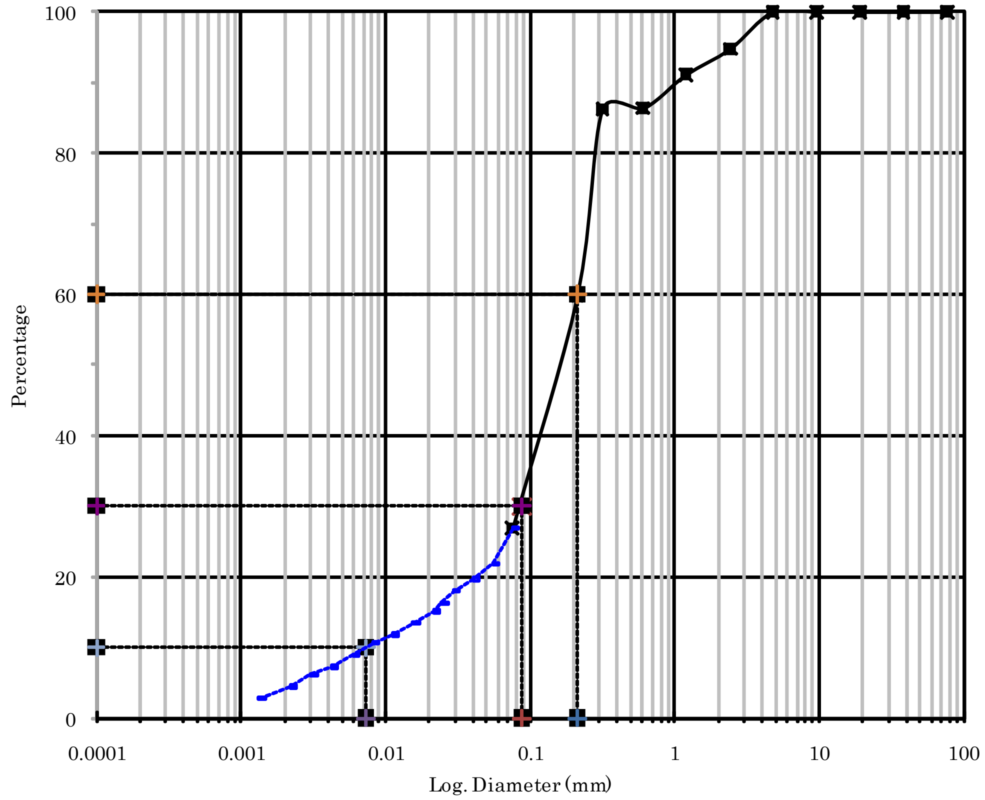
Date: 20 August 2011

Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-02/#2.3	Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Brown; Sandy SILT	Depth of sample	: 1.20 - 2.20 m



		Percentage		
Gravel (> 2 mm) & (< 4 mm)	=	6.48 %	D60 =	0.211 mm
Sand (> 0.075 mm) & (< 2 mm)	=	66.63 %	D30 =	0.088 mm
Fine (< 0.075 mm)	=	26.89 %	D10 =	0.007 mm
			Cu =	28.90
			Cc =	4.99

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Date: 20 August 2011

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-02/#2.4	Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Grey; Silty SAND	Depth of sample	: 2.20 - 4.30 m

[A] Calibration of pycnometer

Pycnometer No.			G26	G27
Wt. of dry, clean pycnometer	Wp	(g)	50.472	50.8624
Wt. of pycnometer + water	Wpw	(g)	150.293	150.563
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	169.134	168.142
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	150.293	150.563
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	50.464	50.858
Wt. of dish + dry soil	Wds	(g)	80.528	78.759
Wt. of dry soil	Ws	(g)	30.064	27.901
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.68	2.70

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.70 / 2.68 = 1.00902 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.69

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SUB CRUCE LUMEN

Reported by : B. Setiawan

Signature:

Date: 20 August 2011

Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.4 Date of Testing : 17-Aug-10
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty SAND Depth of sample : 2.20 - 4.30 m

Moisture content Calculations

Can no.		A
Wt. of wet soil + can	(g)	144.75
Wt. of dry soil + can	(g)	99.87
Wt. of can	(g)	33.18
Wt. of dry soil	(g)	66.69
Wt. of water	(g)	44.88
Moisture content, w	(%)	67.30

Can no.		7
Wt. of wet soil + can	(g)	136.89
Wt. of dry soil + can	(g)	95.12
Wt. of can	(g)	33.11
Wt. of dry soil	(g)	62.01
Wt. of water	(g)	41.77
Moisture content, w	(%)	67.36

Average moisture content	(%)	67.33

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 67.33 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 28.19 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 29.95 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Reported by : B. Setiawan

Signature:
Date: 20 August 2011

Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.4 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty SAND Depth of sample : 2.20 - 4.30 m

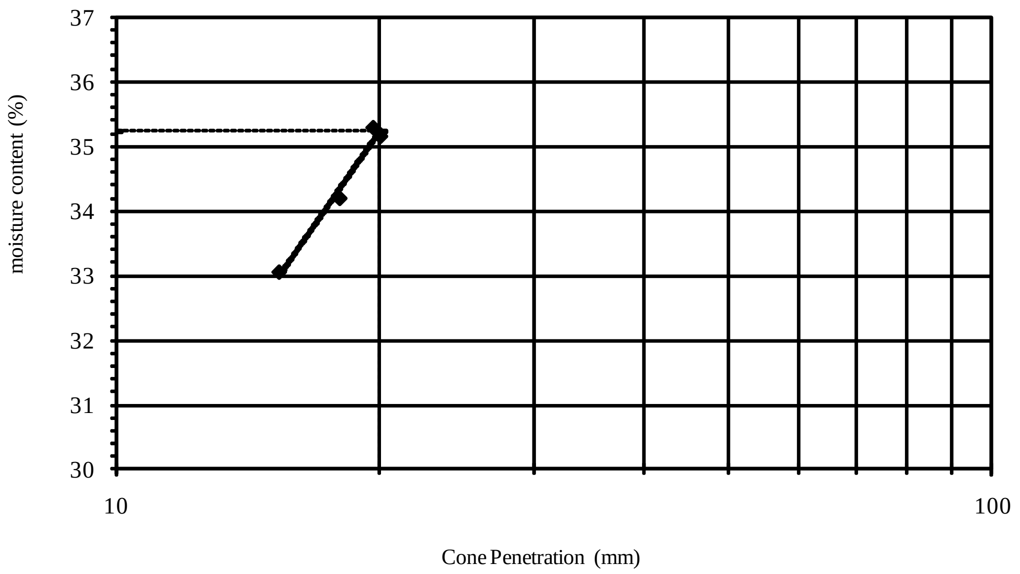
Liquid Limit Calculations

Can no.	C	D	K	3b
Wt. of wet soil + can (g)	64.77	62.03	57.39	67.63
Wt. of dry soil + can (g)	56.43	54.68	50.75	58.54
Wt. of can (g)	31.20	33.19	31.94	32.69
Wt. of dry soil (g)	25.23	21.49	18.81	25.85
Wt. of water (g)	8.34	7.35	6.64	9.09
Moisture content, w (%)	33.06	34.20	35.30	35.16
Cone penetration (mm)	15.38	18.02	19.67	20.05

Plastic Limit Calculations

Can no.	40	45
Wt. of wet soil + can (g)	53.04	55.62
Wt. of dry soil + can (g)	50.18	52.06
Wt. of can (g)	40.92	40.62
Wt. of dry soil (g)	9.26	11.44
Wt. of water (g)	2.86	3.56
Moisture content, w (%)	30.89	31.12

Liquid Limit (LL) (%) = **35.24** Plasticity Indeks, Ip (%) **4.24**
Plastic Limit (PL) (%) = **31.00**



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Reported by: B. Setiawan

Signature:
Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.4 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty SAND Depth of sample : 2.20 - 4.30 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	19.25	3.85	96.15
PAN#2	480.75		
Total	500.00	100.00	0.00
1.190	35.75	11.00	89.00
0.602	17.75	14.55	85.45
0.315	0.00	14.55	85.45
0.211	35.25	21.60	78.40
0.075	281.53	77.91	22.09
PAN#3	110.47		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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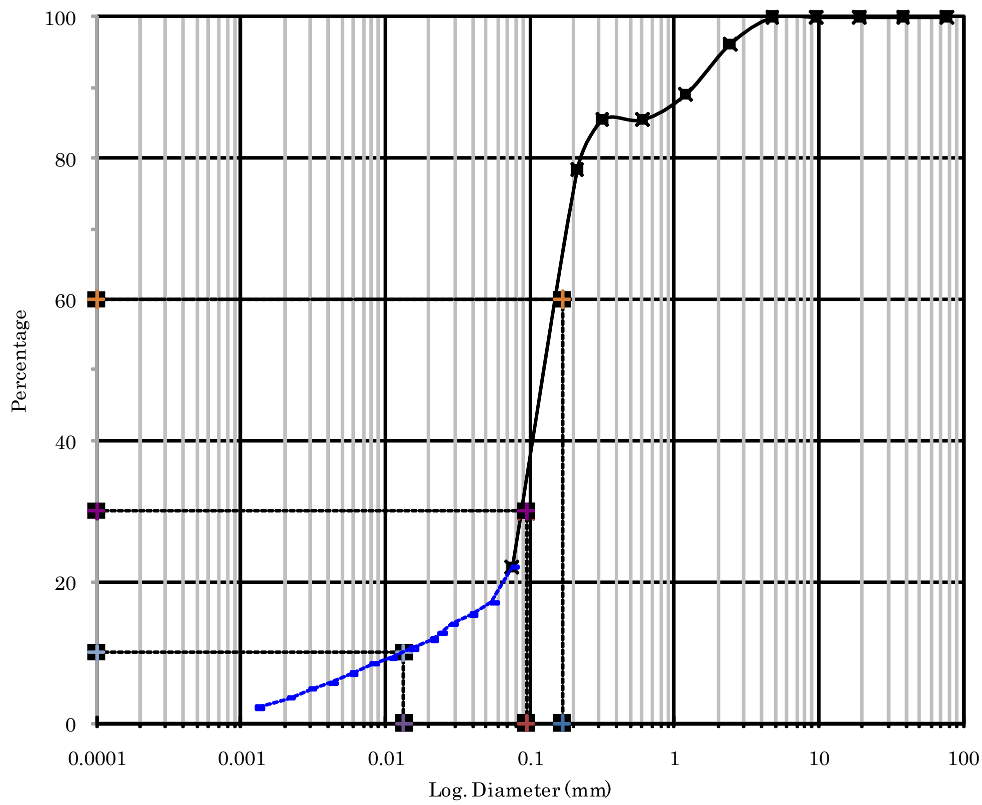
Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-02/#2.4	Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Grey; Silty SAND	Depth of sample	: 2.20 - 4.30 m



		Percentage		
			D60 =	0.167 mm
Gravel (> 2 mm) & (< 4 mm)	=	6.25 %	D30 =	0.094 mm
Sand (> 0.075 mm) & (< 2 mm)	=	71.65 %	D10 =	0.013 mm
Fine (< 0.075 mm)	=	22.09 %	Cu =	12.41
			Cc =	3.96

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10

Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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SPECIFIC GRAVITY OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.5 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty CLAY Depth of sample : 4.30 - 6.30 m

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.443	50.4722
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.052	165.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.443	50.472
Wt. of dish + dry soil	Wds	(g)	43.066	74.380
Wt. of dry soil	Ws	(g)	13.623	23.908
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.63	2.63

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.63 / 2.63 = 1.00025 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.63

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Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: GILL/BH-02/#2.5	Date of Testing	: 17-Aug-10	
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***	
Visual Description	: Grey; Silty CLAY	Depth of sample	: 4.30 - 6.30 m	

Moisture content Calculations

Can no.		3b
Wt. of wet soil + can	(g)	130.15
Wt. of dry soil + can	(g)	90.15
Wt. of can	(g)	32.71
Wt. of dry soil	(g)	57.44
Wt. of water	(g)	40.00
Moisture content, w	(%)	69.64

Can no.		Q
Wt. of wet soil + can	(g)	134.78
Wt. of dry soil + can	(g)	93.21
Wt. of can	(g)	33.12
Wt. of dry soil	(g)	60.09
Wt. of water	(g)	41.57
Moisture content, w	(%)	69.18

Average moisture content	(%)	69.41

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 69.41 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 35.75 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 37.98 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types is applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.5 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty CLAY Depth of sample : 4.30 - 6.30 m

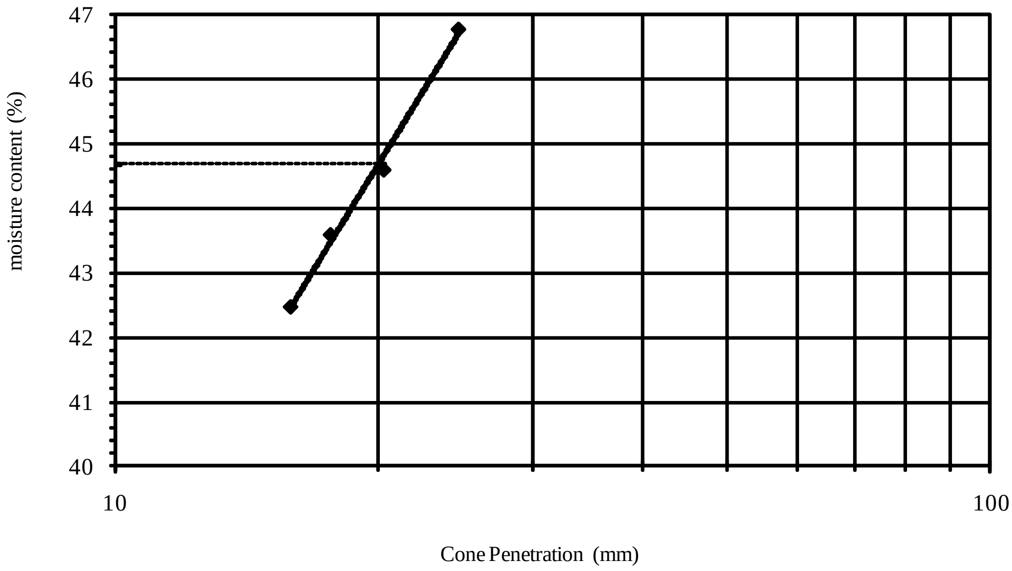
Liquid Limit Calculations

Can no.	44	40	49	45
Wt. of wet soil + can (g)	71.86	73.28	66.69	69.09
Wt. of dry soil + can (g)	62.67	63.46	58.69	60.02
Wt. of can (g)	41.03	40.93	40.75	40.63
Wt. of dry soil (g)	21.64	22.53	17.94	19.39
Wt. of water (g)	9.19	9.82	8.00	9.07
Moisture content, w (%)	42.47	43.59	44.59	46.78
Cone penetration (mm)	15.87	17.62	20.26	24.64

Plastic Limit Calculations

Can no.	33	23
Wt. of wet soil + can (g)	54.92	52.06
Wt. of dry soil + can (g)	53.09	50.23
Wt. of can (g)	45.79	42.73
Wt. of dry soil (g)	7.3	7.5
Wt. of water (g)	1.83	1.83
Moisture content, w (%)	25.07	24.40

Liquid Limit (LL) (%) = **44.68** Plasticity Indeks, Ip (%) **19.95**
Plastic Limit (PL) (%) = **24.73**



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Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.5 — Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description : Grey; Silty CLAY — Depth of sample : 4.30 - 6.30 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	33.04	6.61	93.39
PAN#2	466.96		
Total	500.00	100.00	0.00
1.190	36.51	13.91	86.09
0.602	33.51	20.61	79.39
0.315	0.75	20.76	79.24
0.211	58.01	32.36	67.64
0.075	86.75	49.71	50.29
PAN#3	251.43		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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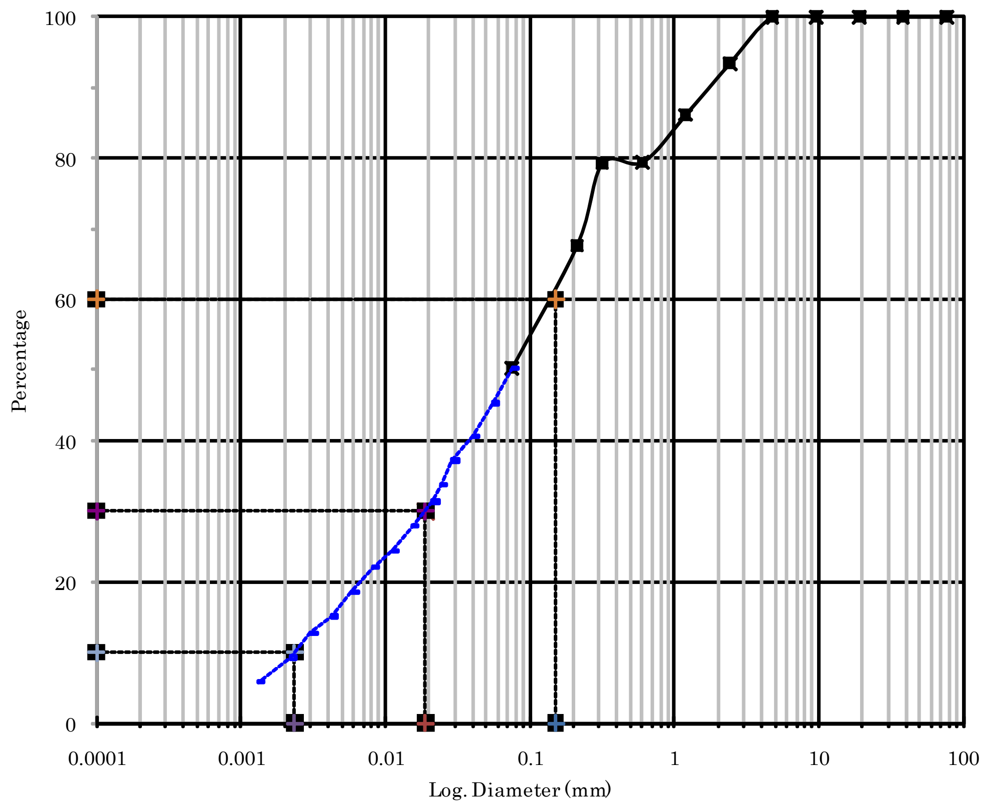
Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.5 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Grey; Silty CLAY Depth of sample : 4.30 - 6.30 m



		Percentage		
			D60 =	0.151 mm
Gravel (> 2 mm) & (< 4 mm)	=	9.06 %	D30 =	0.019 mm
Sand (> 0.075 mm) & (< 2 mm)	=	40.65 %	D10 =	0.002 mm
Fine (< 0.075 mm)	=	50.29 %	Cu =	64.17
			Cc =	1.01

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	:	Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	:	Gillman, SA		
Sample Code	:	GILL/BH-02/#2.6	Date of Testing	: 17-Feb-11
Tested By	:	BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	:	Yellow; Silty SAND	Depth of sample	: 6.30 - 8.50 m

[A] Calibration of pycnometer

Pycnometer No.			G79	G80
Wt. of dry, clean pycnometer	Wp	(g)	48.712	49.0601
Wt. of pycnometer + water	Wpw	(g)	150.069	151.574
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	164.356	170.619
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	150.069	151.574
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	48.712	49.058
Wt. of dish + dry soil	Wds	(g)	71.501	79.549
Wt. of dry soil	Ws	(g)	22.789	30.491
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.68	2.66

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.68 / 2.66 = 1.0061 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.67

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Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :
	MOISTURE CONTENT	

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.6 Date of Testing : 17-Aug-10
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Yellow; Silty SAND Depth of sample : 6.30 - 8.50 m

Moisture content Calculations

Can no.		4b
Wt. of wet soil + can	(g)	149.54
Wt. of dry soil + can	(g)	125.22
Wt. of can	(g)	32.81
Wt. of dry soil	(g)	92.41
Wt. of water	(g)	24.32
Moisture content, w	(%)	26.32

Can no.		2b
Wt. of wet soil + can	(g)	142.56
Wt. of dry soil + can	(g)	121.34
Wt. of can	(g)	42.10
Wt. of dry soil	(g)	79.24
Wt. of water	(g)	21.22
Moisture content, w	(%)	26.78

Average moisture content	(%)	26.55

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 26.55 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 23.03 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 24.47 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.6 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Yellow; Silty SAND Depth of sample : 6.30 - 8.50 m

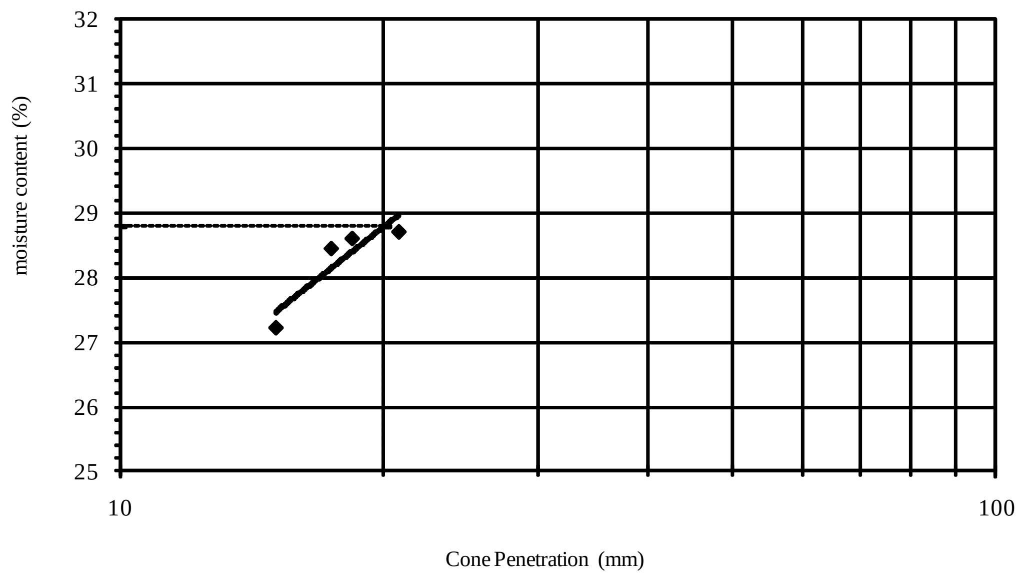
Liquid Limit Calculations

Can no.	1	A	4b	4
Wt. of wet soil + can (g)	59.93	59.43	58.67	71.69
Wt. of dry soil + can (g)	54.07	53.62	52.92	63.09
Wt. of can (g)	32.54	33.19	32.81	33.12
Wt. of dry soil (g)	21.53	20.43	20.11	29.97
Wt. of water (g)	5.86	5.81	5.75	8.60
Moisture content, w (%)	27.22	28.44	28.59	28.70
Cone penetration (mm)	15.04	17.39	18.37	20.76

Plastic Limit Calculations

Can no.	C	2
Wt. of wet soil + can (g)	45.19	47.24
Wt. of dry soil + can (g)	42.31	44.43
Wt. of can (g)	31.21	33.39
Wt. of dry soil (g)	11.1	11.04
Wt. of water (g)	2.88	2.81
Moisture content, w (%)	25.95	25.45

Liquid Limit (LL) (%) = **28.78** Plasticity Indeks, Ip (%) **3.09**
Plastic Limit (PL) (%) = **25.70**



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Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-02/#2.6	Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Yellow; Silty SAND	Depth of sample	: 6.30 - 8.50 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	53.52	10.70	89.30
PAN#2	446.48		
Total	500.00	100.00	0.00
1.190	23.75	15.45	84.55
0.602	23.02	20.06	79.94
0.315	0.53	20.16	79.84
0.211	39.53	28.07	71.93
0.075	265.25	81.12	18.88
PAN#3	94.40		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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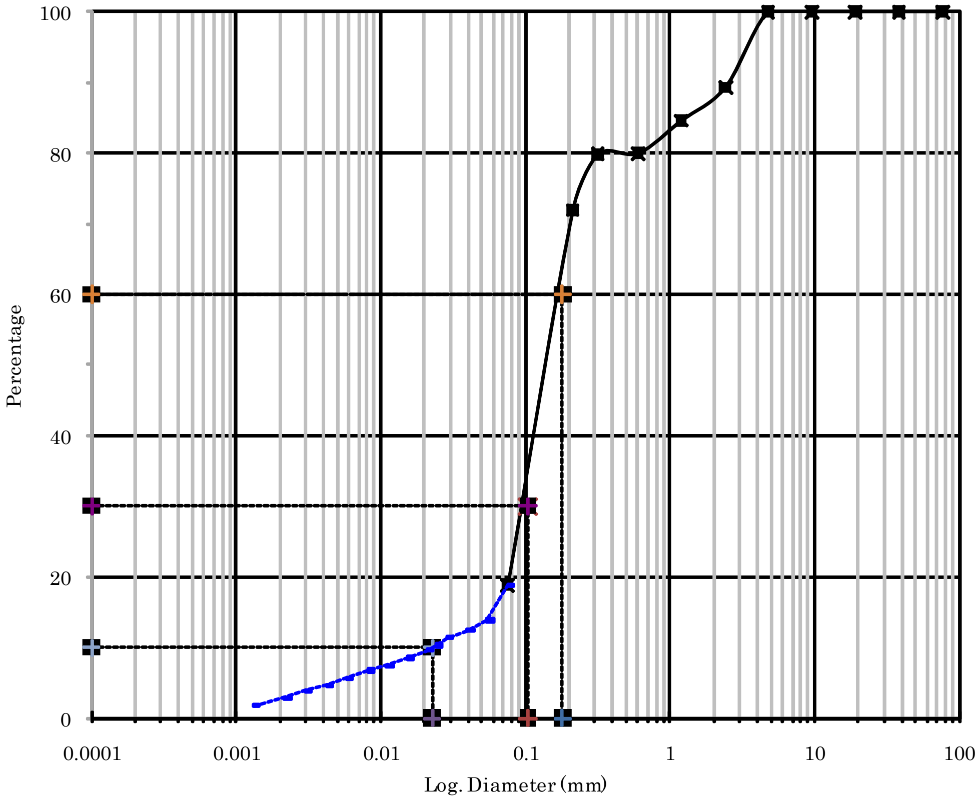
Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-02/#2.6	Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Yellow; Silty SAND	Depth of sample	: 6.30 - 8.50 m



		Percentage		
Gravel (> 2 mm) & (< 4 mm)	=	12.30 %	D60 =	0.180 mm
Sand (> 0.075 mm) & (< 2 mm)	=	68.82 %	D30 =	0.104 mm
Fine (< 0.075 mm)	=	18.88 %	D10 =	0.023 mm
			Cu =	7.97
			Cc =	2.62

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-02/#2.7	Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Light yellow; Slighty sandy SILT	Depth of sample	: 8.50 - 9.10 m

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.443	50.4722
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.052	165.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.443	50.472
Wt. of dish + dry soil	Wds	(g)	43.066	74.380
Wt. of dry soil	Ws	(g)	13.623	23.908
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.63	2.63

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.63 / 2.63 = 1.00025 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.63

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Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	:	Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	:	Gillman, SA		
Sample Code	:	GILL/BH-02/#2.7	Date of Testing	: 17-Aug-10
Tested By	:	BAMBANG SETIAWAN	Eq/Device/Method :	***
Visual Description	:	Light yellow; Slighty sandy SILT	Depth of sample :	8.50 - 9.10 m

Moisture content Calculations

Can no.		C
Wt. of wet soil + can	(g)	132.89
Wt. of dry soil + can	(g)	112.90
Wt. of can	(g)	31.21
Wt. of dry soil	(g)	81.69
Wt. of water	(g)	19.99
Moisture content, w	(%)	24.47

Can no.		36
Wt. of wet soil + can	(g)	134.77
Wt. of dry soil + can	(g)	117.34
Wt. of can	(g)	46.04
Wt. of dry soil	(g)	71.30
Wt. of water	(g)	17.43
Moisture content, w	(%)	24.45

Average moisture content	(%)	24.46

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC):	24.46 %
Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA):	22.93 %
Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB):	24.36 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: GILL/BH-02/#2.7		Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN		Eq/Device/Method	: ***
Visual Description	: Light yellow; Slighty sandy SILT		Depth of sample	: 8.50 - 9.10 m

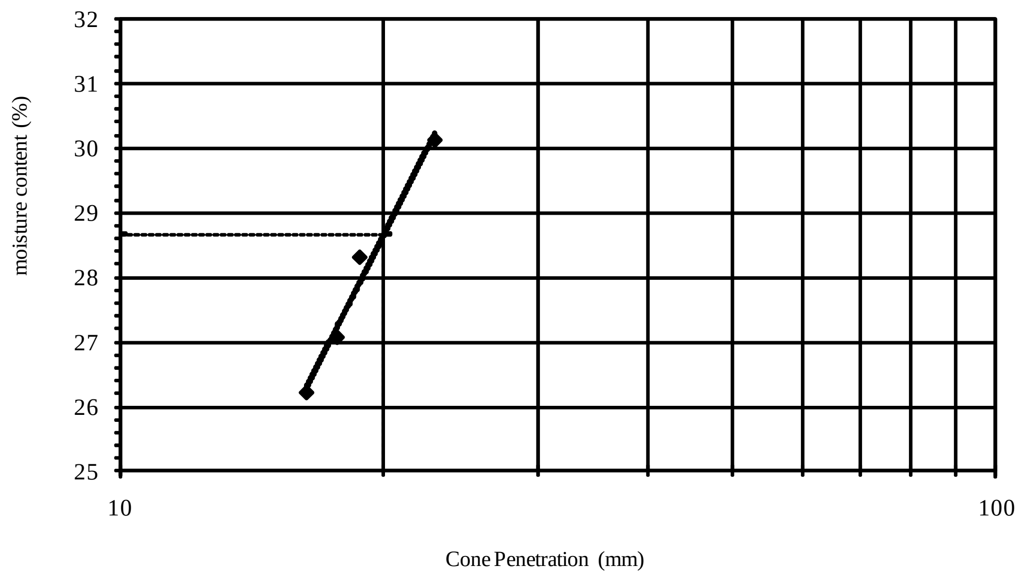
Liquid Limit Calculations

Can no.	39	43	5a	8
Wt. of wet soil + can (g)	72.73	69.58	65.67	59.98
Wt. of dry soil + can (g)	67.18	63.41	60.05	53.37
Wt. of can (g)	46.01	40.62	40.20	31.43
Wt. of dry soil (g)	21.17	22.79	19.85	21.94
Wt. of water (g)	5.55	6.17	5.62	6.61
Moisture content, w (%)	26.22	27.07	28.31	30.13
Cone penetration (mm)	16.34	17.71	18.79	22.9

Plastic Limit Calculations

Can no.	1	32
Wt. of wet soil + can (g)	43.12	57.15
Wt. of dry soil + can (g)	41.81	55.78
Wt. of can (g)	32.54	46.02
Wt. of dry soil (g)	9.27	9.76
Wt. of water (g)	1.31	1.37
Moisture content, w (%)	14.13	14.04

Liquid Limit (LL) (%) =	**28.66**	Plasticity Indeks, Ip (%)	**14.58**
Plastic Limit (PL) (%) =	**14.08**		



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Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: GILL/BH-02/#2.7	Date of Testing	: 17-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Light yellow; Slighty sandy SILT	Depth of sample	: 8.50 - 9.10 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	2.75	0.55	99.45
PAN#2	497.25		
Total	500.00	100.00	0.00
1.190	1.75	0.90	99.10
0.602	1.25	1.15	98.85
0.315	0.53	1.26	98.74
0.211	17.25	4.71	95.29
0.075	108.03	26.31	73.69
PAN#3	368.44		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample

% passing = 100 - % retained

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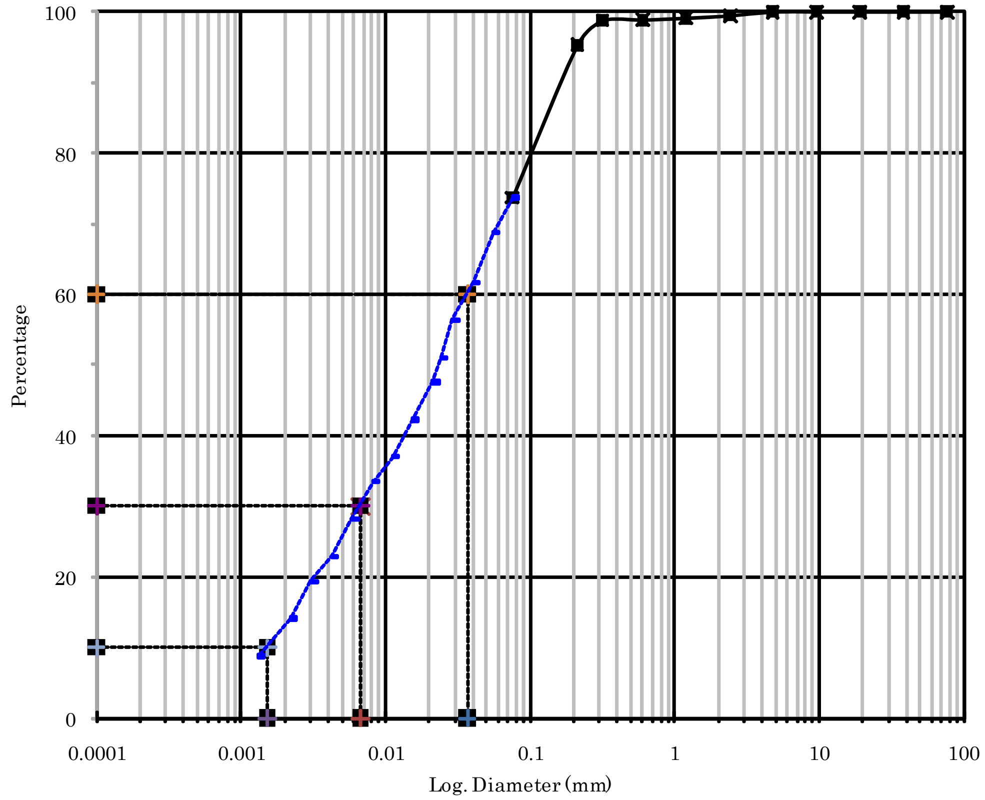
Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.7 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Light yellow; Slighty sandy SILT Depth of sample : 8.50 - 9.10 m



		Percentage		
			D60 =	0.037 mm
Gravel (> 2 mm) & (< 4 mm)	=	0.67 %	D30 =	0.007 mm
Sand (> 0.075 mm) & (< 2 mm)	=	25.64 %	D10 =	0.002 mm
Fine (< 0.075 mm)	=	73.69 %	Cu =	24.25
			Cc =	0.80

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: GILL/BH-02/#2.8	Date of Testing	: 17-Feb-11	
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method :	***	
Visual Description	: Brown; Silty CLAY	Depth of sample :	9.10 - 12.45 m	

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.443	50.4722
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	89.052	165.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.443	50.472
Wt. of dish + dry soil	Wds	(g)	43.066	74.380
Wt. of dry soil	Ws	(g)	13.623	23.908
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.63	2.63

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.63 / 2.63 = 1.00025 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.63

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Form : NMC - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MOISTURE CONTENT

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: GILL/BH-02/#2.8		Date of Testing	: 17-Aug-10
Tested By	: BAMBANG SETIAWAN		Eq/Device/Method	: ***
Visual Description	: Brown; Silty CLAY		Depth of sample	: 9.10 - 12.45 m

Moisture content Calculations

Can no.		48
Wt. of wet soil + can	(g)	185.32
Wt. of dry soil + can	(g)	166.29
Wt. of can	(g)	40.61
Wt. of dry soil	(g)	125.68
Wt. of water	(g)	19.03
Moisture content, w	(%)	15.14

Can no.		H
Wt. of wet soil + can	(g)	178.08
Wt. of dry soil + can	(g)	158.87
Wt. of can	(g)	32.74
Wt. of dry soil	(g)	126.13
Wt. of water	(g)	19.21
Moisture content, w	(%)	15.23

Average moisture content	(%)	15.19

Assessment of liquefiable soil types (Seed et al., 2003):

Natural moisture content of the sample (NMC): 15.19 %

Threshold moisture content at Zone A of a graph of Plasticity Index & Liquid Limit proposed by Seed et al., 2003 (TZA): 24.66 %

Threshold moisture content at Zone B of a graph of Plasticity Index & Liquid Limit graph proposed by Seed et al., 2003 (TZB): 26.20 %

- If the soil is in the Zone A and NMC > TZA, the soil is potentially liquefiable.
- If the soil is in the Zone B and NMC > TZB, additional test is necessary.

The assessment of liquefiable soil types above is only applicable for:
a) Fine Content ≥ 20% if Plasticity Index >12%
b) Fine Content ≥ 35% if Plasticity Index <12%

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Form : ATT - 01 = 1 / 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

LIQUID AND PLASTIC LIMITS OF A SOIL

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.8 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown; Silty CLAY Depth of sample : 9.10 - 12.45 m

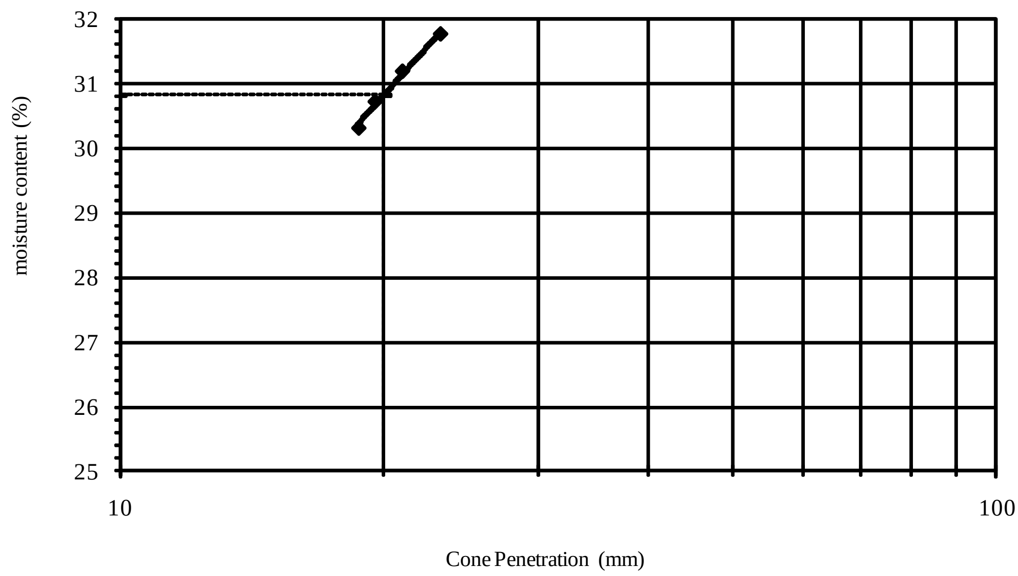
Liquid Limit Calculations

Can no.	H	Aa	3	Q
Wt. of wet soil + can (g)	56.72	55.33	57.98	57.47
Wt. of dry soil + can (g)	51.14	49.85	52.07	51.60
Wt. of can (g)	32.73	32.01	33.12	33.12
Wt. of dry soil (g)	18.41	17.84	18.95	18.48
Wt. of water (g)	5.58	5.48	5.91	5.87
Moisture content, w (%)	30.31	30.72	31.19	31.76
Cone penetration (mm)	18.69	19.52	20.99	23.23

Plastic Limit Calculations

Can no.	7	D
Wt. of wet soil + can (g)	55.77	43.41
Wt. of dry soil + can (g)	54.09	42.18
Wt. of can (g)	41.78	33.20
Wt. of dry soil (g)	12.31	8.98
Wt. of water (g)	1.68	1.23
Moisture content, w (%)	13.65	13.70

Liquid Limit (LL) (%) = **30.82** Plasticity Indeks, Ip (%) **17.15**
Plastic Limit (PL) (%) = **13.67**



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Signature:
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Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.8 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown; Silty CLAY Depth of sample : 9.10 - 12.45 m

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	500	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	500.00		
Total	500.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	13.25	2.65	97.35
PAN#2	486.75		
Total	500.00	100.00	0.00
1.190	7.25	4.10	95.90
0.602	14.52	7.00	93.00
0.315	0.53	7.11	92.89
0.211	46.02	16.31	83.69
0.075	76.52	31.62	68.38
PAN#3	341.91		
Total	500.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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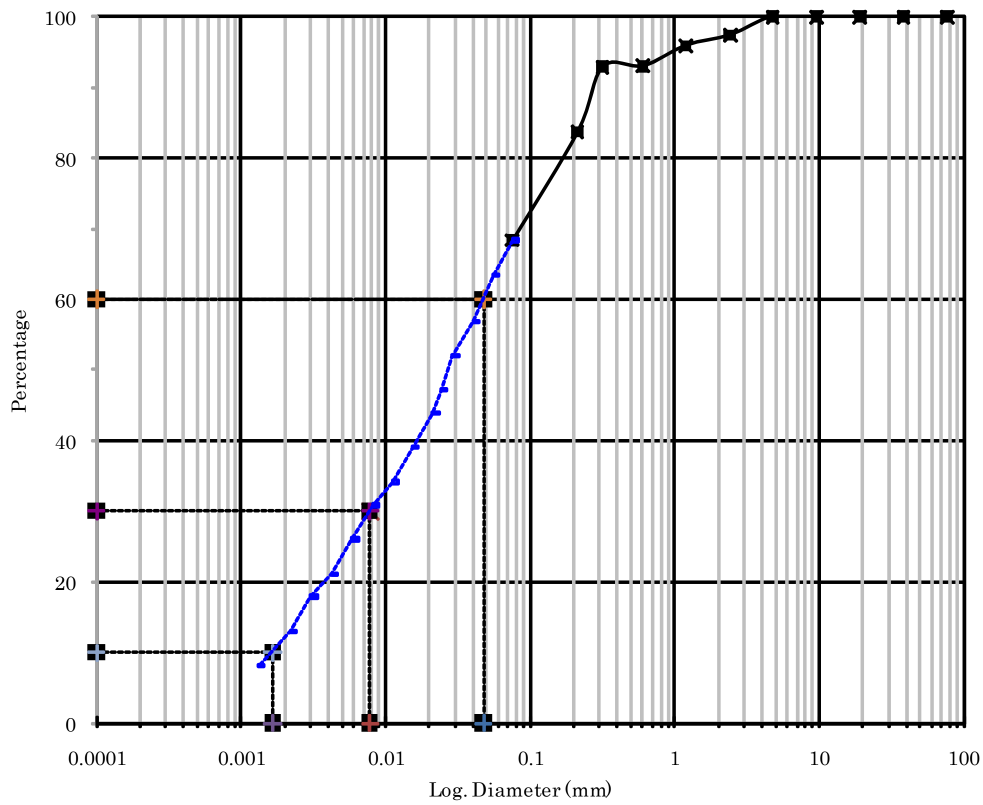
Date: 20 August 2011

Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.8 Date of Testing : 17-Feb-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : Brown; Silty CLAY Depth of sample : 9.10 - 12.45 m



		Percentage		
			D60 =	0.047 mm
Gravel (> 2 mm) & (< 4 mm)	=	3.14 %	D30 =	0.008 mm
Sand (> 0.075 mm) & (< 2 mm)	=	28.48 %	D10 =	0.002 mm
Fine (< 0.075 mm)	=	68.38 %	Cu =	28.68
			Cc =	0.77

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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APPENDIX E

MEMBRANE STIFFNESS TESTING RESULTS

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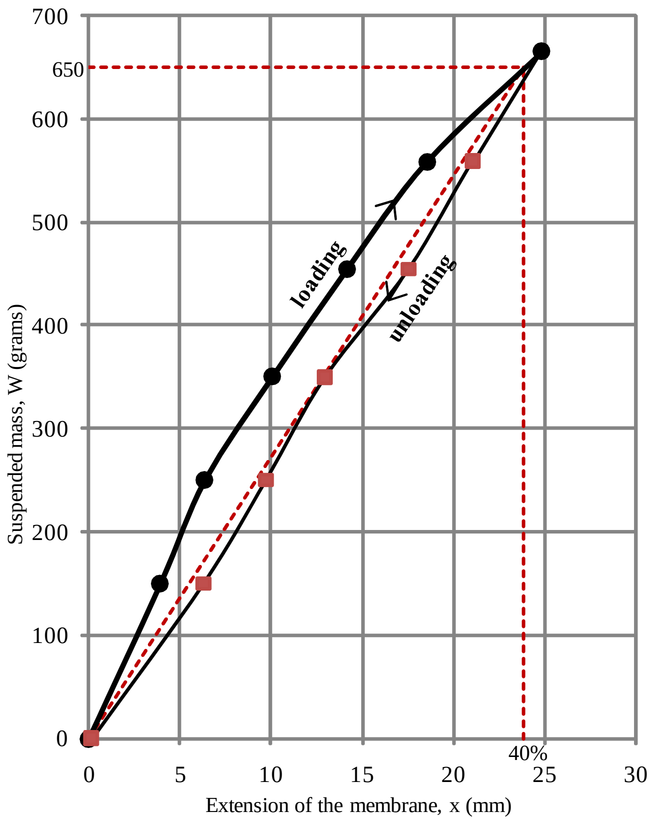
Form : LAB MCT - 01 = 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MEMBRANE CALIBRATION TEST

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : MEMBRANE SAMPLE#1 Date of Testing : 09-May-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***

Calibration testing graph



-Membrane diameter, D = 38 mm
-Membrane width = 25 mm
-Membrane thickness = 0.44 mm
-Rod diameter, d = 6.38 mm
-Nominal initial length, πD = 119.32 mm
-40% strain of the membrane = 23.86 mm
-Load for the 40% strain = 650 g

Membrane modulus (M) @40% strain

3188.25	/	10000	N/mm
	M value	0.32	N/mm
		0.32	**kN/m**

MEMBRANE SAMPLE#1 DATA

Weight	**Membrane extension during loading**	**Membrane extension during unloading**	**Remarks**
0 g	0.00 mm	0.15 mm	
150 g	3.91 mm	6.26 mm	
250 g	6.34 mm	9.69 mm	
350 g	10.04 mm	12.95 mm	
454.3 g	14.13 mm	17.54 mm	
559 g	18.54 mm	21.05 mm	
665.1 g	24.84 mm		

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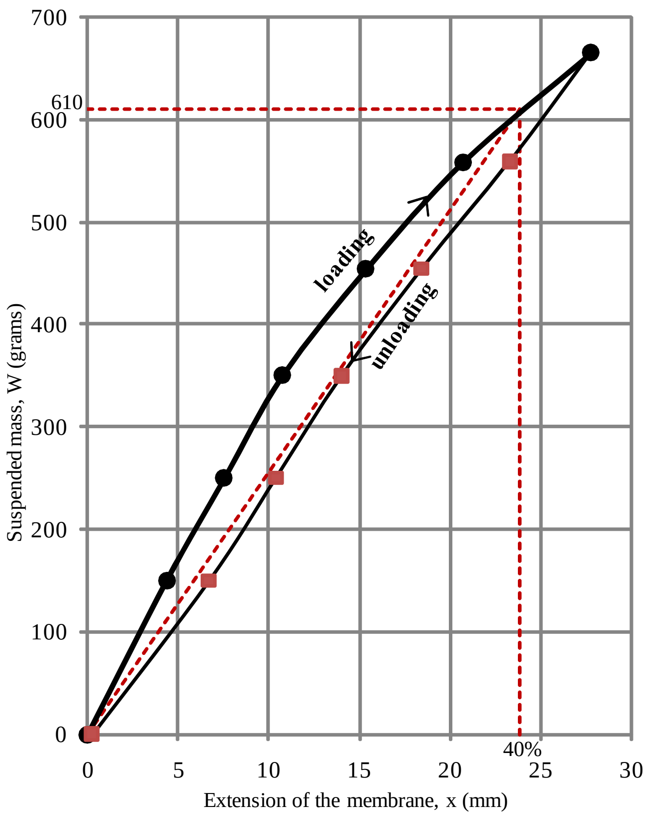
Date: 20 August 2011

Form : LAB MCT - 01 = 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MEMBRANE CALIBRATION TEST

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : MEMBRANE SAMPLE#2 Date of Testing : 10-May-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***

Calibration testing graph



-Membrane diameter, D
= 38 mm
-Membrane width
= 25 mm
-Membrane thickness
= 0.44 mm
-Rod diameter, d
= 6.38 mm
-Nominal initial length, πD
= 119.32 mm
-40% strain of the membrane
= 23.86 mm
-Load for the 40% strain
= 610 g

Membrane modulus (M)
@40% strain

2992.05	/	10000	N/mm
	M value	0.30	N/mm
		0.30	**kN/m**

MEMBRANE SAMPLE#2 DATA

Weight	Membrane extension during loading	Membrane extension during unloading	Remarks
0 g	0.00 mm	0.26 mm	
150 g	4.34 mm	6.69 mm	
250 g	7.54 mm	10.37 mm	
350 g	10.74 mm	14.01 mm	
454.3 g	15.37 mm	18.43 mm	
559 g	20.72 mm	23.26 mm	
665.1 g	27.77 mm		

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Reported by : B. Setiawan

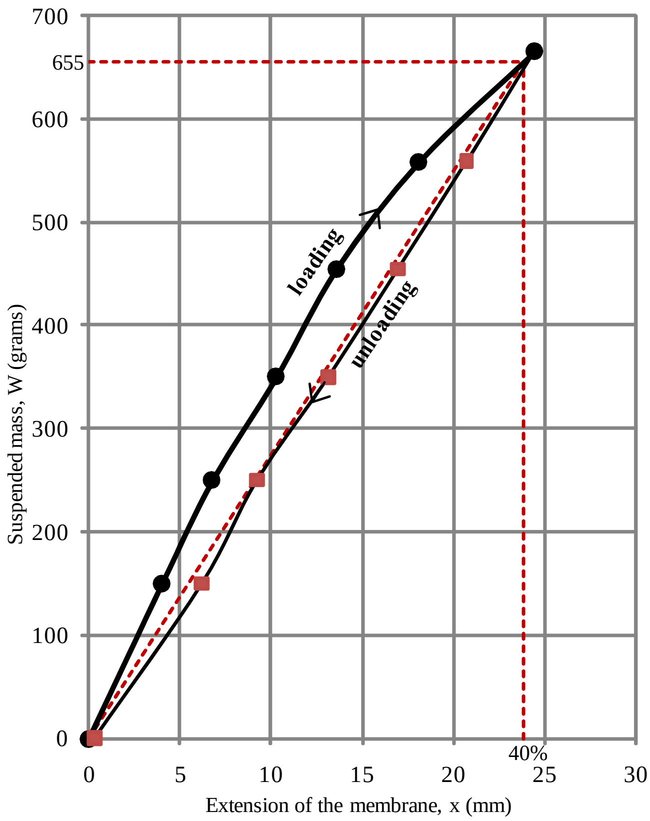
Siganture:
Date: 20 August 2011

Form : LAB MCT - 01 = 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

MEMBRANE CALIBRATION TEST

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : MEMBRANE SAMPLE#3 Date of Testing : 10-May-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***

Calibration testing graph



-Membrane diameter, D = 38 mm
-Membrane width = 25 mm
-Membrane thickness = 0.44 mm
-Rod diameter, d = 6.38 mm
-Nominal initial length, πD = 119.32 mm
-40% strain of the membrane = 23.86 mm
-Load for the 40% strain = 655 g

Membrane modulus @40% strain	(M)	3212.78	/	10000	N/mm
			M value	0.32	N/mm
				0.32	**kN/m**

MEMBRANE SAMPLE#3 DATA

Weight	Membrane extension during loading	Membrane extension during unloading	Remarks
0 g	0.00 mm	0.30 mm	
150 g	4.00 mm	6.20 mm	
250 g	6.77 mm	9.22 mm	
350 g	10.28 mm	13.13 mm	
454.3 g	13.55 mm	16.94 mm	
559 g	18.11 mm	20.70 mm	
665.1 g	24.42 mm		

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Siganture:
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APPENDIX F

CHARACTERISTICS AND SIMPLE CS TESTING RESULTS OF CALIBRATION SAMPLES

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Form : SPG - 01 = 1 / 1	GEOTEHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

SPECIFIC GRAVITY OF A SOIL

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: CALIBRATION SAMPLE	Date of Testing	: 16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	: ***
Visual Description	: Light brown, light grey; SAND	Depth of sample	: -

[A] Calibration of pycnometer

Pycnometer No.			G1	G26
Wt. of dry, clean pycnometer	Wp	(g)	29.444	50.473
Wt. of pycnometer + water	Wpw	(g)	80.606	150.293
Observed temperature of water	Ti	°C	20.5	20.5
Density of water in temp. Ti	ρi	(g/mm^3)	0.9981	0.9981

[B] Specific gravity determination

Test no.			1	2
Method of air removal			Boiling	Boiling
Wt. of pycnometer+soil+water	Wpsw	(m)	90.062	171.112
Temperature	Tx	°C	20.5	20.5
Density of water in temp. Tx	ρx	(g/mm^3)	0.9981	0.9981
Wt. of pycnometer+water at Tx	Wpw'	(g)	80.606	150.293
Evaporation Dish No.			A	B
Wt. of dish	Wd	(g)	29.444	50.473
Wt. of dish + dry soil	Wds	(g)	44.566	83.880
Wt. of dry soil	Ws	(g)	15.122	33.407
Conversion factor, K			0.99990	0.99990
Specific Gravity			2.67	2.65

Checking the test for an acceptance criterion which is until achieved two Gs values that are wirhin 2 percent of each other, or defined as follows:

- (Largest value of Gs/Smallest value of Gs) ≤ 1.02

- 2.67 / 2.65 = 1.0056 (TEST IS ACCEPTED)

Average specific gravity of soil solids (Gs) is 2.66

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Signature:

Date: 20 August 2011

Form : GSA - 1/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (1)

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing		
Location	: Gillman, SA		
Sample Code	: CALIBRATION SAMPLE	Date of Testing	: 16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method :	***
Visual Description	: Light brown, light grey; SAND	Depth of sample :	-

Minimum Mass of Soil Sub-sample (AS 1289.1.1-2001)

Nominal diameter of the largest particle	Minimum mass of sub-sample (g)	Nominal diameter of the largest particle	Minimum mass of sub-sample (g)
- 13.20 mm	2500	- 4.75 mm	500
- 9.50 mm	1000	- 3.35 mm	250
- 6.70 mm	600	- 2.36 mm	200

Wt. of dry sample + container	0	gram
Wt. of container	0	gram
Wt. of dry sample	800	gram

Sieve analysis Calculations

Sieve opening diameter (mm)	Wt. retained (g)	%retained (%)	%passing (%)
76.200	0.00	0.00	100.00
38.100	0.00	0.00	100.00
19.100	0.00	0.00	100.00
PAN#1	800.00		
Total	800.00	100.00	0.00
9.520	0.00	0.00	100.00
4.760	0.00	0.00	100.00
2.410	0.00	0.00	100.00
PAN#2	800.00		
Total	800.00	100.00	0.00
1.190	1.00	0.13	99.88
0.602	60.40	7.68	92.33
0.315	525.10	73.31	26.69
0.211	154.40	92.61	7.39
0.075	58.60	99.94	0.06
PAN#3	0.50		
Total	800.00	100.00	0.00

%retained = Wt. retained/Wt. of dry sample
% passing = 100 - % retained

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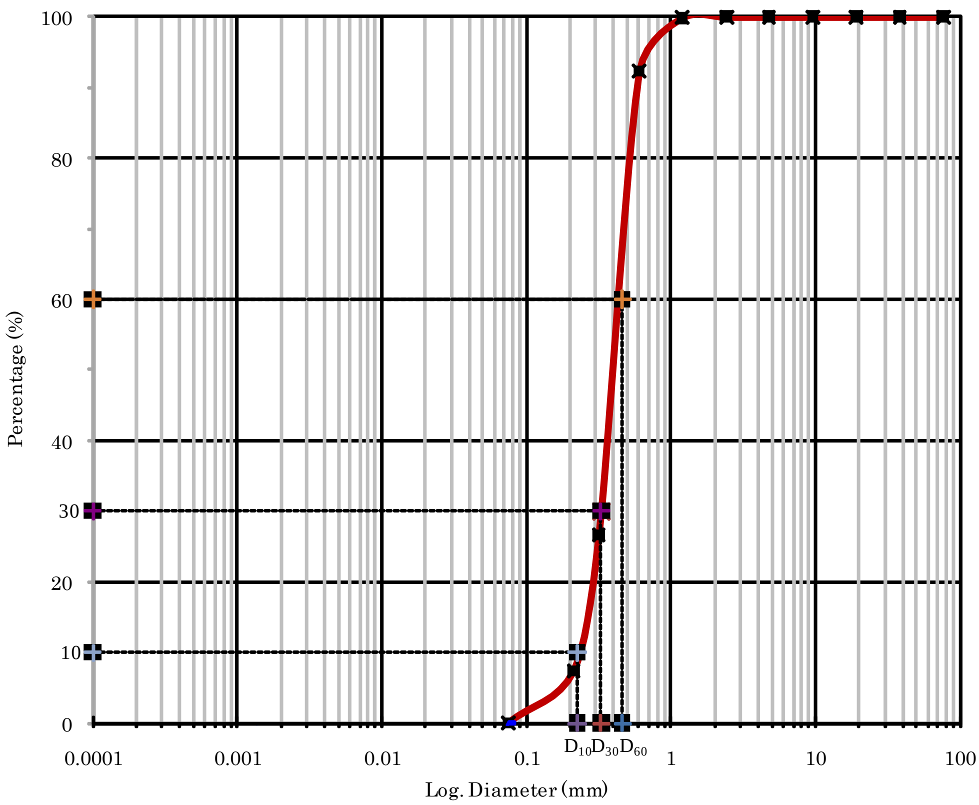
Signature:
Date: 20 August 2011

Form : GSA - 3/3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

PARTICLE SIZE DISTRIBUTION OF A SOIL (3)

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: CALIBRATION SAMPLE	Date of Testing	:	16-Feb-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	:	***
Visual Description	: Light brown, light grey; SAND	Depth of sample	:	-



		Percentage		
			D60 =	0.461 mm
Gravel (> 2 mm) & (< 4 mm)	=	0.04 %	D30 =	0.329 mm
Sand (> 0.075 mm) & (< 2 mm)	=	99.90 %	D10 =	0.225 mm
Fine (< 0.075 mm)	=	0.06 %	Cu =	2.05
			Cc =	1.05

Fraction (mm)	Clay	Silt	Sand	Gravel
AASHTO	0.0001 - 0.002	0.002 - 0.075	0.075 - 2.00	2.00 - 75.00
ASTM	< 0.075		0.075 - 4.750	4.750 - 75.00

Cu = D60/D10 Cc = {(D30)^2}/(D10*D60)

Note : Form GSA-2/3 is only attached if there is hydrometer test for this particular sample.

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Date: 20 August 2011

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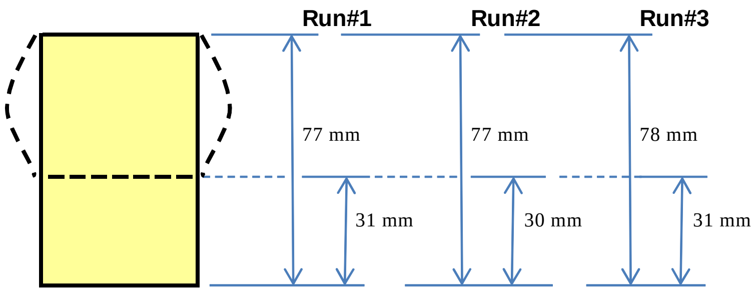
Form : LAB CSL - 01 = 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : CALIBRATION SPECIMEN#1 Date of Testing : 13-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Initial Measurements

Volume of device without soil (V_d) 500 - 580.5 ml



Critical state friction angle (ϕ_{cs})	30.00	30.00	31	(°)
		Average	30.3	(°)

Run #1 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	104 mm	0.266 m
2	15 kPa	112 mm	0.258 m
3	20 kPa	112 mm	0.258 m
4	25 kPa	146 mm	0.224 m
5	30 kPa	178 mm	0.192 m
6	35 kPa	180 mm	0.19 m
7	40 kPa	209 mm	0.161 m
8	50 kPa	242 mm	0.128 m
9	60 kPa	309 mm	0.061 m
10	80 kPa	286 mm	0.084 m
11	100 kPa	326 mm	0.044 m

Temperature of water (T) 22 (°C)

Total volume (V_t) 500 - 658 ml

Height of water when measuring Vt (h_o) 370 mm

Soil dry weight (W_s) 127.91 g

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Date: 20 August 2011

Form : LAB CSL - 02 = 2	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : CALIBRATION SPECIMEN#1 Date of Testing : 13-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Run #2 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	87 mm	0.283 m
2	15 kPa	122 mm	0.248 m
3	20 kPa	138 mm	0.232 m
4	25 kPa	170 mm	0.2 m
5	30 kPa	171 mm	0.199 m
6	35 kPa	155 mm	0.215 m
7	40 kPa	162 mm	0.208 m
8	50 kPa	176 mm	0.194 m
9	60 kPa	238 mm	0.132 m
10	80 kPa	284 mm	0.086 m
11	100 kPa	328 mm	0.042 m

Temperature of water (T) 22 (°C)

Total volume (V_t) 500 - 658 ml

Height of water when measuring Vt (h_o) 370 mm

Soil dry weight (W_s) 127.91 g

Run #3 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	73 mm	0.297 m
2	15 kPa	90 mm	0.28 m
3	20 kPa	120 mm	0.25 m
4	25 kPa	111 mm	0.259 m
5	30 kPa	141 mm	0.229 m
6	35 kPa	162 mm	0.208 m
7	40 kPa	171 mm	0.199 m
8	50 kPa	200 mm	0.17 m
9	60 kPa	225 mm	0.145 m
10	80 kPa	281 mm	0.089 m
11	100 kPa	312 mm	0.058 m

Temperature of water (T) 22 (°C)

Total volume (V_t) 500 - 658 ml

Height of water when measuring Vt (h_o) 370 mm

Soil dry weight (W_s) 127.91 g

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SUB CRUCE LUMEN

Reported by: B. Setiawan

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Date: 20 August 2011

Form : LAB CSL - 03 = 3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : CALIBRATION SPECIMEN#1 Date of Testing : 13-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Initial Parameters		Run#1	Run#2	Run#3	
Volume of device without soil	(V_d)	0.0000805	0.0000805	0.0000805	m^3
Additional radial stress	(σ_m')	7.83	7.76	7.81	kN/m^2
Critical state friction angle	(ϕ_{cs})	30.3	30.3	30.3	degree
Soil mass	(W_s)	0.128	0.128	0.128	kg
Soil soilds volume - Vs = Ws / (Gs*γw)	(V_s)	4.818E-05	4.81778E-05	4.818E-05	m^3
Area inside tube	(A_t)	0.00001256	0.00001256	0.00001256	m^2
Unit weight of water	(γ_w)	9.788	9.788	9.788	kN/m^3
Specific gravity of soil sample	(G_s)	2.66	2.66	2.66	
Total volume	(V_t)	0.000158	0.000158	0.000158	m^3
Specimen volume - Vsp = Vt - Vd	(V_{sp})	0.0000775	0.0000775	0.0000775	m^3
Ref. water vol.-Vwo = Vsp - Vs	(V_{wo})	2.932E-05	2.932E-05	2.932E-05	m^3

Run #1 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.83	12.26	0.266	3.341E-06	3.266E-05	0.671
2	15	22.83	15.69	0.258	3.240E-06	3.256E-05	0.676
3	20	27.83	19.13	0.258	3.240E-06	3.256E-05	0.676
4	25	32.83	22.57	0.224	2.813E-06	3.214E-05	0.667
5	30	37.83	26.00	0.192	2.412E-06	3.173E-05	0.659
6	35	42.83	29.44	0.190	2.386E-06	3.171E-05	0.658
7	40	47.83	32.88	0.161	2.022E-06	3.134E-05	0.651
8	50	57.83	39.75	0.128	1.608E-06	3.093E-05	0.642
9	60	67.83	46.62	0.061	7.662E-07	3.009E-05	0.625
10	80	87.83	60.37	0.084	1.055E-06	3.038E-05	0.631
11	100	107.83	74.12	0.044	5.526E-07	2.987E-05	0.620

Run #2 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.76	12.21	0.283	3.554E-06	3.288E-05	0.682
2	15	22.76	15.64	0.248	3.115E-06	3.244E-05	0.673
3	20	27.81	19.12	0.232	2.914E-06	3.224E-05	0.669
4	25	32.81	22.55	0.200	2.512E-06	3.183E-05	0.661
5	30	37.81	25.99	0.199	2.499E-06	3.182E-05	0.661
6	35	42.81	29.43	0.215	2.700E-06	3.202E-05	0.665
7	40	47.81	32.86	0.208	2.612E-06	3.193E-05	0.663
8	50	57.81	39.74	0.194	2.437E-06	3.176E-05	0.659
9	60	67.81	46.61	0.132	1.658E-06	3.098E-05	0.643
10	80	87.81	60.36	0.086	1.080E-06	3.040E-05	0.631
11	100	107.81	74.10	0.042	5.275E-07	2.985E-05	0.620

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Reported by : B. Setiawan

Siganture:
Date: 20 August 2011

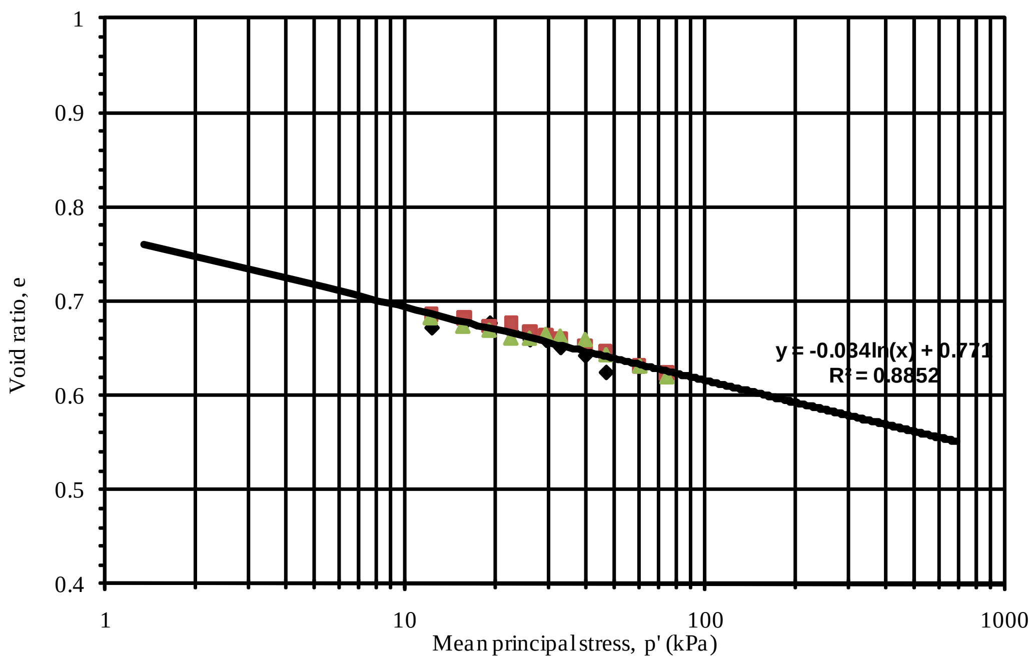
Form : LAB CSL - 04 = 4	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : CALIBRATION SPECIMEN#1 Date of Testing : 13-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Run #3 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.81	12.24	0.297	3.730E-06	3.305E-05	0.686
2	15	22.81	15.68	0.280	3.517E-06	3.284E-05	0.682
3	20	27.81	19.12	0.250	3.140E-06	3.246E-05	0.674
4	25	32.81	22.55	0.259	3.253E-06	3.258E-05	0.676
5	30	37.81	25.99	0.229	2.876E-06	3.220E-05	0.668
6	35	42.81	29.43	0.208	2.612E-06	3.193E-05	0.663
7	40	47.81	32.86	0.199	2.499E-06	3.182E-05	0.661
8	50	57.81	39.74	0.170	2.135E-06	3.146E-05	0.653
9	60	67.81	46.61	0.145	1.821E-06	3.114E-05	0.646
10	80	87.81	60.36	0.089	1.118E-06	3.044E-05	0.632
11	100	107.81	74.10	0.058	7.285E-07	3.005E-05	0.624



No.	Parameters	Equations	Unit
1	Applied pressure (σ_{ci}')		kN/m²
2	Correction (σ_{3i}')	$\sigma_{3i}'=\sigma_{ci}' + \sigma_m'$	kN/m²
3	Mean principal stress (p_i')	$p_i'=\sigma_{3i}'[\{3-\sin\phi_{cs}\}/\{3(1-\sin\phi_{cs})\}]$	kN/m²
4	Distance (d_i)	$d_i=h_o - h_i$	m
5	Volume change (ΔV_i)	$\Delta V_i=d_i*A_t$	m³
6	Water volume (V_{wi})	$V_{wi}=V_{wo}+\Delta V_i$	m³
7	Void ratio (e_i)	$e_i=(V_{wi}*G_s*\gamma_w)/W_s$	

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Date: 20 August 2011

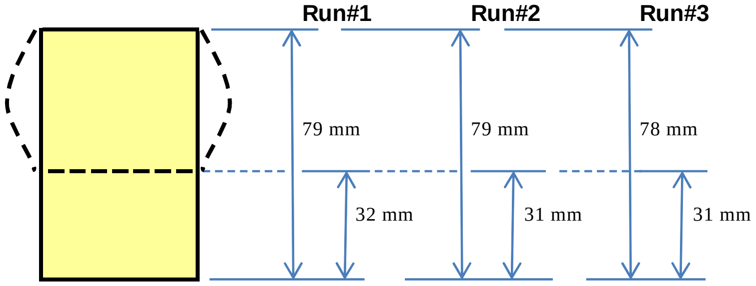
Form : LAB CSL - 01 = 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : CALIBRATION SPECIMEN#2 Date of Testing : 13-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Initial Measurements

Volume of device without soil (V_d) 500 - 580.5 ml



Critical state friction angle (ϕ_{cs})

30.00	30.00	31	(°)
	Average	30.3	(°)

Run #1 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	14 mm	0.472 m
2	15 kPa	34 mm	0.452 m
3	20 kPa	36 mm	0.45 m
4	25 kPa	54 mm	0.432 m
5	30 kPa	116 mm	0.37 m
6	35 kPa	144 mm	0.342 m
7	40 kPa	143 mm	0.343 m
8	50 kPa	202 mm	0.284 m
9	60 kPa	225 mm	0.261 m
10	80 kPa	329 mm	0.157 m
11	100 kPa	469 mm	0.017 m

Temperature of water (T) 21 (°C)

Total volume (V_t) 500 - 673 ml

Height of water when measuring Vt (h_o) 486 mm

Soil dry weight (W_s) 152.82 g

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Date: 20 August 2011

Form : LAB CSL - 02 = 2	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : CALIBRATION SPECIMEN#2 Date of Testing : 13-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Run #2 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	73 mm	0.413 m
2	15 kPa	142 mm	0.344 m
3	20 kPa	87 mm	0.399 m
4	25 kPa	102 mm	0.384 m
5	30 kPa	104 mm	0.382 m
6	35 kPa	166 mm	0.32 m
7	40 kPa	200 mm	0.286 m
8	50 kPa	252 mm	0.234 m
9	60 kPa	274 mm	0.212 m
10	80 kPa	261 mm	0.225 m
11	100 kPa	471 mm	0.015 m

Temperature of water (T) 21 (^oC)

Total volume (V_t) 500 - 673 ml

Height of water when measuring Vt (h_o) 486 mm

Soil dry weight (W_s) 152.82 g

Run #3 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	44 mm	0.442 m
2	15 kPa	113 mm	0.373 m
3	20 kPa	104 mm	0.382 m
4	25 kPa	179 mm	0.307 m
5	30 kPa	143 mm	0.343 m
6	35 kPa	198 mm	0.288 m
7	40 kPa	200 mm	0.286 m
8	50 kPa	200 mm	0.286 m
9	60 kPa	244 mm	0.242 m
10	80 kPa	328 mm	0.158 m
11	100 kPa	484 mm	0.002 m

Temperature of water (T) 21.5 (^oC)

Total volume (V_t) 500 - 673 ml

Height of water when measuring Vt (h_o) 486 mm

Soil dry weight (W_s) 152.82 g

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Reported by: B. Setiawan

Signature:
Date: 20 August 2011

Form : LAB CSL - 03 = 3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project	:	Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location	:	Gillman, SA
Sample Code	:	CALIBRATION SPECIMEN#2 — Date of Testing : 13-Apr-11
Tested By	:	BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description	:	-

Initial Parameters

		Run#1	Run#2	Run#3	
Volume of device without soil	(V_d)	0.0000805	0.0000805	0.0000805	m^3
Additional radial stress	(σ_m')	7.86	7.78	7.81	kN/m^2
Critical state friction angle	(ϕ_{cs})	30.3	30.3	30.3	degree
Soil mass	(W_s)	0.153	0.153	0.153	kg
Soil soilds volume - Vs = Ws / (Gs*γw)	(V_s)	5.755E-05	5.75475E-05	5.755E-05	m^3
Area inside tube	(A_t)	0.00001256	0.00001256	0.00001256	m^2
Unit weight of water	(γ_w)	9.791	9.791	9.789	kN/m^3
Specific gravity of soil sample	(G_s)	*2.66*	2.66	2.66	
Total volume	(V_t)	0.000173	0.000173	0.000173	m^3
Specimen volume - Vsp = Vt - Vd	(V_{sp})	0.0000925	0.0000925	0.0000925	m^3
Ref. water vol.-Vwo = Vsp - Vs	(V_{wo})	3.495E-05	3.495E-05	3.495E-05	m^3

Run #1 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.86	12.28	0.472	5.928E-06	4.088E-05	0.703
2	15	22.86	15.71	0.452	5.677E-06	4.063E-05	0.706
3	20	27.86	19.15	0.450	5.652E-06	4.060E-05	0.706
4	25	32.86	22.59	0.432	5.426E-06	4.038E-05	0.702
5	30	37.86	26.02	0.370	4.647E-06	3.960E-05	0.688
6	35	42.86	29.46	0.342	4.296E-06	3.925E-05	0.682
7	40	47.86	32.90	0.343	4.308E-06	3.926E-05	0.682
8	50	57.86	39.77	0.284	3.567E-06	3.852E-05	0.669
9	60	67.86	46.64	0.261	3.278E-06	3.823E-05	0.664
10	80	87.86	60.39	0.157	1.972E-06	3.692E-05	0.642
11	100	107.86	74.14	0.017	2.135E-07	3.517E-05	0.611

Run #2 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.78	12.22	0.413	5.187E-06	4.014E-05	0.698
2	15	22.78	15.66	0.344	4.321E-06	3.927E-05	0.682
3	20	27.81	19.12	0.399	5.011E-06	3.996E-05	0.694
4	25	32.81	22.55	0.384	4.823E-06	3.978E-05	0.691
5	30	37.81	25.99	0.382	4.798E-06	3.975E-05	0.691
6	35	42.81	29.43	0.320	4.019E-06	3.897E-05	0.677
7	40	47.81	32.86	0.286	3.592E-06	3.854E-05	0.670
8	50	57.81	39.74	0.234	2.939E-06	3.789E-05	0.658
9	60	67.81	46.61	0.212	2.663E-06	3.762E-05	0.654
10	80	87.81	60.36	0.225	2.826E-06	3.778E-05	0.656
11	100	107.81	74.10	0.015	1.884E-07	3.514E-05	0.611

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Reported by : B. Setiawan

Siganture:

Date: 20 August 2011

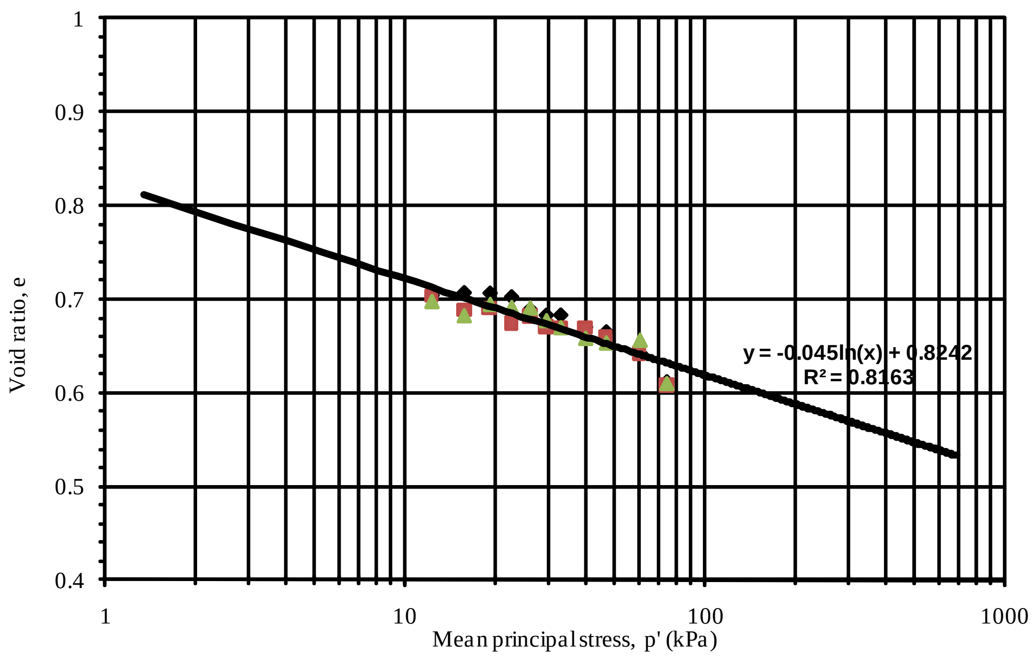
Form : LAB CSL - 04 = 4	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : CALIBRATION SPECIMEN#2 — Date of Testing : 13-Apr-11
Tested By : BAMBANG SETIAWAN — Eq/Device/Method : ***
Visual Description : -

Run #3 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.81	12.24	0.442	5.552E-06	4.050E-05	0.704
2	15	22.81	15.68	0.373	4.685E-06	3.963E-05	0.689
3	20	27.81	19.12	0.382	4.798E-06	3.974E-05	0.691
4	25	32.81	22.55	0.307	3.856E-06	3.880E-05	0.674
5	30	37.81	25.99	0.343	4.308E-06	3.925E-05	0.682
6	35	42.81	29.43	0.288	3.617E-06	3.856E-05	0.670
7	40	47.81	32.86	0.286	3.592E-06	3.854E-05	0.670
8	50	57.81	39.74	0.286	3.592E-06	3.854E-05	0.670
9	60	67.81	46.61	0.242	3.040E-06	3.799E-05	0.660
10	80	87.81	60.36	0.158	1.984E-06	3.693E-05	0.642
11	100	107.81	74.10	0.002	2.512E-08	3.497E-05	0.608



No.	Parameters	Equations	Unit
1	Applied pressure (σ_{ci}')		kN/m²
2	Correction (σ_{3i}')	$\sigma_{3i}'=\sigma_{ci}' + \sigma_m'$	kN/m²
3	Mean principal stress (p_i')	$p_i'=\sigma_{3i}'[\{3-\sin\phi_{cs}\}/\{3(1-\sin\phi_{cs})\}]$	kN/m²
4	Distance (d_i)	$d_i=h_o - h_i$	m
5	Volume change (ΔV_i)	$\Delta V_i=d_i*A_t$	m³
6	Water volume (V_{wi})	$V_{wi}=V_{wo}+\Delta V_i$	m³
7	Void ratio (e_i)	$e_i=(V_{wi}*G_s*\gamma_w)/W_s$	

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Date: 20 August 2011

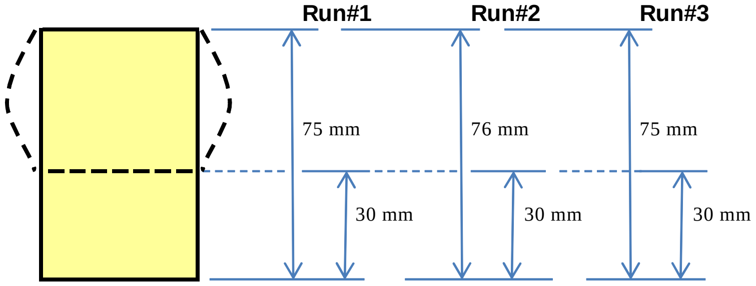
Form : LAB CSL - 01 = 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : CALIBRATION SPECIMEN#3 Date of Testing : 14-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Initial Measurements

Volume of device without soil (V_d) 500 - 580.5 ml



Critical state friction angle (ϕ_{cs})	30.00	30.00	31	(°)
		Average	30.3	(°)

Run #1 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	130 mm	0.424 m
2	15 kPa	154 mm	0.4 m
3	20 kPa	187 mm	0.367 m
4	25 kPa	189 mm	0.365 m
5	30 kPa	252 mm	0.302 m
6	35 kPa	249 mm	0.305 m
7	40 kPa	278 mm	0.276 m
8	50 kPa	311 mm	0.243 m
9	60 kPa	325 mm	0.229 m
10	80 kPa	374 mm	0.18 m
11	100 kPa	488 mm	0.066 m

Temperature of water (T) 22 (°C)

Total volume (V_t) 500 - 659 ml

Height of water when measuring Vt (h_o) 554 mm

Soil dry weight (W_s) 133.68 g

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CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : CALIBRATION SPECIMEN#3 Date of Testing : 14-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Run #2 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	171 mm	0.383 m
2	15 kPa	195 mm	0.359 m
3	20 kPa	181 mm	0.373 m
4	25 kPa	214 mm	0.34 m
5	30 kPa	204 mm	0.35 m
6	35 kPa	218 mm	0.336 m
7	40 kPa	222 mm	0.332 m
8	50 kPa	261 mm	0.293 m
9	60 kPa	286 mm	0.268 m
10	80 kPa	334 mm	0.22 m
11	100 kPa	492 mm	0.062 m

Temperature of water (T) 22 (^oC)

Total volume (V_t) 500 - 659 ml

Height of water when measuring Vt (h_o) 554 mm

Soil dry weight (W_s) 133.68 g

Run #3 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	169 mm	0.385 m
2	15 kPa	148 mm	0.406 m
3	20 kPa	161 mm	0.393 m
4	25 kPa	146 mm	0.408 m
5	30 kPa	162 mm	0.392 m
6	35 kPa	188 mm	0.366 m
7	40 kPa	187 mm	0.367 m
8	50 kPa	226 mm	0.328 m
9	60 kPa	240 mm	0.314 m
10	80 kPa	321 mm	0.233 m
11	100 kPa	421 mm	0.133 m

Temperature of water (T) 23 (^oC)

Total volume (V_t) 500 - 659 ml

Height of water when measuring Vt (h_o) 554 mm

Soil dry weight (W_s) 133.68 g

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Date: 20 August 2011

Form : LAB CSL - 03 = 3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : -
Sample Code : CALIBRATION SPECIMEN#3 Date of Testing : 14-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Initial Parameters		Run#1	Run#2	Run#3	
Volume of device without soil	(V_d)	0.0000805	0.0000805	0.0000805	m^3
Additional radial stress	(σ_m')	7.83	7.8	7.83	kN/m^2
Critical state friction angle	(ϕ_{cs})	30.3	30.3	30.3	degree
Soil mass	(W_s)	0.134	0.134	0.134	kg
Soil soilds volume - Vs = Ws / (Gs*γw)	(V_s)	5.035E-05	5.0351E-05	5.036E-05	m^3
Area inside tube	(A_t)	0.00001256	0.00001256	0.00001256	m^2
Unit weight of water	(γ_w)	9.788	9.788	9.786	kN/m^3
Specific gravity of soil sample	(G_s)	2.66	2.66	2.66	
Total volume	(V_t)	0.000159	0.000159	0.000159	m^3
Specimen volume - Vsp = Vt - Vd	(V_{sp})	0.0000785	0.0000785	0.0000785	m^3
Ref. water vol.-Vwo = Vsp - Vs	(V_{wo})	2.815E-05	2.815E-05	2.814E-05	m^3

Run #1 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.83	12.26	0.424	5.325E-06	3.347E-05	0.658
2	15	22.83	15.69	0.400	5.024E-06	3.317E-05	0.659
3	20	27.83	19.13	0.367	4.610E-06	3.276E-05	0.651
4	25	32.83	22.57	0.365	4.584E-06	3.273E-05	0.650
5	30	37.83	26.00	0.302	3.793E-06	3.194E-05	0.634
6	35	42.83	29.44	0.305	3.831E-06	3.198E-05	0.635
7	40	47.83	32.88	0.276	3.467E-06	3.162E-05	0.628
8	50	57.83	39.75	0.243	3.052E-06	3.120E-05	0.620
9	60	67.83	46.62	0.229	2.876E-06	3.103E-05	0.616
10	80	87.83	60.37	0.180	2.261E-06	3.041E-05	0.604
11	100	107.83	74.12	0.066	8.290E-07	2.898E-05	0.576

Run #2 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.8	12.23	0.383	4.810E-06	3.296E-05	0.655
2	15	22.8	15.67	0.359	4.509E-06	3.266E-05	0.649
3	20	27.83	19.13	0.373	4.685E-06	3.283E-05	0.652
4	25	32.83	22.57	0.340	4.270E-06	3.242E-05	0.644
5	30	37.83	26.00	0.350	4.396E-06	3.254E-05	0.646
6	35	42.83	29.44	0.336	4.220E-06	3.237E-05	0.643
7	40	47.83	32.88	0.332	4.170E-06	3.232E-05	0.642
8	50	57.83	39.75	0.293	3.680E-06	3.183E-05	0.632
9	60	67.83	46.62	0.268	3.366E-06	3.152E-05	0.626
10	80	87.83	60.37	0.220	2.763E-06	3.091E-05	0.614
11	100	107.83	74.12	0.062	7.787E-07	2.893E-05	0.575

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SUB CRUCE LUMEN

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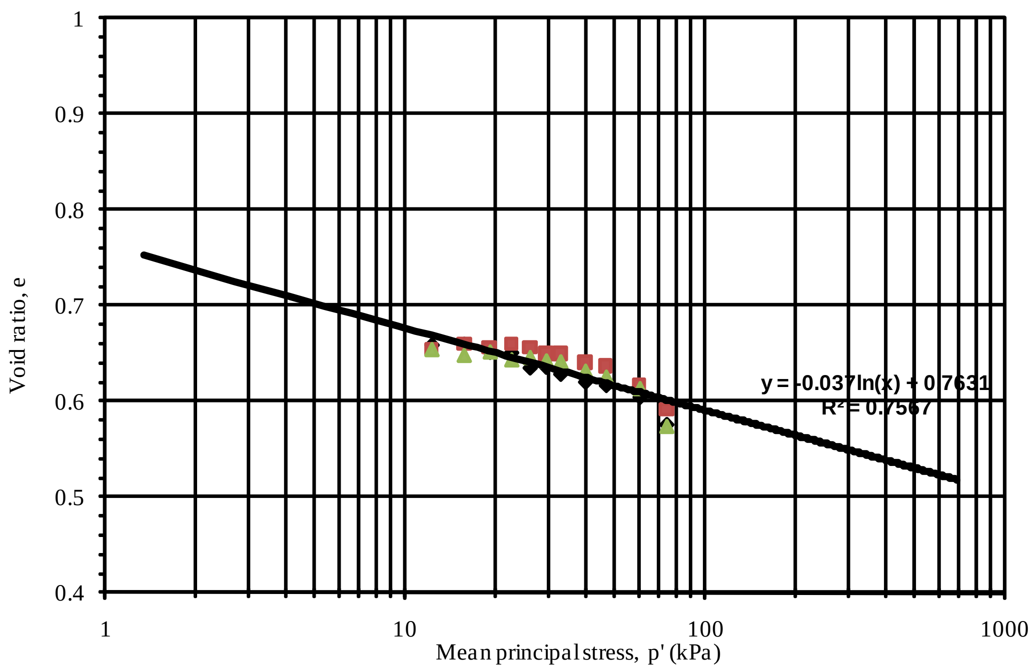
Form : LAB CSL - 04 = 4	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : -
Sample Code : CALIBRATION SPECIMEN#3 Date of Testing : 14-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Visual Description : -

Run #3 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.83	12.26	0.385	4.836E-06	3.297E-05	0.655
2	15	22.83	15.69	0.406	5.099E-06	3.324E-05	0.660
3	20	27.83	19.13	0.393	4.936E-06	3.307E-05	0.657
4	25	32.83	22.57	0.408	5.124E-06	3.326E-05	0.660
5	30	37.83	26.00	0.392	4.924E-06	3.306E-05	0.656
6	35	42.83	29.44	0.366	4.597E-06	3.273E-05	0.650
7	40	47.83	32.88	0.367	4.610E-06	3.275E-05	0.650
8	50	57.83	39.75	0.328	4.120E-06	3.226E-05	0.640
9	60	67.83	46.62	0.314	3.944E-06	3.208E-05	0.637
10	80	87.83	60.37	0.233	2.926E-06	3.106E-05	0.617
11	100	107.83	74.12	0.133	1.670E-06	2.981E-05	0.592



No.	Parameters	Equations	Unit
1	Applied pressure (σ_{ci}')		kN/m²
2	Correction (σ_{3i}')	$\sigma_{3i}'=\sigma_{ci}' + \sigma_m'$	kN/m²
3	Mean principal stress (p_i')	$p_i'=\sigma_{3i}'[\{3-\sin\phi_{cs}\}/\{3(1-\sin\phi_{cs})\}]$	kN/m²
4	Distance (d_i)	$d_i=h_o - h_i$	m
5	Volume change (ΔV_i)	$\Delta V_i=d_i*A_t$	m³
6	Water volume (V_{wi})	$V_{wi}=V_{wo}+\Delta V_i$	m³
7	Void ratio (e_i)	$e_i=(V_{wi}*G_s*\gamma_w)/W_s$	

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Date: 20 August 2011

APPENDIX G

SIMPLE CRITICAL STATE PARAMETER TESTING RESULTS OF SITE SOIL SAMPLES

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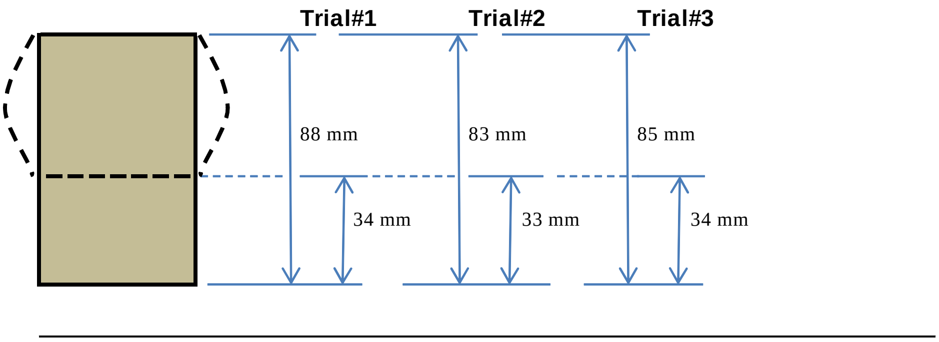
Form : LAB CSL - 01 = 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.2 Date of Testing : 07-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 1.35 - 2.70 m

Initial Measurements

Volume of device without soil (V_d) 500 - 583 ml



Critical state friction angle (ϕ_{cs})

29.00	28.00	28	(°)
	Average	28.3	(°)

Trial #1 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	409 mm	0.181 m
2	15 kPa	407 mm	0.183 m
3	20 kPa	452 mm	0.138 m
4	25 kPa	456 mm	0.134 m
5	30 kPa	466 mm	0.124 m
6	35 kPa	492 mm	0.098 m
7	40 kPa	526 mm	0.064 m
8	50 kPa	531 mm	0.059 m
9	60 kPa	540 mm	0.05 m
10	80 kPa	555 mm	0.035 m
11	100 kPa	558 mm	0.032 m

Temperature of water (T) 23 (°C)

Total volume (V_t) 500 - 671 ml

Height of water when measuring Vt (h_o) 590 mm

Soil dry weight (W_s) 148.34 g

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CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.2 Date of Testing : 07-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 1.35 - 2.70 m

Trial #2 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	350 mm	0.13 m
2	15 kPa	350 mm	0.13 m
3	20 kPa	364 mm	0.116 m
4	25 kPa	387 mm	0.093 m
5	30 kPa	380 mm	0.1 m
6	35 kPa	401 mm	0.079 m
7	40 kPa	399 mm	0.081 m
8	50 kPa	405 mm	0.075 m
9	60 kPa	415 mm	0.065 m
10	80 kPa	464 mm	0.016 m
11	100 kPa	475 mm	0.005 m

Temperature of water (T) 24 (°C)

Total volume (V_t) 500 - 658 ml

Height of water when measuring Vt (h_o) 480 mm

Soil dry weight (W_s) 113.08 g

Trial #3 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	408 mm	0.107 m
2	15 kPa	394 mm	0.121 m
3	20 kPa	386 mm	0.129 m
4	25 kPa	397 mm	0.118 m
5	30 kPa	434 mm	0.081 m
6	35 kPa	485 mm	0.03 m
7	40 kPa	421 mm	0.094 m
8	50 kPa	429 mm	0.086 m
9	60 kPa	496 mm	0.019 m
10	80 kPa	478 mm	0.037 m
11	100 kPa	492 mm	0.023 m

Temperature of water (T) 24 (°C)

Total volume (V_t) 500 - 656 ml

Height of water when measuring Vt (h_o) 515 mm

Soil dry weight (W_s) 113.08 g

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Form : LAB CSL - 03 = 3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.2 Date of Testing : 07-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 1.35 - 2.70 m

Initial Parameters

Parameter	Symbol	Trial#1	Trial#2	Trial#3	Unit
Volume of device without soil	(V_d)	0.000083	0.000083	0.000083	m^3
Additional radial stress	(σ_m')	7.73	7.82	7.83	kN/m^2
Critical state friction angle	(ϕ_{cs})	28.3	28.3	28.3	degree
Soil mass	(W_s)	0.148	0.113	0.113	kg
Soil soilds volume - Vs = Ws / (Gs*γw)	(V_s)	5.652E-05	4.30981E-05	4.310E-05	m^3
Area inside tube	(A_t)	0.00001256	0.00001256	0.00001256	m^2
Unit weight of water	(γ_w)	9.786	9.784	9.784	kN/m^3
Specific gravity of soil sample	(G_s)	2.63	2.63	2.63	
Total volume	(V_t)	0.000171	0.000158	0.000156	m^3
Specimen volume - Vsp = Vt - Vd	(V_{sp})	0.000088	0.000075	0.000073	m^3
Ref. water vol.-Vwo = Vsp - Vs	(V_{wo})	3.148E-05	3.190E-05	2.990E-05	m^3

Trial #1 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.73	17.07	0.181	2.273E-06	3.375E-05	0.591
2	15	22.73	21.89	0.183	2.298E-06	3.378E-05	0.598
3	20	27.73	26.70	0.138	1.733E-06	3.321E-05	0.588
4	25	32.73	31.52	0.134	1.683E-06	3.316E-05	0.587
5	30	37.73	36.33	0.124	1.557E-06	3.303E-05	0.584
6	35	42.73	41.14	0.098	1.231E-06	3.271E-05	0.579
7	40	47.73	45.96	0.064	8.038E-07	3.228E-05	0.571
8	50	57.73	55.59	0.059	7.410E-07	3.222E-05	0.570
9	60	67.73	65.22	0.050	6.280E-07	3.210E-05	0.568
10	80	87.73	84.47	0.035	4.396E-07	3.192E-05	0.565
11	100	107.73	103.73	0.032	4.019E-07	3.188E-05	0.564

Trial #2 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.82	17.16	0.130	1.633E-06	3.353E-05	0.778
2	15	22.82	21.97	0.130	1.633E-06	3.353E-05	0.778
3	20	27.83	26.80	0.116	1.457E-06	3.336E-05	0.774
4	25	32.83	31.61	0.093	1.168E-06	3.307E-05	0.767
5	30	37.83	36.43	0.100	1.256E-06	3.316E-05	0.769
6	35	42.83	41.24	0.079	9.922E-07	3.289E-05	0.763
7	40	47.83	46.05	0.081	1.017E-06	3.292E-05	0.764
8	50	57.83	55.68	0.075	9.420E-07	3.284E-05	0.762
9	60	67.83	65.31	0.065	8.164E-07	3.272E-05	0.759
10	80	87.83	84.57	0.016	2.010E-07	3.210E-05	0.745
11	100	107.83	103.83	0.005	6.280E-08	3.196E-05	0.742

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Date: 20 August 2011

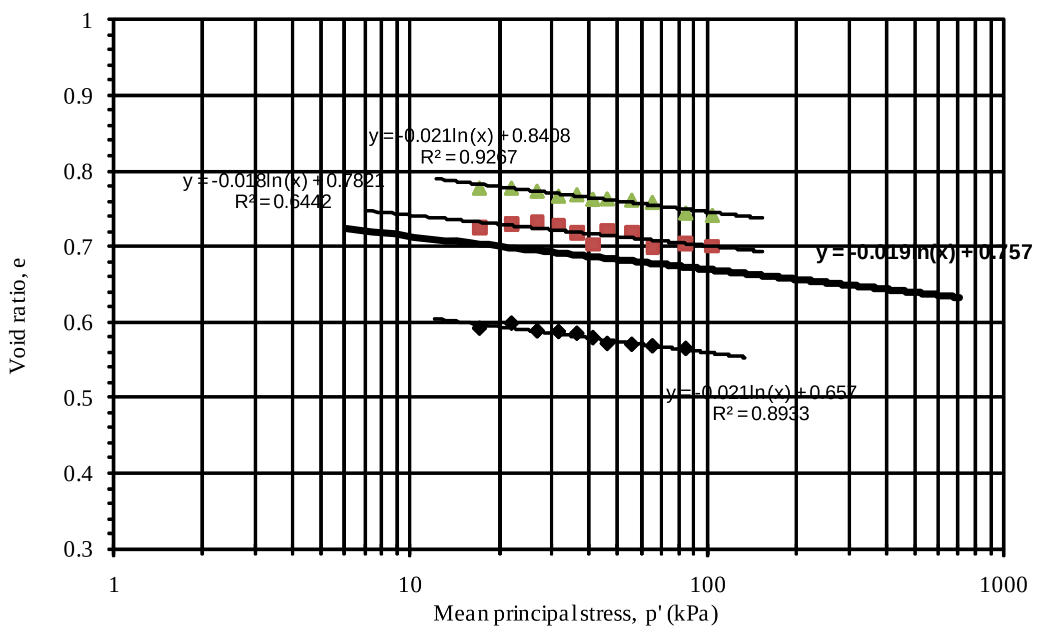
Form : LAB CSL - 04 = 4	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.2 Date of Testing : 07-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 1.35 - 2.70 m

Trial #3 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.83	17.17	0.107	1.344E-06	3.125E-05	0.725
2	15	22.83	21.98	0.121	1.520E-06	3.142E-05	0.729
3	20	27.83	26.80	0.129	1.620E-06	3.152E-05	0.731
4	25	32.83	31.61	0.118	1.482E-06	3.138E-05	0.728
5	30	37.83	36.43	0.081	1.017E-06	3.092E-05	0.717
6	35	42.83	41.24	0.030	3.768E-07	3.028E-05	0.703
7	40	47.83	46.05	0.094	1.181E-06	3.108E-05	0.721
8	50	57.83	55.68	0.086	1.080E-06	3.098E-05	0.719
9	60	67.83	65.31	0.019	2.386E-07	3.014E-05	0.699
10	80	87.83	84.57	0.037	4.647E-07	3.037E-05	0.705
11	100	107.83	103.83	0.023	2.889E-07	3.019E-05	0.701



No.	Parameters	Equations	Unit
1	Applied pressure (σ_{ci}')		kN/m²
2	Correction (σ_{3i}')	$\sigma_{3i}'=\sigma_{ci}' + \sigma_m'$	kN/m²
3	Mean principal stress (p_i')	$p_i'=\sigma_{3i}'[\{3-\sin\phi_{cs}\}/\{3(1-\sin\phi_{cs})\}]$	kN/m²
4	Distance (d_i)	$d_i=h_o - h_i$	m
5	Volume change (ΔV_i)	$\Delta V_i=d_i*A_t$	m³
6	Water volume (V_{wi})	$V_{wi}=V_{wo}+\Delta V_i$	m³
7	Void ratio (e_i)	$e_i=(V_{wi}*G_s*\gamma_w)/W_s$	

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Date: 20 August 2011

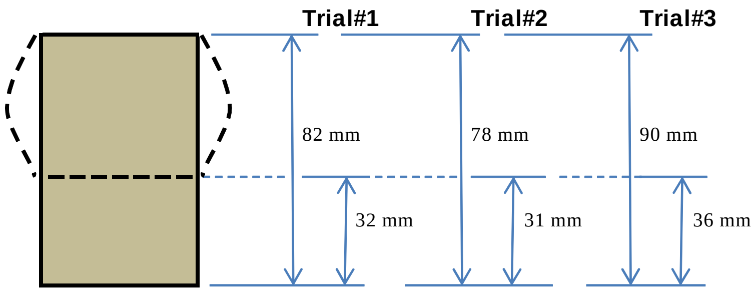
Form : LAB CSL - 01 = 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.3 Date of Testing : 12-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 2.70 - 4.70 m

Initial Measurements

Volume of device without soil (V_d) 500 - 582 ml



Critical state friction angle (ϕ_{cs})

26.0	24.5	24.5	(°)
	Average	25	(°)

Trial #1 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	460 mm	0.217 m
2	15 kPa	467 mm	0.21 m
3	20 kPa	516 mm	0.161 m
4	25 kPa	559 mm	0.118 m
5	30 kPa	613 mm	0.064 m
6	35 kPa	590 mm	0.087 m
7	40 kPa	608 mm	0.069 m
8	50 kPa	671 mm	0.006 m

Temperature of water (T) 22 (°C)

Total volume (V_t) 500 - 657 ml

Height of water when measuring Vt (h_o) 677 mm

Soil dry weight (W_s) 103.54 g

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Reported by : B. Setiawan

Siganture:
Date: 20 August 2011

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CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.3 Date of Testing : 12-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 2.70 - 4.70 m

Trial #2 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	289 mm	0.218 m
2	15 kPa	291 mm	0.216 m
3	20 kPa	322 mm	0.185 m
4	25 kPa	339 mm	0.168 m
5	30 kPa	358 mm	0.149 m
6	35 kPa	380 mm	0.127 m
7	40 kPa	391 mm	0.116 m
8	50 kPa	407 mm	0.1 m
9	60 kPa	443 mm	0.064 m
10	80 kPa	467 mm	0.04 m
11	100 kPa	491 mm	0.016 m

Temperature of water (T) 21 (°C)

Total volume (V_t) 500 - 656 ml

Height of water when measuring Vt (h_o) 507 mm

Soil dry weight (W_s) 105.1 g

Trial #3 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	229 mm	0.32 m
2	15 kPa	234 mm	0.315 m
3	20 kPa	253 mm	0.296 m
4	25 kPa	283 mm	0.266 m
5	30 kPa	308 mm	0.241 m
6	35 kPa	320 mm	0.229 m
7	40 kPa	352 mm	0.197 m
8	50 kPa	424 mm	0.125 m
9	60 kPa	418 mm	0.131 m
10	80 kPa	488 mm	0.061 m
11	100 kPa	515 mm	0.034 m

Temperature of water (T) 21.5 (°C)

Total volume (V_t) 500 - 654 ml

Height of water when measuring Vt (h_o) 549 mm

Soil dry weight (W_s) 105 g

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Date: 20 August 2011

Form : LAB CSL - 03 = 3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.3 Date of Testing : 12-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 2.70 - 4.70 m

Initial Parameters

		Trial#1	Trial#2	Trial#3	
Volume of device without soil	(V_d)	0.000082	0.000082	0.000082	m^3
Additional radial stress	(σ_m')	7.76	7.81	7.83	kN/m^2
Critical state friction angle	(ϕ_{cs})	25	25	25	degree
Soil mass	(W_s)	0.104	0.105	0.105	kg
Soil solids volume - Vs = Ws / (Gs*γw)	(V_s)	3.871E-05	3.92822E-05	3.925E-05	m^3
Area inside tube	(A_t)	0.00001256	0.00001256	0.00001256	m^2
Unit weight of water	(γ_w)	9.788	9.791	9.789	kN/m^3
Specific gravity of soil sample	(G_s)	2.68	2.68	2.68	
Total volume	(V_t)	0.000157	0.000156	0.000154	m^3
Specimen volume - Vsp = Vt - Vd	(V_{sp})	0.000075	0.000074	0.000072	m^3
Ref. water vol.-Vwo = Vsp - Vs	(V_{wo})	3.629E-05	3.472E-05	3.275E-05	m^3

Trial #1 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.76	16.38	0.217	2.726E-06	3.902E-05	1.008
2	15	22.76	20.99	0.210	2.638E-06	3.893E-05	1.006
3	20	27.76	25.60	0.161	2.022E-06	3.831E-05	0.990
4	25	32.76	30.21	0.118	1.482E-06	3.777E-05	0.976
5	30	37.76	34.82	0.064	8.038E-07	3.710E-05	0.958
6	35	42.76	39.43	0.087	1.093E-06	3.739E-05	0.966
7	40	47.76	44.04	0.069	8.666E-07	3.716E-05	0.960
8	50	57.76	53.26	0.006	7.536E-08	3.637E-05	0.940

Trial #2 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.81	16.42	0.218	2.738E-06	3.746E-05	0.954
2	15	22.81	21.03	0.216	2.713E-06	3.743E-05	0.953
3	20	27.83	25.66	0.185	2.324E-06	3.704E-05	0.943
4	25	32.83	30.27	0.168	2.110E-06	3.683E-05	0.938
5	30	37.83	34.88	0.149	1.871E-06	3.659E-05	0.931
6	35	42.83	39.49	0.127	1.595E-06	3.631E-05	0.924
7	40	47.83	44.10	0.116	1.457E-06	3.617E-05	0.921
8	50	57.83	53.32	0.100	1.256E-06	3.597E-05	0.916
9	60	67.83	62.54	0.064	8.038E-07	3.552E-05	0.904
10	80	87.83	80.99	0.040	5.024E-07	3.522E-05	0.897
11	100	107.83	99.43	0.016	2.010E-07	3.492E-05	0.889

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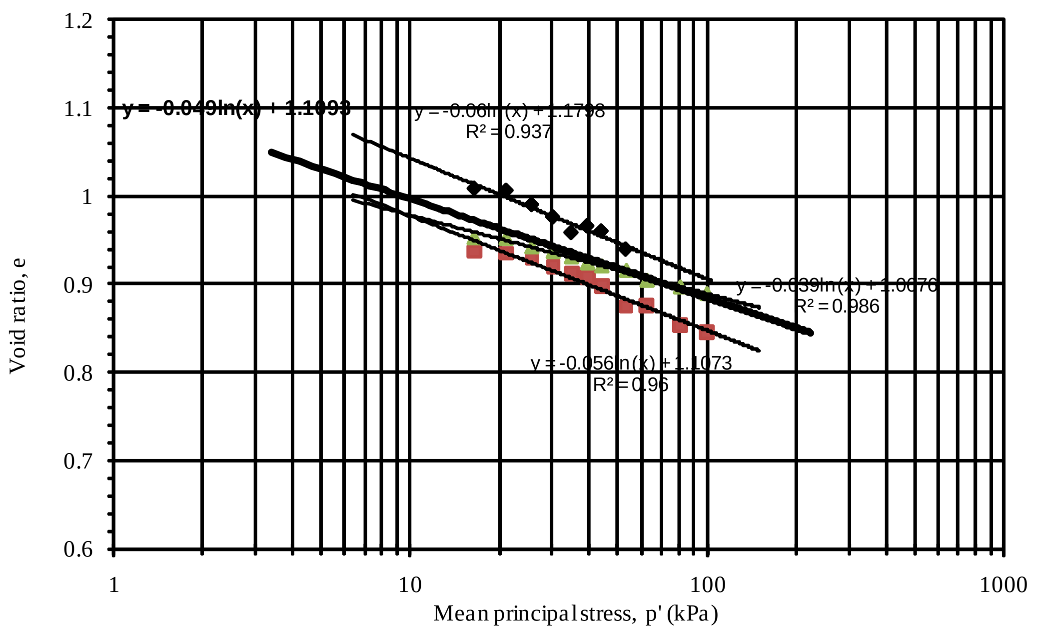
CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.3 Date of Testing : 12-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 2.70 - 4.70 m

Trial #3 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.83	16.44	0.320	4.019E-06	3.677E-05	0.937
2	15	22.83	21.05	0.315	3.956E-06	3.671E-05	0.935
3	20	27.83	25.66	0.296	3.718E-06	3.647E-05	0.929
4	25	32.83	30.27	0.266	3.341E-06	3.609E-05	0.920
5	30	37.83	34.88	0.241	3.027E-06	3.578E-05	0.912
6	35	42.83	39.49	0.229	2.876E-06	3.563E-05	0.908
7	40	47.83	44.10	0.197	2.474E-06	3.523E-05	0.897
8	50	57.83	53.32	0.125	1.570E-06	3.432E-05	0.874
9	60	67.83	62.54	0.131	1.645E-06	3.440E-05	0.876
10	80	87.83	80.99	0.061	7.662E-07	3.352E-05	0.854
11	100	107.83	99.43	0.034	4.270E-07	3.318E-05	0.845



No.	Parameters	Equations	Unit
1	Applied pressure (σ_{ci}')		kN/m²
2	Correction (σ_{3i}')	$\sigma_{3i}'=\sigma_{ci}' + \sigma_m'$	kN/m²
3	Mean principal stress (p_i')	$p_i'=\sigma_{3i}'[\{3-\sin\phi_{cs}\}/\{3(1-\sin\phi_{cs})\}]$	kN/m²
4	Distance (d_i)	$d_i=h_o - h_i$	m
5	Volume change (ΔV_i)	$\Delta V_i=d_i{*}A_t$	m³
6	Water volume (V_{wi})	$V_{wi}=V_{wo}+\Delta V_i$	m³
7	Void ratio (e_i)	$e_i=(V_{wi}{*}G_s{*}\gamma_w)/W_s$	

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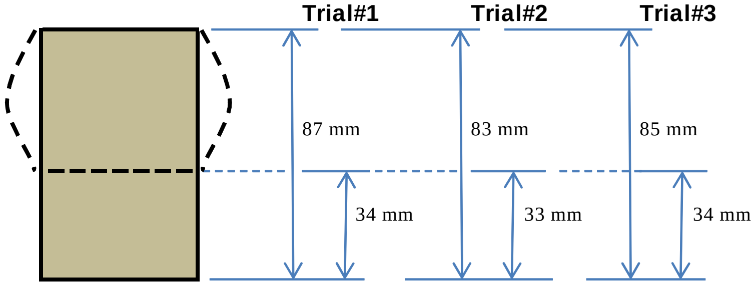
CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.5 Date of Testing : 28-Mar-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 6.00 - 9.00 m

Initial Measurements

Volume of device without soil (V_d) 500 - 582 ml



Critical state friction angle (ϕ_{cs})

30.50	30.00	29.5	(°)
	Average	30	(°)

Trial #1 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	277 mm	0.38 m
2	15 kPa	309 mm	0.348 m
3	20 kPa	295 mm	0.362 m
4	25 kPa	331 mm	0.326 m
5	30 kPa	312 mm	0.345 m
6	35 kPa	340 mm	0.317 m
7	40 kPa	391 mm	0.266 m
8	60 kPa	464 mm	0.193 m
9	80 kPa	562 mm	0.095 m
10	100 kPa	654 mm	0.003 m

Temperature of water (T) 24.5 (°C)

Total volume (V_t) 500 - 655 ml

Height of water when measuring Vt (h_o) 657 mm

Soil dry weight (W_s) 115.89 g

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CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.5 Date of Testing : 28-Mar-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 6.00 - 9.00 m

Trial #2 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	194 mm	0.527 m
2	15 kPa	244 mm	0.477 m
3	20 kPa	285 mm	0.436 m
4	25 kPa	303 mm	0.418 m
5	30 kPa	357 mm	0.364 m
6	35 kPa	353 mm	0.368 m
7	40 kPa	387 mm	0.334 m
8	50 kPa	439 mm	0.282 m
9	60 kPa	519 mm	0.202 m
10	80 kPa	562 mm	0.159 m
11	100 kPa	670 mm	0.051 m

Temperature of water (T) 24 (°C)

Total volume (V_t) 500 - 660 ml

Height of water when measuring Vt (h_o) 721 mm

Soil dry weight (W_s) 116.53 g

Trial #3 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	509 mm	0.34 m
2	15 kPa	542 mm	0.307 m
3	20 kPa	504 mm	0.345 m
4	25 kPa	556 mm	0.293 m
5	30 kPa	581 mm	0.268 m
6	35 kPa	589 mm	0.26 m
7	40 kPa	594 mm	0.255 m
8	50 kPa	650 mm	0.199 m
9	60 kPa	650 mm	0.199 m
10	80 kPa	705 mm	0.144 m
11	100 kPa	794 mm	0.055 m

Temperature of water (T) 24 (°C)

Total volume (V_t) 500 - 650 ml

Height of water when measuring Vt (h_o) 849 mm

Soil dry weight (W_s) 103.34 g

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CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.5 Date of Testing : 28-Mar-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 6.00 - 9.00 m

Initial Parameters		**Trial#1**	**Trial#2**	**Trial#3**	
Volume of device without soil	(V_d)	0.000082	0.000082	0.000082	m^3
Additional radial stress	(σ_m')	7.77	7.82	7.83	kN/m^2
Critical state friction angle	(ϕ_{cs})	30	30	30	degree
Soil mass	(W_s)	0.116	0.117	0.103	kg
Soil soilds volume - Vs = Ws / (Gs*γw)	(V_s)	4.335E-05	4.35844E-05	3.865E-05	m^3
Area inside tube	(A_t)	0.00001256	0.00001256	0.00001256	m^2
Unit weight of water	(γ_w)	9.783	9.784	9.784	kN/m^3
Specific gravity of soil sample	(G_s)	2.68	2.68	2.68	
Total volume	(V_t)	0.000155	0.00016	0.00015	m^3
Specimen volume - Vsp = Vt - Vd	(V_{sp})	0.000073	0.000078	0.000068	m^3
Ref. water vol.-Vwo = Vsp - Vs	(V_{wo})	2.965E-05	3.442E-05	2.935E-05	m^3

Trial #1 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.77	11.88	0.380	4.773E-06	3.442E-05	0.786
2	15	22.77	15.23	0.348	4.371E-06	3.402E-05	0.785
3	20	27.77	18.57	0.362	4.547E-06	3.420E-05	0.789
4	25	32.77	21.91	0.326	4.095E-06	3.374E-05	0.778
5	30	37.77	25.26	0.345	4.333E-06	3.398E-05	0.784
6	35	42.77	28.60	0.317	3.982E-06	3.363E-05	0.776
7	40	47.77	31.94	0.266	3.341E-06	3.299E-05	0.761
8	60	67.77	45.32	0.193	2.424E-06	3.207E-05	0.740
9	80	87.77	58.69	0.095	1.193E-06	3.084E-05	0.711
10	100	107.77	72.06	0.003	3.768E-08	2.969E-05	0.685

Trial #2 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.82	11.92	0.527	6.619E-06	4.103E-05	0.941
2	15	22.82	15.26	0.477	5.991E-06	4.041E-05	0.927
3	20	27.83	18.61	0.436	5.476E-06	3.989E-05	0.915
4	25	32.83	21.95	0.418	5.250E-06	3.967E-05	0.910
5	30	37.83	25.30	0.364	4.572E-06	3.899E-05	0.895
6	35	42.83	28.64	0.368	4.622E-06	3.904E-05	0.896
7	40	47.83	31.98	0.334	4.195E-06	3.861E-05	0.886
8	50	57.83	38.67	0.282	3.542E-06	3.796E-05	0.871
9	60	67.83	45.36	0.202	2.537E-06	3.695E-05	0.848
10	80	87.83	58.73	0.159	1.997E-06	3.641E-05	0.835
11	100	107.83	72.10	0.051	6.406E-07	3.506E-05	0.804

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Date: 20 August 2011

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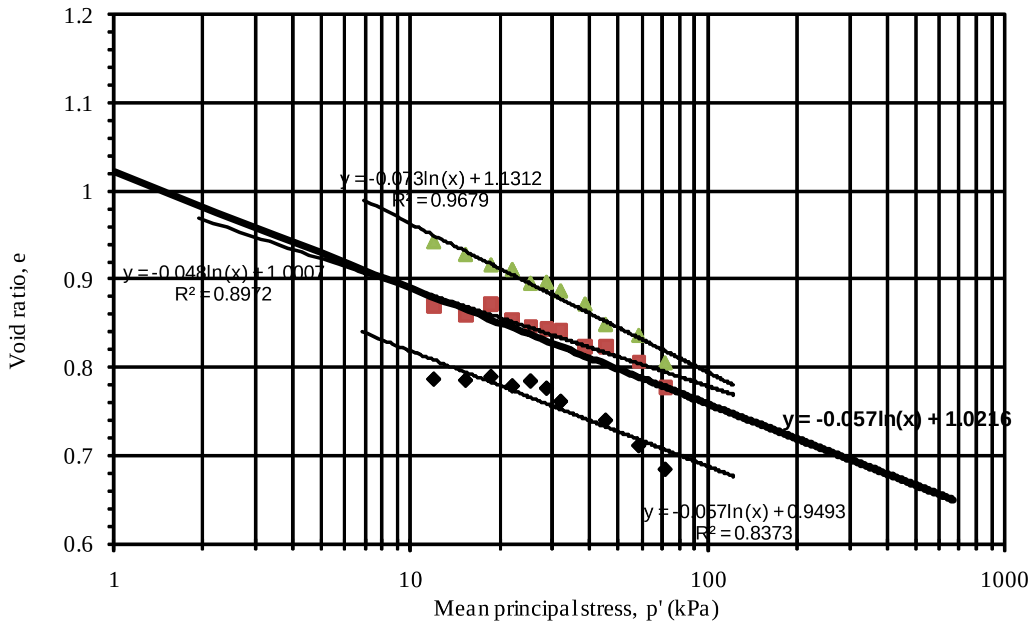
CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-01/#1.5 Date of Testing : 28-Mar-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 6.00 - 9.00 m

Trial #3 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.83	11.92	0.340	4.270E-06	3.362E-05	0.870
2	15	22.83	15.27	0.307	3.856E-06	3.320E-05	0.859
3	20	27.83	18.61	0.345	4.333E-06	3.368E-05	0.871
4	25	32.83	21.95	0.293	3.680E-06	3.303E-05	0.855
5	30	37.83	25.30	0.268	3.366E-06	3.271E-05	0.846
6	35	42.83	28.64	0.260	3.266E-06	3.261E-05	0.844
7	40	47.83	31.98	0.255	3.203E-06	3.255E-05	0.842
8	50	57.83	38.67	0.199	2.499E-06	3.185E-05	0.824
9	60	67.83	45.36	0.199	2.499E-06	3.185E-05	0.824
10	80	87.83	58.73	0.144	1.809E-06	3.116E-05	0.806
11	100	107.83	72.10	0.055	6.908E-07	3.004E-05	0.777



No.	Parameters	Equations	Unit
1	Applied pressure (σ_{ci}')		kN/m²
2	Correction (σ_{3i}')	$\sigma_{3i}'=\sigma_{ci}' + \sigma_m'$	kN/m²
3	Mean principal stress (p_i')	$p_i'=\sigma_{3i}'[\{3-\sin\phi_{cs}\}/\{3(1-\sin\phi_{cs})\}]$	kN/m²
4	Distance (d_i)	$d_i=h_o - h_i$	m
5	Volume change (ΔV_i)	$\Delta V_i=d_i*A_t$	m³
6	Water volume (V_{wi})	$V_{wi}=V_{wo}+\Delta V_i$	m³
7	Void ratio (e_i)	$e_i=(V_{wi}*G_s*\gamma_w)/W_s$	

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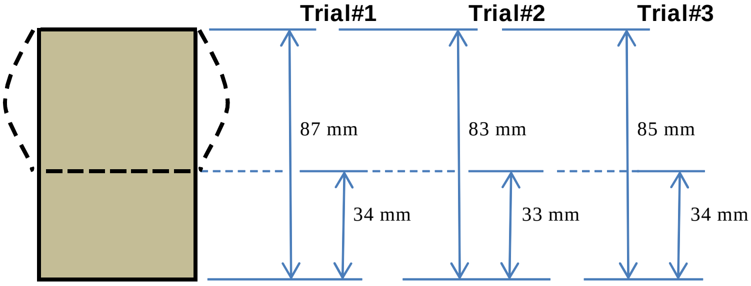
CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.3 Date of Testing : 29-Mar-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 1.20 - 2.20 m

Initial Measurements

Volume of device without soil (V_d) 500 - 582 ml



Critical state friction angle (ϕ_{cs})

28.00	30.00	35	(°)
	Average	31	(°)

Trial #1 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	431 mm	0.413 m
2	15 kPa	468 mm	0.376 m
3	20 kPa	484 mm	0.36 m
4	25 kPa	540 mm	0.304 m
5	30 kPa	572 mm	0.272 m
6	35 kPa	586 mm	0.258 m
7	40 kPa	590 mm	0.254 m
8	50 kPa	574 mm	0.27 m
9	60 kPa	573 mm	0.271 m
10	80 kPa	612 mm	0.232 m
11	100 kPa	669 mm	0.175 m

Temperature of water (T) 23 (°C)

Total volume (V_t) 500 - 665 ml

Height of water when measuring Vt (h_o) 844 mm

Soil dry weight (W_s) 135.05 g

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CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.3 Date of Testing : 29-Mar-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 1.20 - 2.20 m

Trial #2 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	549 mm	0.31 m
2	15 kPa	540 mm	0.319 m
3	20 kPa	532 mm	0.327 m
4	25 kPa	553 mm	0.306 m
5	30 kPa	552 mm	0.307 m
6	35 kPa	563 mm	0.296 m
7	40 kPa	547 mm	0.312 m
8	50 kPa	569 mm	0.29 m
9	60 kPa	567 mm	0.292 m
10	80 kPa	584 mm	0.275 m
11	100 kPa	596 mm	0.263 m

Temperature of water (T) 23.5 (°C)

Total volume (V_t) 500 - 660 ml

Height of water when measuring Vt (h_o) 859 mm

Soil dry weight (W_s) 121.99 g

Trial #3 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	515 mm	0.43 m
2	15 kPa	604 mm	0.341 m
3	20 kPa	631 mm	0.314 m
4	25 kPa	663 mm	0.282 m
5	30 kPa	721 mm	0.224 m
6	35 kPa	739 mm	0.206 m
7	40 kPa	748 mm	0.197 m
8	50 kPa	688 mm	0.257 m
9	60 kPa	734 mm	0.211 m
10	80 kPa	744 mm	0.201 m
11	100 kPa	683 mm	0.262 m

Temperature of water (T) 22 (°C)

Total volume (V_t) 500 - 615 ml

Height of water when measuring Vt (h_o) 945 mm

Soil dry weight (W_s) 57.75 g

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Reported by: B. Setiawan

Signature:
Date: 20 August 2011

Form : LAB CSL - 03 = 3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.3 Date of Testing : 29-Mar-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 1.20 - 2.20 m

Initial Parameters		**Trial#1**	**Trial#2**	**Trial#3**	
Volume of device without soil	(V_d)	0.000082	0.000082	0.000082	m^3
Additional radial stress	(σ_m')	7.77	7.82	7.83	kN/m^2
Critical state friction angle	(ϕ_{cs})	31	31	31	degree
Soil mass	(W_s)	0.135	0.122	0.058	kg
Soil soilds volume - Vs = Ws / (Gs*γw)	(V_s)	5.166E-05	4.66658E-05	2.208E-05	m^3
Area inside tube	(A_t)	0.00001256	0.00001256	0.00001256	m^2
Unit weight of water	(γ_w)	9.786	9.785	9.788	kN/m^3
Specific gravity of soil sample	(G_s)	2.62	2.62	2.62	
Total volume	(V_t)	0.000165	0.00016	0.000115	m^3
Specimen volume - Vsp = Vt - Vd	(V_{sp})	0.000083	0.000078	0.000033	m^3
Ref. water vol.-Vwo = Vsp - Vs	(V_{wo})	3.134E-05	3.133E-05	1.092E-05	m^3

Trial #1 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.77	14.36	0.413	5.187E-06	3.653E-05	0.700
2	15	22.77	18.40	0.376	4.723E-06	3.607E-05	0.698
3	20	27.77	22.44	0.360	4.522E-06	3.587E-05	0.694
4	25	32.77	26.48	0.304	3.818E-06	3.516E-05	0.681
5	30	37.77	30.52	0.272	3.416E-06	3.476E-05	0.673
6	35	42.77	34.56	0.258	3.240E-06	3.458E-05	0.670
7	40	47.77	38.61	0.254	3.190E-06	3.453E-05	0.669
8	50	57.77	46.69	0.270	3.391E-06	3.474E-05	0.672
9	60	67.77	54.77	0.271	3.404E-06	3.475E-05	0.673
10	80	87.77	70.93	0.232	2.914E-06	3.426E-05	0.663
11	100	107.77	87.09	0.175	2.198E-06	3.354E-05	0.649

Trial #2 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.82	14.40	0.310	3.894E-06	3.523E-05	0.755
2	15	22.82	18.44	0.319	4.007E-06	3.534E-05	0.757
3	20	27.83	22.49	0.327	4.107E-06	3.544E-05	0.759
4	25	32.83	26.53	0.306	3.843E-06	3.518E-05	0.754
5	30	37.83	30.57	0.307	3.856E-06	3.519E-05	0.754
6	35	42.83	34.61	0.296	3.718E-06	3.505E-05	0.751
7	40	47.83	38.65	0.312	3.919E-06	3.525E-05	0.755
8	50	57.83	46.74	0.290	3.642E-06	3.498E-05	0.750
9	60	67.83	54.82	0.292	3.668E-06	3.500E-05	0.750
10	80	87.83	70.98	0.275	3.454E-06	3.479E-05	0.745
11	100	107.83	87.14	0.263	3.303E-06	3.464E-05	0.742

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SUB CRUCE LUMEN

Reported by : B. Setiawan

Siganture:
Date: 20 August 2011

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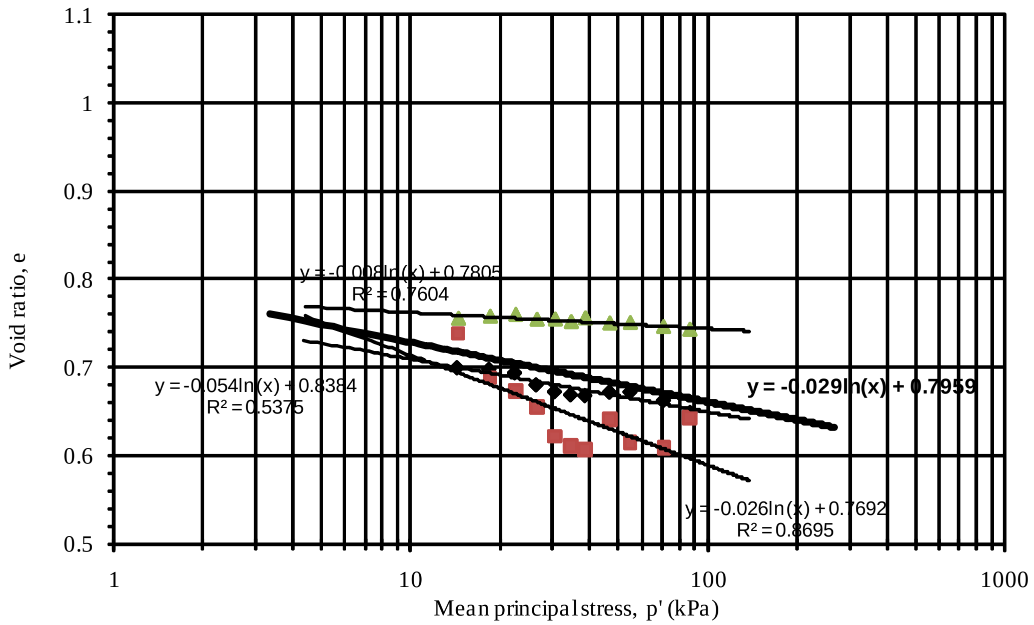
CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.3 Date of Testing : 29-Mar-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 1.20 - 2.20 m

Trial #3 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.83	14.41	0.430	5.401E-06	1.632E-05	0.739
2	15	22.83	18.45	0.341	4.283E-06	1.520E-05	0.688
3	20	27.83	22.49	0.314	3.944E-06	1.486E-05	0.673
4	25	32.83	26.53	0.282	3.542E-06	1.446E-05	0.655
5	30	37.83	30.57	0.224	2.813E-06	1.373E-05	0.622
6	35	42.83	34.61	0.206	2.587E-06	1.350E-05	0.611
7	40	47.83	38.65	0.197	2.474E-06	1.339E-05	0.606
8	50	57.83	46.74	0.257	3.228E-06	1.414E-05	0.640
9	60	67.83	54.82	0.211	2.650E-06	1.357E-05	0.614
10	80	87.83	70.98	0.201	2.525E-06	1.344E-05	0.609
11	100	107.83	87.14	0.262	3.291E-06	1.421E-05	0.643



No.	Parameters	Equations	Unit
1	Applied pressure (σ_{ci}')		kN/m²
2	Correction (σ_{3i}')	$\sigma_{3i}'=\sigma_{ci}' + \sigma_m'$	kN/m²
3	Mean principal stress (p_i')	$p_i'=\sigma_{3i}'[\{3-\sin\phi_{cs}\}/\{3(1-\sin\phi_{cs})\}]$	kN/m²
4	Distance (d_i)	$d_i=h_o - h_i$	m
5	Volume change (ΔV_i)	$\Delta V_i=d_i*A_t$	m³
6	Water volume (V_{wi})	$V_{wi}=V_{wo}+\Delta V_i$	m³
7	Void ratio (e_i)	$e_i=(V_{wi}*G_s*\gamma_w)/W_s$	

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Date: 20 August 2011

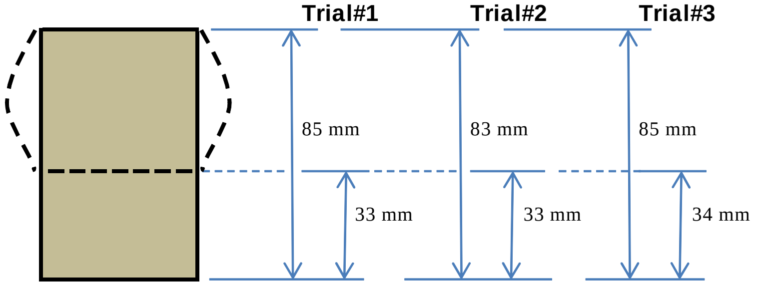
Form : LAB CSL - 01 = 1	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project	: Assessing Liquefaction Potential of Soil Utilising In-situ Testing			
Location	: Gillman, SA			
Sample Code	: GILL/BH-02/#2.4	Date of Testing	:	06-Apr-11
Tested By	: BAMBANG SETIAWAN	Eq/Device/Method	:	***
Depth of the sample	: 2.20 - 4.30 m			

Initial Measurements

Volume of device without soil (V_d) 500 - 582 ml



Critical state friction angle (ϕ_{cs})

34.00	35.00	35	(°)
	Average	34.7	(°)

Trial #1 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	412 mm	0.483 m
2	15 kPa	625 mm	0.27 m
3	20 kPa	646 mm	0.249 m
4	25 kPa	662 mm	0.233 m
5	30 kPa	760 mm	0.135 m
6	35 kPa	794 mm	0.101 m
7	40 kPa	786 mm	0.109 m
8	50 kPa	770 mm	0.125 m
9	60 kPa	852 mm	0.043 m
10	80 kPa	874 mm	0.021 m
11	100 kPa	882 mm	0.013 m

Temperature of water (T) 22 (°C)

Total volume (V_t) 500 - 661 ml

Height of water when measuring Vt (h_o) 895 mm

Soil dry weight (W_s) 110.3 g

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Date: 20 August 2011

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CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.4 Date of Testing : 06-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 2.20 - 4.30 m

Trial #2 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	516 mm	0.378 m
2	15 kPa	474 mm	0.42 m
3	20 kPa	529 mm	0.365 m
4	25 kPa	492 mm	0.402 m
5	30 kPa	485 mm	0.409 m
6	35 kPa	528 mm	0.366 m
7	40 kPa	563 mm	0.331 m
8	50 kPa	522 mm	0.372 m
9	60 kPa	610 mm	0.284 m
10	80 kPa	661 mm	0.233 m
11	100 kPa	610 mm	0.284 m

Temperature of water (T) 23 (°C)

Total volume (V_t) 500 - 665 ml

Height of water when measuring Vt (h_o) 894 mm

Soil dry weight (W_s) 122.72 g

Trial #3 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	328 mm	0.545 m
2	15 kPa	322 mm	0.551 m
3	20 kPa	343 mm	0.53 m
4	25 kPa	364 mm	0.509 m
5	30 kPa	402 mm	0.471 m
6	35 kPa	423 mm	0.45 m
7	40 kPa	396 mm	0.477 m
8	50 kPa	466 mm	0.407 m
9	60 kPa	436 mm	0.437 m
10	80 kPa	454 mm	0.419 m
11	100 kPa	485 mm	0.388 m

Temperature of water (T) 23 (°C)

Total volume (V_t) 500 - 670 ml

Height of water when measuring Vt (h_o) 873 mm

Soil dry weight (W_s) 139.81 g

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Date: 20 August 2011

Form : LAB CSL - 03 = 3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.4 Date of Testing : 06-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 2.20 - 4.30 m

Initial Parameters

		Trial#1	Trial#2	Trial#3	
Volume of device without soil	(V_d)	0.000082	0.000082	0.000082	m³
Additional radial stress	(σ_m')	7.75	7.82	7.83	kN/m²
Critical state friction angle	(ϕ_{cs})	34.67	34.67	34.67	degree
Soil mass	(W_s)	0.110	0.123	0.140	kg
Soil soilds volume - Vs = Ws / (Gs*γw)	(V_s)	4.108E-05	4.5718E-05	5.208E-05	m³
Area inside tube	(A_t)	0.00001256	0.00001256	0.00001256	m²
Unit weight of water	(γ_w)	9.788	9.786	9.786	kN/m³
Specific gravity of soil sample	(G_s)	2.69	2.69	2.69	
Total volume	(V_t)	0.000161	0.000165	0.00017	m³
Specimen volume - Vsp = Vt - Vd	(V_{sp})	0.000079	0.000083	0.000088	m³
Ref. water vol.-Vwo = Vsp - Vs	(V_{wo})	3.792E-05	3.728E-05	3.592E-05	m³

Trial #1 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.75	16.59	0.483	6.066E-06	4.398E-05	1.060
2	15	22.75	21.26	0.270	3.391E-06	4.131E-05	1.006
3	20	27.75	25.93	0.249	3.127E-06	4.105E-05	0.999
4	25	32.75	30.61	0.233	2.926E-06	4.084E-05	0.994
5	30	37.75	35.28	0.135	1.696E-06	3.961E-05	0.964
6	35	42.75	39.95	0.101	1.269E-06	3.919E-05	0.954
7	40	47.75	44.62	0.109	1.369E-06	3.929E-05	0.956
8	50	57.75	53.97	0.125	1.570E-06	3.949E-05	0.961
9	60	67.75	63.31	0.043	5.401E-07	3.846E-05	0.936
10	80	87.75	82.00	0.021	2.638E-07	3.818E-05	0.929
11	100	107.75	100.69	0.013	1.633E-07	3.808E-05	0.927

Trial #2 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.82	16.65	0.378	4.748E-06	4.203E-05	0.919
2	15	22.82	21.33	0.420	5.275E-06	4.256E-05	0.931
3	20	27.83	26.01	0.365	4.584E-06	4.187E-05	0.916
4	25	32.83	30.68	0.402	5.049E-06	4.233E-05	0.926
5	30	37.83	35.35	0.409	5.137E-06	4.242E-05	0.928
6	35	42.83	40.03	0.366	4.597E-06	4.188E-05	0.916
7	40	47.83	44.70	0.331	4.157E-06	4.144E-05	0.906
8	50	57.83	54.04	0.372	4.672E-06	4.195E-05	0.918
9	60	67.83	63.39	0.284	3.567E-06	4.085E-05	0.894
10	80	87.83	82.08	0.233	2.926E-06	4.021E-05	0.879
11	100	107.83	100.77	0.284	3.567E-06	4.085E-05	0.894

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Reported by : B. Setiawan

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Date: 20 August 2011

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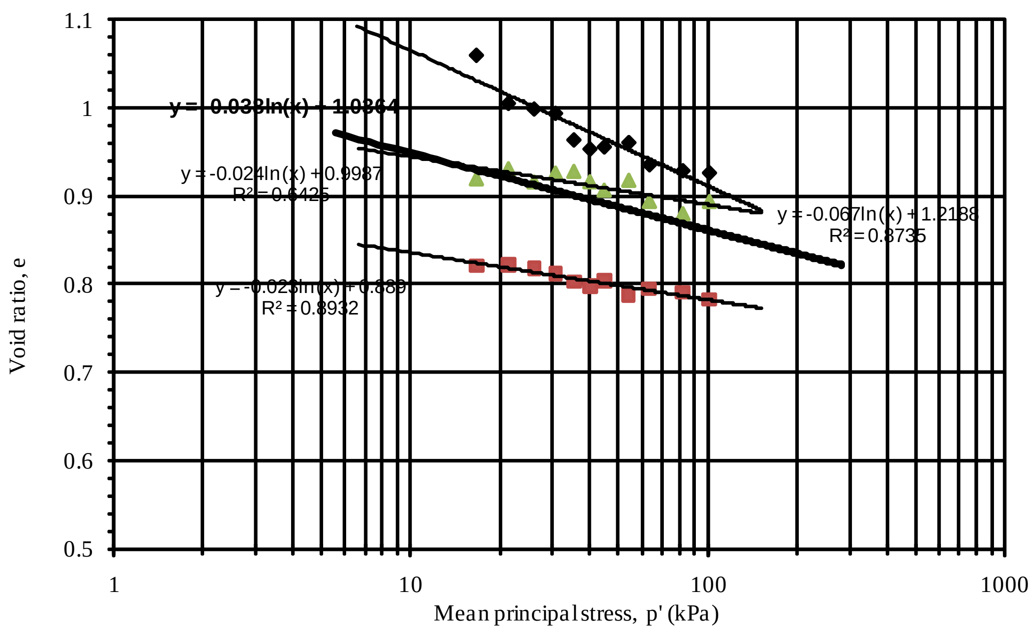
CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.4 Date of Testing : 06-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 2.20 - 4.30 m

Trial #3 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.83	16.66	0.545	6.845E-06	4.276E-05	0.821
2	15	22.83	21.33	0.551	6.921E-06	4.284E-05	0.822
3	20	27.83	26.01	0.530	6.657E-06	4.257E-05	0.817
4	25	32.83	30.68	0.509	6.393E-06	4.231E-05	0.812
5	30	37.83	35.35	0.471	5.916E-06	4.183E-05	0.803
6	35	42.83	40.03	0.450	5.652E-06	4.157E-05	0.798
7	40	47.83	44.70	0.477	5.991E-06	4.191E-05	0.805
8	50	57.83	54.04	0.407	5.112E-06	4.103E-05	0.788
9	60	67.83	63.39	0.437	5.489E-06	4.140E-05	0.795
10	80	87.83	82.08	0.419	5.263E-06	4.118E-05	0.791
11	100	107.83	100.77	0.388	4.873E-06	4.079E-05	0.783



No.	Parameters	Equations	Unit
1	Applied pressure (σ_{ci}')		kN/m²
2	Correction (σ_{3i}')	$\sigma_{3i}' = \sigma_{ci}' + \sigma_m'$	kN/m²
3	Mean principal stress (p_i')	$p_i' = \sigma_{3i}'[\{3-\sin\phi_{cs}\}/\{3(1-\sin\phi_{cs})\}]$	kN/m²
4	Distance (d_i)	$d_i = h_o - h_i$	m
5	Volume change (ΔV_i)	$\Delta V_i = d_i * A_t$	m³
6	Water volume (V_{wi})	$V_{wi} = V_{wo} + \Delta V_i$	m³
7	Void ratio (e_i)	$e_i = (V_{wi} * G_s * \gamma_w)/W_s$	

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Reported by: B. Setiawan

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Date: 20 August 2011

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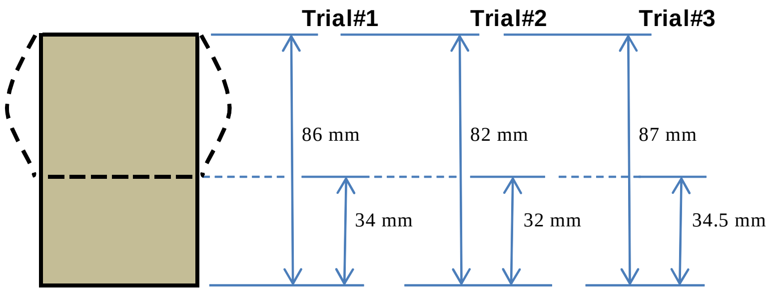
CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.6 Date of Testing : 05-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 6.30 - 8.50 m

Initial Measurements

Volume of device without soil (V_d) 500 - 582 ml



Critical state friction angle (ϕ_{cs})

26.50	28.00	30.5	(°)
	Average	28.3	(°)

Trial #1 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	618 mm	0.263 m
2	15 kPa	679 mm	0.202 m
3	20 kPa	698 mm	0.183 m
4	25 kPa	702 mm	0.179 m
5	30 kPa	728 mm	0.153 m
6	35 kPa	719 mm	0.162 m
7	40 kPa	763 mm	0.118 m
8	50 kPa	714 mm	0.167 m
9	60 kPa	798 mm	0.083 m
10	80 kPa	804 mm	0.077 m
11	100 kPa	809 mm	0.072 m

Temperature of water (T) 22 (°C)

Total volume (V_t) 500 - 665 ml

Height of water when measuring Vt (h_o) 881 mm

Soil dry weight (W_s) 123.79 g

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Reported by : B. Setiawan

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Date: 20 August 2011

Form : LAB CSL - 02 = 2	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.6 Date of Testing : 05-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 6.30 - 8.50 m

Trial #2 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	214 mm	0.406 m
2	15 kPa	306 mm	0.314 m
3	20 kPa	345 mm	0.275 m
4	25 kPa	433 mm	0.187 m
5	30 kPa	406 mm	0.214 m
6	35 kPa	432 mm	0.188 m
7	40 kPa	488 mm	0.132 m
8	50 kPa	459 mm	0.161 m
9	60 kPa	492 mm	0.128 m
10	80 kPa	536 mm	0.084 m
11	100 kPa	545 mm	0.075 m

Temperature of water (T) 22 (°C)

Total volume (V_t) 500 - 667 ml

Height of water when measuring Vt (h_o) 620 mm

Soil dry weight (W_s) 125.41 g

Trial #3 Data

#i	Applied pressure	Elevation of the water (h_i)	Remarks
1	10 kPa	616 mm	0.23 m
2	15 kPa	589 mm	0.257 m
3	20 kPa	639 mm	0.207 m
4	25 kPa	709 mm	0.137 m
5	30 kPa	659 mm	0.187 m
6	35 kPa	698 mm	0.148 m
7	40 kPa	718 mm	0.128 m
8	50 kPa	633 mm	0.213 m
9	60 kPa	773 mm	0.073 m
10	80 kPa	731 mm	0.115 m
11	100 kPa	845 mm	0.001 m

Temperature of water (T) 23 (°C)

Total volume (V_t) 500 - 655 ml

Height of water when measuring Vt (h_o) 846 mm

Soil dry weight (W_s) 109.09 g

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Reported by: B. Setiawan

Signature:
Date: 20 August 2011

Form : LAB CSL - 03 = 3	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.6 Date of Testing : 05-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 6.30 - 8.50 m

Initial Parameters		**Trial#1**	**Trial#2**	**Trial#3**	
Volume of device without soil	(V_d)	0.000082	0.000082	0.000082	m³
Additional radial stress	(σ_m')	7.8	7.76	7.81	kN/m²
Critical state friction angle	(ϕ_{cs})	28.3	28.3	28.3	degree
Soil mass	(W_s)	0.124	0.125	0.109	kg
Soil soilds volume - Vs = Ws / (Gs*γw)	(V_s)	4.645E-05	4.70592E-05	4.094E-05	m³
Area inside tube	(A_t)	0.00001256	0.00001256	0.00001256	m²
Unit weight of water	(γ_w)	9.788	9.788	9.786	kN/m³
Specific gravity of soil sample	(G_s)	2.67	2.67	2.67	
Total volume	(V_t)	0.000165	0.000167	0.000155	m³
Specimen volume - Vsp = Vt - Vd	(V_{sp})	0.000083	0.000085	0.000073	m³
Ref. water vol.-Vwo = Vsp - Vs	(V_{wo})	3.655E-05	3.794E-05	3.206E-05	m³

Trial #1 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.8	17.14	0.263	3.303E-06	3.985E-05	0.849
2	15	22.8	21.95	0.202	2.537E-06	3.909E-05	0.841
3	20	27.8	26.77	0.183	2.298E-06	3.885E-05	0.836
4	25	32.8	31.58	0.179	2.248E-06	3.880E-05	0.835
5	30	37.8	36.40	0.153	1.922E-06	3.847E-05	0.828
6	35	42.8	41.21	0.162	2.035E-06	3.858E-05	0.831
7	40	47.8	46.03	0.118	1.482E-06	3.803E-05	0.819
8	50	57.8	55.65	0.167	2.098E-06	3.865E-05	0.832
9	60	67.8	65.28	0.083	1.042E-06	3.759E-05	0.809
10	80	87.8	84.54	0.077	9.671E-07	3.752E-05	0.808
11	100	107.8	103.80	0.072	9.043E-07	3.745E-05	0.806

Trial #2 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.76	17.10	0.406	5.099E-06	4.304E-05	0.915
2	15	22.76	21.92	0.314	3.944E-06	4.188E-05	0.890
3	20	27.81	26.78	0.275	3.454E-06	4.139E-05	0.880
4	25	32.81	31.59	0.187	2.349E-06	4.029E-05	0.856
5	30	37.81	36.41	0.214	2.688E-06	4.063E-05	0.863
6	35	42.81	41.22	0.188	2.361E-06	4.030E-05	0.856
7	40	47.81	46.04	0.132	1.658E-06	3.960E-05	0.841
8	50	57.81	55.66	0.161	2.022E-06	3.996E-05	0.849
9	60	67.81	65.29	0.128	1.608E-06	3.955E-05	0.840
10	80	87.81	84.55	0.084	1.055E-06	3.900E-05	0.829
11	100	107.81	103.81	0.075	9.420E-07	3.888E-05	0.826

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by : B. Setiawan

Siganture:
Date: 20 August 2011

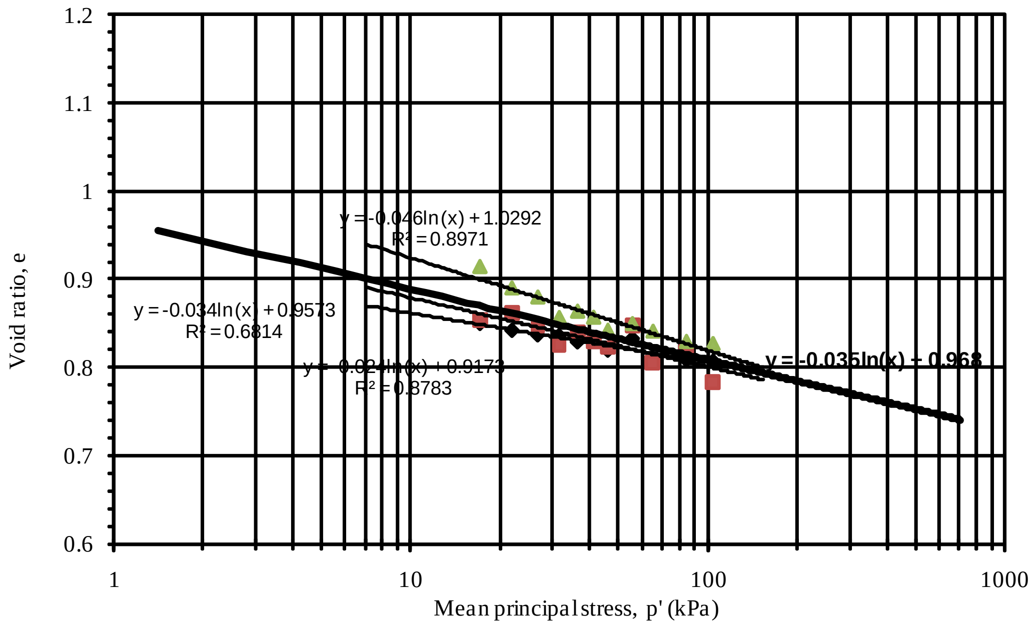
Form : LAB CSL - 04 = 4	GEOTECHNICAL LABORATORY THE UNIVERSITY OF ADELAIDE	Page :

CRITICAL STATE PARAMETERS

Project : Assessing Liquefaction Potential of Soil Utilising In-situ Testing
Location : Gillman, SA
Sample Code : GILL/BH-02/#2.6 Date of Testing : 05-Apr-11
Tested By : BAMBANG SETIAWAN Eq/Device/Method : ***
Depth of the sample : 6.30 - 8.50 m

Trial #3 Calculations

#i	Applied pressure	Correction	Mean principal stress	Distance	Volume change	Water volume	Void ratio
1	10	17.81	17.15	0.230	2.889E-06	3.494E-05	0.853
2	15	22.81	21.96	0.257	3.228E-06	3.528E-05	0.862
3	20	27.81	26.78	0.207	2.600E-06	3.466E-05	0.846
4	25	32.81	31.59	0.137	1.721E-06	3.378E-05	0.825
5	30	37.81	36.41	0.187	2.349E-06	3.440E-05	0.840
6	35	42.81	41.22	0.148	1.859E-06	3.391E-05	0.828
7	40	47.81	46.04	0.128	1.608E-06	3.366E-05	0.822
8	50	57.81	55.66	0.213	2.675E-06	3.473E-05	0.848
9	60	67.81	65.29	0.073	9.169E-07	3.297E-05	0.805
10	80	87.81	84.55	0.115	1.444E-06	3.350E-05	0.818
11	100	107.81	103.81	0.001	1.256E-08	3.207E-05	0.783



No.	Parameters	Equations	Unit
1	Applied pressure (σ_{ci}')		kN/m²
2	Correction (σ_{3i}')	$\sigma_{3i}'=\sigma_{ci}' + \sigma_m'$	kN/m²
3	Mean principal stress (p_i')	$p_i'=\sigma_{3i}'[\{3-\sin\phi_{cs}\}/\{3(1-\sin\phi_{cs})\}]$	kN/m²
4	Distance (d_i)	$d_i=h_o - h_i$	m
5	Volume change (ΔV_i)	$\Delta V_i=d_i*A_t$	m³
6	Water volume (V_{wi})	$V_{wi}=V_{wo}+\Delta V_i$	m³
7	Void ratio (e_i)	$e_i=(V_{wi}*G_s*\gamma_w)/W_s$	

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: B. Setiawan

Signature:
Date: 20 August 2011

APPENDIX H

INTERPRETING IN-SITU STATE PARAMETER FROM CPT DATA

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CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#1

SHEET : 1 OF 8

INTERPRETATION USING SLOPE OF CSL TESTING @ BH#1

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	γ (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	Q	Qp	k	m	Ψ	$\lambda_{BH\#1}$	Remarks
200	6140	43.15	20.60	4.12	4.12											
400	6610	127.25	21.28	8.38	8.38											
600	9080	124.85	20.93	12.56	12.56											
800	4720	137.10	20.90	16.74	16.74											
1000	2630	127.47	20.67	20.88	20.88											
1200	1600	81.35	20.00	24.88	24.88	2.10	0.7	16.55	**19.32**	63	81.515	46.89	12.06	-0.046	0.019	DILATIVE
1400	4570	58.50	19.59	28.79	28.79	4.84	1.0	28.90	**28.86**	158	157.329	46.89	12.06	-0.100	0.019	DILATIVE
1600	3130	62.65	19.58	32.71	32.71	3.05	0.8	25.62	**27.98**	95	110.681	46.89	12.06	-0.071	0.019	DILATIVE
1800	3290	45.45	19.15	36.54	36.54	2.83	0.8	27.42	**30.46**	89	106.821	46.89	12.06	-0.068	0.019	DILATIVE
2000	1710	61.26	19.34	40.41	40.41	1.21	0.5	20.21	**26.94**	41	61.966	46.89	12.06	-0.023	0.019	DILATIVE
2200	1780	41.05	18.85	44.18	44.18	1.13	0.5	21.28	**28.91**	39	60.041	46.89	12.06	-0.021	0.019	DILATIVE
2400	1360	33.25	18.51	47.88	45.92	0.73	0.4	18.31	**27.51**	29	47.688	46.89	12.06	-0.001	0.019	DILATIVE
2600	2110	27.95	18.34	51.55	47.62	1.26	0.5	24.01	**31.88**	43	64.571	46.89	12.06	-0.027	0.019	DILATIVE
2800	2480	30.60	18.40	55.23	49.34	1.47	0.5	26.55	**34.15**	49	71.008	16.97	11.11	-0.129	0.049	DILATIVE
3000	2520	29.74	18.32	58.89	51.04	1.44	0.5	27.10	**35.08**	48	70.149	16.97	11.11	-0.128	0.049	DILATIVE
3200	2560	30.53	18.30	62.55	52.74	1.40	0.5	27.65	**36.02**	47	69.343	16.97	11.11	-0.127	0.049	DILATIVE
3400	2100	28.15	18.16	66.18	54.41	1.05	0.5	25.01	**34.81**	37	58.423	16.97	11.11	-0.111	0.049	DILATIVE
3600	1020	26.50	17.90	69.76	56.03	0.32	0.3	15.79	**29.20**	17	32.540	16.97	11.11	-0.059	0.049	DILATIVE
3800	610	25.65	17.62	73.29	57.60	0.09	0.2	10.24	**26.03**	9	20.623	16.97	11.11	-0.018	0.049	DILATIVE
4000	530	23.05	17.40	76.77	59.11	0.06	0.2	8.88	**25.62**	8	17.689	16.97	11.11	-0.004	0.049	DILATIVE
4200	440	23.89	17.29	80.22	60.61	0.03	0.1	7.16	**24.97**	6	14.406	16.97	11.11	0.015	0.049	CONTRACTIVE
4400	450	23.40	17.25	83.67	62.10	0.03	0.1	7.33	**25.59**	6	14.317	16.97	11.11	0.015	0.049	CONTRACTIVE
4600	480	20.50	17.12	87.10	63.56	0.03	0.1	7.90	**26.45**	6	14.852	16.97	11.11	0.012	0.049	CONTRACTIVE
4800	500	24.95	17.32	90.56	65.06											
5000	430	22.60	17.09	93.98	66.52											
5200	460	19.63	16.96	97.37	67.95											
5400	550	23.70	17.24	100.82	69.44											
5600	1670	39.85	18.15	104.45	71.11											
5800	1960	36.63	18.06	108.06	72.76											
6000	2790	132.95	19.46	111.96	74.69	0.99	0.4	32.64	**46.66**	36	57.401	15.45	10.96	-0.120	0.057	DILATIVE
6200	1180	107.55	19.08	115.77	76.54	0.24	0.2	18.69	**37.98**	14	28.024	15.45	10.96	-0.054	0.057	DILATIVE
6400	1530	24.85	17.53	119.28	78.09	0.38	0.3	22.67	**41.14**	18	34.290	15.45	10.96	-0.073	0.057	DILATIVE
6600	2060	47.42	18.26	122.93	79.78	0.59	0.3	27.77	**45.11**	24	42.944	15.45	10.96	-0.093	0.057	DILATIVE
6800	1650	35.10	17.88	126.50	81.39	0.40	0.3	24.12	**43.21**	19	35.260	15.45	10.96	-0.075	0.057	DILATIVE
7000	1870	33.05	17.81	130.07	82.99	0.48	0.3	26.37	**45.24**	21	38.456	15.45	10.96	-0.083	0.057	DILATIVE
7200	4420	30.47	17.74	133.62	84.58	1.48	0.5	43.79	**57.39**	51	74.691	15.45	10.96	-0.144	0.057	DILATIVE
7400	2320	23.60	17.43	137.10	86.11	0.63	0.4	30.59	**49.10**	25	44.463	15.45	10.96	-0.096	0.057	DILATIVE
7600	1660	18.35	17.10	140.52	87.56	0.36	0.3	24.65	**45.62**	17	33.307	15.45	10.96	-0.070	0.057	DILATIVE
7800	1970	20.60	17.23	143.97	89.05	0.46	0.3	27.80	**48.22**	21	37.872	15.45	10.96	-0.082	0.057	DILATIVE
8000	1020	15.75	16.78	147.32	90.44	0.12	0.2	16.99	**41.47**	10	21.043	15.45	10.96	-0.028	0.057	DILATIVE
8200	870	10.74	16.29	150.58	91.74	0.08	0.2	14.71	**40.39**	8	17.813	15.45	10.96	-0.013	0.057	DILATIVE
8400	850	11.20	16.31	153.84	93.04	0.07	0.2	14.40	**40.61**	7	17.141	15.45	10.96	-0.009	0.057	DILATIVE
8600	2460	49.75	18.14	157.47	94.71	0.60	0.3	32.61	**53.31**	24	43.192	15.45	10.96	-0.094	0.057	DILATIVE
8800	1820	46.10	18.01	161.07	96.35	0.36	0.3	26.88	**50.04**	17	33.155	15.45	10.96	-0.070	0.057	DILATIVE
9000	2960	98.16	18.85	164.85	98.16	0.74	0.4	36.89	**57.31**	28	48.770	15.45	10.96	-0.105	0.057	DILATIVE

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#1

SHEET : 2 OF 8

INTERPRETATION USING SLOPE OF CSL TESTING @ BH#2

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	γ (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	Q	Qp	k	m	Ψ	$\lambda_{BH\#2}$	Remarks
200	6140	43.15	20.60	4.12	4.12											
400	6610	127.25	21.28	8.38	8.38											
600	9080	124.85	20.93	12.56	12.56											
800	4720	137.10	20.90	16.74	16.74											
1000	2630	127.47	20.67	20.88	20.88											
1200	1600	81.35	20.00	24.88	24.88	2.10	0.7	16.55	**19.32**	63	81.515	26.42	11.64	-0.097	0.029	DILATIVE
1400	4570	58.50	19.59	28.79	28.79	4.84	1.0	28.90	**28.86**	158	157.329	26.42	11.64	-0.153	0.029	DILATIVE
1600	3130	62.65	19.58	32.71	32.71	3.05	0.8	25.62	**27.98**	95	110.681	26.42	11.64	-0.123	0.029	DILATIVE
1800	3290	45.45	19.15	36.54	36.54	2.83	0.8	27.42	**30.46**	89	106.821	26.42	11.64	-0.120	0.029	DILATIVE
2000	1710	61.26	19.34	40.41	40.41	1.21	0.5	20.21	**26.94**	41	61.966	26.42	11.64	-0.073	0.029	DILATIVE
2200	1780	41.05	18.85	44.18	44.18	1.13	0.5	21.28	**28.91**	39	60.041	26.42	11.64	-0.071	0.029	DILATIVE
2400	1360	33.25	18.51	47.88	45.92	0.73	0.4	18.31	**27.51**	29	47.688	26.42	11.64	-0.051	0.029	DILATIVE
2600	2110	27.95	18.34	51.55	47.62	1.26	0.5	24.01	**31.88**	43	64.571	26.42	11.64	-0.077	0.029	DILATIVE
2800	2480	30.60	18.40	55.23	49.34	1.47	0.5	26.55	**34.15**	49	71.008	20.50	11.37	-0.109	0.038	DILATIVE
3000	2520	29.74	18.32	58.89	51.04	1.44	0.5	27.10	**35.08**	48	70.149	20.50	11.37	-0.108	0.038	DILATIVE
3200	2560	30.53	18.30	62.55	52.74	1.40	0.5	27.65	**36.02**	47	69.343	20.50	11.37	-0.107	0.038	DILATIVE
3400	2100	28.15	18.16	66.18	54.41	1.05	0.5	25.01	**34.81**	37	58.423	20.50	11.37	-0.092	0.038	DILATIVE
3600	1020	26.50	17.90	69.76	56.03	0.32	0.3	15.79	**29.20**	17	32.540	20.50	11.37	-0.041	0.038	DILATIVE
3800	610	25.65	17.62	73.29	57.60	0.09	0.2	10.24	**26.03**	9	20.623	20.50	11.37	-0.001	0.038	DILATIVE
4000	530	23.05	17.40	76.77	59.11	0.06	0.2	8.88	**25.62**	8	17.689	20.50	11.37	0.013	0.038	CONTRACTIVE
4200	440	23.89	17.29	80.22	60.61	0.03	0.1	7.16	**24.97**	6	14.406	20.50	11.37	0.031	0.038	CONTRACTIVE
4400	450	23.40	17.25	83.67	62.10	0.03	0.1	7.33	**25.59**	6	14.317	20.50	11.37	0.032	0.038	CONTRACTIVE
4600	480	20.50	17.12	87.10	63.56	0.03	0.1	7.90	**26.45**	6	14.852	20.50	11.37	0.028	0.038	CONTRACTIVE
4800	500	24.95	17.32	90.56	65.06											
5000	430	22.60	17.09	93.98	66.52											
5200	460	19.63	16.96	97.37	67.95											
5400	550	23.70	17.24	100.82	69.44											
5600	1670	39.85	18.15	104.45	71.11											
5800	1960	36.63	18.06	108.06	72.76											
6000	2790	132.95	19.46	111.96	74.69	0.99	0.4	32.64	**46.66**	36	57.401	22.00	11.45	-0.084	0.035	DILATIVE
6200	1180	107.55	19.08	115.77	76.54	0.24	0.2	18.69	**37.98**	14	28.024	22.00	11.45	-0.021	0.035	DILATIVE
6400	1530	24.85	17.53	119.28	78.09	0.38	0.3	22.67	**41.14**	18	34.290	22.00	11.45	-0.039	0.035	DILATIVE
6600	2060	47.42	18.26	122.93	79.78	0.59	0.3	27.77	**45.11**	24	42.944	22.00	11.45	-0.058	0.035	DILATIVE
6800	1650	35.10	17.88	126.50	81.39	0.40	0.3	24.12	**43.21**	19	35.260	22.00	11.45	-0.041	0.035	DILATIVE
7000	1870	33.05	17.81	130.07	82.99	0.48	0.3	26.37	**45.24**	21	38.456	22.00	11.45	-0.049	0.035	DILATIVE
7200	4420	30.47	17.74	133.62	84.58	1.48	0.5	43.79	**57.39**	51	74.691	22.00	11.45	-0.107	0.035	DILATIVE
7400	2320	23.60	17.43	137.10	86.11	0.63	0.4	30.59	**49.10**	25	44.463	22.00	11.45	-0.061	0.035	DILATIVE
7600	1660	18.35	17.10	140.52	87.56	0.36	0.3	24.65	**45.62**	17	33.307	22.00	11.45	-0.036	0.035	DILATIVE
7800	1970	20.60	17.23	143.97	89.05	0.46	0.3	27.80	**48.22**	21	37.872	22.00	11.45	-0.047	0.035	DILATIVE
8000	1020	15.75	16.78	147.32	90.44	0.12	0.2	16.99	**41.47**	10	21.043	22.00	11.45	0.004	0.035	CONTRACTIVE
8200	870	10.74	16.29	150.58	91.74	0.08	0.2	14.71	**40.39**	8	17.813	22.00	11.45	0.018	0.035	CONTRACTIVE
8400	850	11.20	16.31	153.84	93.04	0.07	0.2	14.40	**40.61**	7	17.141	22.00	11.45	0.022	0.035	CONTRACTIVE
8600	2460	49.75	18.14	157.47	94.71	0.60	0.3	32.61	**53.31**	24	43.192	22.00	11.45	-0.059	0.035	DILATIVE
8800	1820	46.10	18.01	161.07	96.35	0.36	0.3	26.88	**50.04**	17	33.155	22.00	11.45	-0.036	0.035	DILATIVE
9000	2960	98.16	18.85	164.85	98.16	0.74	0.4	36.89	**57.31**	28	48.770	22.00	11.45	-0.070	0.035	DILATIVE

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#1

SHEET : 3 OF 8

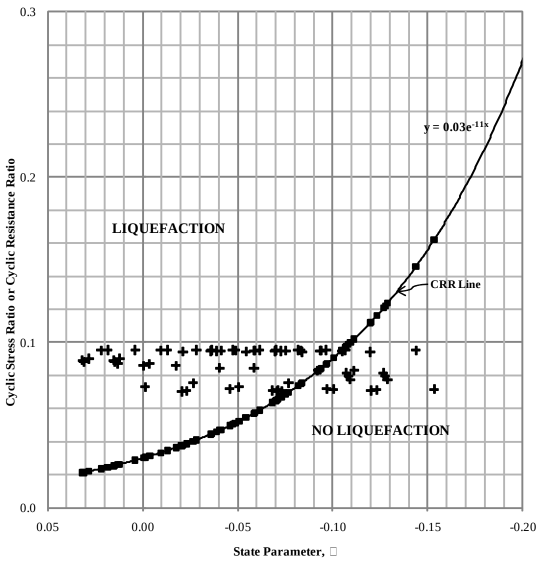
STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=5.0	q_{c1N}	Ψ		$CRR_{M=7.5}$		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0
			BH#1	BH#2	BH#1	BH#2	
200							
400							
600							
800							
1000							
1200	0.07	30.81	-0.05	-0.10	0.05	0.09	NO LIQUEFACTION
1400	0.07	80.80	-0.10	-0.15	0.09	0.16	NO LIQUEFACTION
1600	0.07	51.90	-0.07	-0.12	0.07	0.12	NO LIQUEFACTION
1800	0.07	54.09	-0.07	-0.12	0.06	0.11	NO LIQUEFACTION
2000	0.07	26.71	-0.02	-0.07	0.04	0.07	LIQUEFACTION
2200	0.07	27.57	-0.02	-0.07	0.04	0.07	LIQUEFACTION
2400	0.07	20.98	0.00	-0.05	0.03	0.05	LIQUEFACTION
2600	0.08	30.88	-0.03	-0.08	0.04	0.07	LIQUEFACTION
2800	0.08	34.45	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3000	0.08	33.83	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3200	0.08	33.15	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3400	0.08	26.56	-0.11	-0.09	0.10	0.08	LIQUEFACTION
3600	0.08	12.89	-0.06	-0.04	0.06	0.05	LIQUEFACTION
3800	0.09	7.77	-0.02	0.00	0.04	0.03	LIQUEFACTION
4000	0.09	6.61	0.00	0.01	0.03	0.03	LIQUEFACTION
4200	0.09	5.38	0.01	0.03	0.03	0.02	LIQUEFACTION
4400	0.09	5.29	0.02	0.03	0.03	0.02	LIQUEFACTION
4600	0.09	5.42	0.01	0.03	0.03	0.02	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.09	26.51	-0.12	-0.08	0.11	0.08	NO LIQUEFACTION
6200	0.09	10.91	-0.05	-0.02	0.05	0.04	LIQUEFACTION
6400	0.09	13.65	-0.07	-0.04	0.07	0.05	LIQUEFACTION
6600	0.09	18.41	-0.09	-0.06	0.08	0.06	LIQUEFACTION
6800	0.10	14.35	-0.08	-0.04	0.07	0.05	LIQUEFACTION
7000	0.10	16.02	-0.08	-0.05	0.07	0.05	LIQUEFACTION
7200	0.10	37.33	-0.14	-0.11	0.15	0.10	NO LIQUEFACTION
7400	0.10	19.07	-0.10	-0.06	0.09	0.06	LIQUEFACTION
7600	0.10	13.22	-0.07	-0.04	0.06	0.04	LIQUEFACTION
7800	0.10	15.58	-0.08	-0.05	0.07	0.05	LIQUEFACTION
8000	0.10	7.67	-0.03	0.00	0.04	0.03	LIQUEFACTION
8200	0.10	6.26	-0.01	0.02	0.03	0.02	LIQUEFACTION
8400	0.10	6.02	-0.01	0.02	0.03	0.02	LIQUEFACTION
8600	0.10	19.49	-0.09	-0.06	0.08	0.06	LIQUEFACTION
8800	0.09	14.07	-0.07	-0.04	0.06	0.04	LIQUEFACTION
9000	0.09	23.95	-0.10	-0.07	0.10	0.06	NO LIQUEFACTION

GRAPH

OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 5.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#1

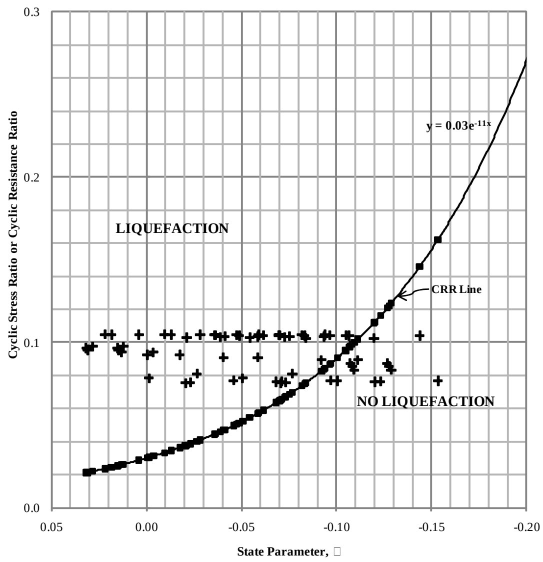
SHEET : 4 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=5.5**	**q_{c1N}**	**Ψ**		**$CRR_{M=7.5}$**		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.5
			BH#1	**BH#2**	**BH#1**	**BH#2**	
200							
400							
600							
800							
1000							
1200	0.08	30.81	-0.05	-0.10	0.05	0.09	**NO LIQUEFACTION**
1400	0.08	80.80	-0.10	-0.15	0.09	0.16	**NO LIQUEFACTION**
1600	0.08	51.90	-0.07	-0.12	0.07	0.12	**NO LIQUEFACTION**
1800	0.08	54.09	-0.07	-0.12	0.06	0.11	**NO LIQUEFACTION**
2000	0.08	26.71	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2200	0.08	27.57	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2400	0.08	20.98	0.00	-0.05	0.03	0.05	**LIQUEFACTION**
2600	0.08	30.88	-0.03	-0.08	0.04	0.07	**LIQUEFACTION**
2800	0.08	34.45	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3000	0.09	33.83	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3200	0.09	33.15	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3400	0.09	26.56	-0.11	-0.09	0.10	0.08	**NO LIQUEFACTION**
3600	0.09	12.89	-0.06	-0.04	0.06	0.05	**LIQUEFACTION**
3800	0.09	7.77	-0.02	0.00	0.04	0.03	**LIQUEFACTION**
4000	0.09	6.61	0.00	0.01	0.03	0.03	**LIQUEFACTION**
4200	0.10	5.38	0.01	0.03	0.03	0.02	**LIQUEFACTION**
4400	0.10	5.29	0.02	0.03	0.03	0.02	**LIQUEFACTION**
4600	0.10	5.42	0.01	0.03	0.03	0.02	**LIQUEFACTION**
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.10	26.51	-0.12	-0.08	0.11	0.08	**NO LIQUEFACTION**
6200	0.10	10.91	-0.05	-0.02	0.05	0.04	**LIQUEFACTION**
6400	0.10	13.65	-0.07	-0.04	0.07	0.05	**LIQUEFACTION**
6600	0.10	18.41	-0.09	-0.06	0.08	0.06	**LIQUEFACTION**
6800	0.10	14.35	-0.08	-0.04	0.07	0.05	**LIQUEFACTION**
7000	0.10	16.02	-0.08	-0.05	0.07	0.05	**LIQUEFACTION**
7200	0.10	37.33	-0.14	-0.11	0.15	0.10	**NO LIQUEFACTION**
7400	0.10	19.07	-0.10	-0.06	0.09	0.06	**LIQUEFACTION**
7600	0.10	13.22	-0.07	-0.04	0.06	0.04	**LIQUEFACTION**
7800	0.10	15.58	-0.08	-0.05	0.07	0.05	**LIQUEFACTION**
8000	0.10	7.67	-0.03	0.00	0.04	0.03	**LIQUEFACTION**
8200	0.10	6.26	-0.01	0.02	0.03	0.02	**LIQUEFACTION**
8400	0.10	6.02	-0.01	0.02	0.03	0.02	**LIQUEFACTION**
8600	0.10	19.49	-0.09	-0.06	0.08	0.06	**LIQUEFACTION**
8800	0.10	14.07	-0.07	-0.04	0.06	0.04	**LIQUEFACTION**
9000	0.10	23.95	-0.10	-0.07	0.10	0.06	**LIQUEFACTION**

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#1

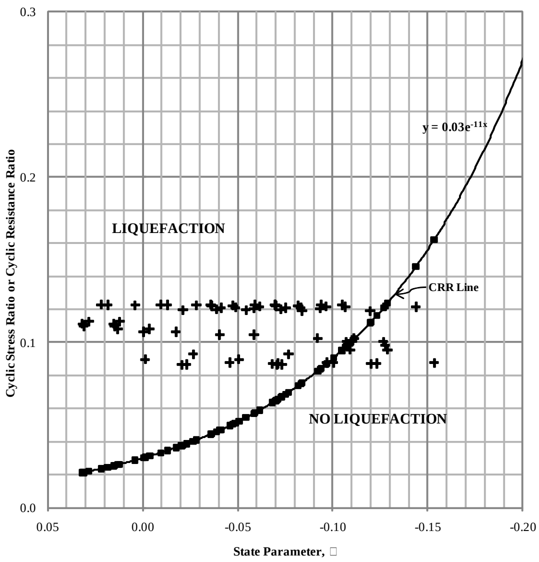
SHEET : 5 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=6.0	q_{c1N}	Ψ		$CRR_{M=7.5}$		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.0
			BH#1	BH#2	BH#1	BH#2	
200							
400							
600							
800							
1000							
1200	0.09	30.81	-0.05	-0.10	0.05	0.09	LIQUEFACTION
1400	0.09	80.80	-0.10	-0.15	0.09	0.16	NO LIQUEFACTION
1600	0.09	51.90	-0.07	-0.12	0.07	0.12	NO LIQUEFACTION
1800	0.09	54.09	-0.07	-0.12	0.06	0.11	NO LIQUEFACTION
2000	0.09	26.71	-0.02	-0.07	0.04	0.07	LIQUEFACTION
2200	0.09	27.57	-0.02	-0.07	0.04	0.07	LIQUEFACTION
2400	0.09	20.98	0.00	-0.05	0.03	0.05	LIQUEFACTION
2600	0.09	30.88	-0.03	-0.08	0.04	0.07	LIQUEFACTION
2800	0.10	34.45	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3000	0.10	33.83	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3200	0.10	33.15	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3400	0.10	26.56	-0.11	-0.09	0.10	0.08	LIQUEFACTION
3600	0.10	12.89	-0.06	-0.04	0.06	0.05	LIQUEFACTION
3800	0.11	7.77	-0.02	0.00	0.04	0.03	LIQUEFACTION
4000	0.11	6.61	0.00	0.01	0.03	0.03	LIQUEFACTION
4200	0.11	5.38	0.01	0.03	0.03	0.02	LIQUEFACTION
4400	0.11	5.29	0.02	0.03	0.03	0.02	LIQUEFACTION
4600	0.11	5.42	0.01	0.03	0.03	0.02	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.12	26.51	-0.12	-0.08	0.11	0.08	LIQUEFACTION
6200	0.12	10.91	-0.05	-0.02	0.05	0.04	LIQUEFACTION
6400	0.12	13.65	-0.07	-0.04	0.07	0.05	LIQUEFACTION
6600	0.12	18.41	-0.09	-0.06	0.08	0.06	LIQUEFACTION
6800	0.12	14.35	-0.08	-0.04	0.07	0.05	LIQUEFACTION
7000	0.12	16.02	-0.08	-0.05	0.07	0.05	LIQUEFACTION
7200	0.12	37.33	-0.14	-0.11	0.15	0.10	NO LIQUEFACTION
7400	0.12	19.07	-0.10	-0.06	0.09	0.06	LIQUEFACTION
7600	0.12	13.22	-0.07	-0.04	0.06	0.04	LIQUEFACTION
7800	0.12	15.58	-0.08	-0.05	0.07	0.05	LIQUEFACTION
8000	0.12	7.67	-0.03	0.00	0.04	0.03	LIQUEFACTION
8200	0.12	6.26	-0.01	0.02	0.03	0.02	LIQUEFACTION
8400	0.12	6.02	-0.01	0.02	0.03	0.02	LIQUEFACTION
8600	0.12	19.49	-0.09	-0.06	0.08	0.06	LIQUEFACTION
8800	0.12	14.07	-0.07	-0.04	0.06	0.04	LIQUEFACTION
9000	0.12	23.95	-0.10	-0.07	0.10	0.06	LIQUEFACTION

GRAPH
OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 6.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#1

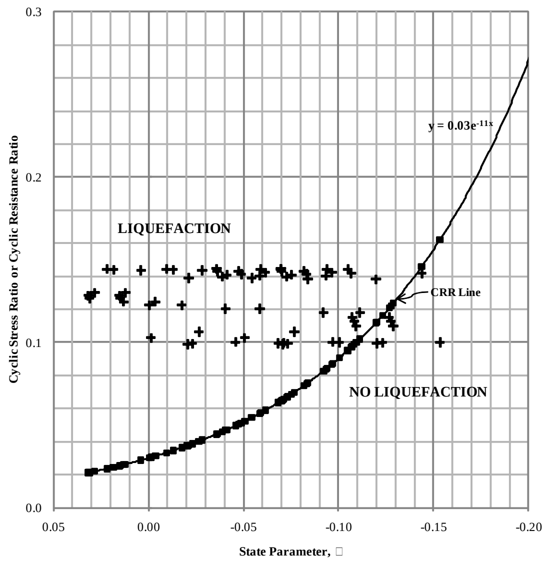
SHEET : 6 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=6.5**	**q_{c1N}**	**Ψ**		**$CRR_{M=7.5}$**		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.5
			BH#1	**BH#2**	**BH#1**	**BH#2**	
200							
400							
600							
800							
1000							
1200	0.10	30.81	-0.05	-0.10	0.05	0.09	**LIQUEFACTION**
1400	0.10	80.80	-0.10	-0.15	0.09	0.16	**NO LIQUEFACTION**
1600	0.10	51.90	-0.07	-0.12	0.07	0.12	**NO LIQUEFACTION**
1800	0.10	54.09	-0.07	-0.12	0.06	0.11	**NO LIQUEFACTION**
2000	0.10	26.71	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2200	0.10	27.57	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2400	0.10	20.98	0.00	-0.05	0.03	0.05	**LIQUEFACTION**
2600	0.11	30.88	-0.03	-0.08	0.04	0.07	**LIQUEFACTION**
2800	0.11	34.45	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3000	0.11	33.83	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3200	0.12	33.15	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3400	0.12	26.56	-0.11	-0.09	0.10	0.08	**LIQUEFACTION**
3600	0.12	12.89	-0.06	-0.04	0.06	0.05	**LIQUEFACTION**
3800	0.12	7.77	-0.02	0.00	0.04	0.03	**LIQUEFACTION**
4000	0.12	6.61	0.00	0.01	0.03	0.03	**LIQUEFACTION**
4200	0.13	5.38	0.01	0.03	0.03	0.02	**LIQUEFACTION**
4400	0.13	5.29	0.02	0.03	0.03	0.02	**LIQUEFACTION**
4600	0.13	5.42	0.01	0.03	0.03	0.02	**LIQUEFACTION**
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.14	26.51	-0.12	-0.08	0.11	0.08	**LIQUEFACTION**
6200	0.14	10.91	-0.05	-0.02	0.05	0.04	**LIQUEFACTION**
6400	0.14	13.65	-0.07	-0.04	0.07	0.05	**LIQUEFACTION**
6600	0.14	18.41	-0.09	-0.06	0.08	0.06	**LIQUEFACTION**
6800	0.14	14.35	-0.08	-0.04	0.07	0.05	**LIQUEFACTION**
7000	0.14	16.02	-0.08	-0.05	0.07	0.05	**LIQUEFACTION**
7200	0.14	37.33	-0.14	-0.11	0.15	0.10	**NO LIQUEFACTION**
7400	0.14	19.07	-0.10	-0.06	0.09	0.06	**LIQUEFACTION**
7600	0.14	13.22	-0.07	-0.04	0.06	0.04	**LIQUEFACTION**
7800	0.14	15.58	-0.08	-0.05	0.07	0.05	**LIQUEFACTION**
8000	0.14	7.67	-0.03	0.00	0.04	0.03	**LIQUEFACTION**
8200	0.14	6.26	-0.01	0.02	0.03	0.02	**LIQUEFACTION**
8400	0.14	6.02	-0.01	0.02	0.03	0.02	**LIQUEFACTION**
8600	0.14	19.49	-0.09	-0.06	0.08	0.06	**LIQUEFACTION**
8800	0.14	14.07	-0.07	-0.04	0.06	0.04	**LIQUEFACTION**
9000	0.14	23.95	-0.10	-0.07	0.10	0.06	**LIQUEFACTION**

GRAPH
OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

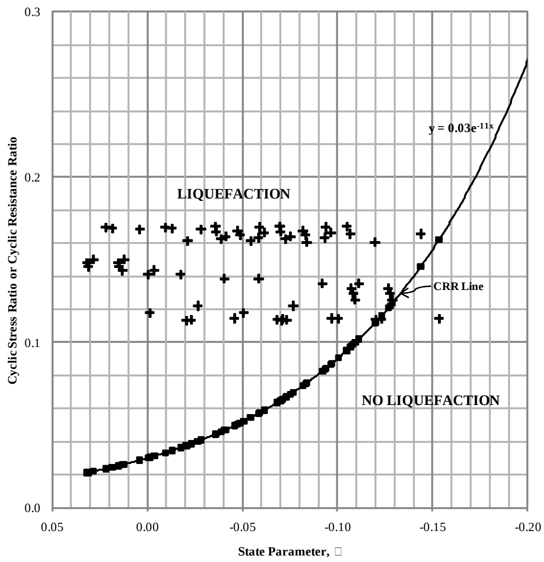
Date : 20 August 2011

CONE PENETRATION TEST (CPT)	**CPT#1**	**SHEET : 7 OF 8**	
STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)		STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=7.0	

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=7.0**	**q_{c1N}**	**Ψ**		**$CRR_{M=7.5}$**		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.0
			BH#1	**BH#2**	**BH#1**	**BH#2**	
200							
400							
600							
800							
1000							
1200	0.11	30.81	-0.05	-0.10	0.05	0.09	**LIQUEFACTION**
1400	0.11	80.80	-0.10	-0.15	0.09	0.16	**NO LIQUEFACTION**
1600	0.11	51.90	-0.07	-0.12	0.07	0.12	**NO LIQUEFACTION**
1800	0.11	54.09	-0.07	-0.12	0.06	0.11	**LIQUEFACTION**
2000	0.11	26.71	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2200	0.11	27.57	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2400	0.12	20.98	0.00	-0.05	0.03	0.05	**LIQUEFACTION**
2600	0.12	30.88	-0.03	-0.08	0.04	0.07	**LIQUEFACTION**
2800	0.13	34.45	-0.13	-0.11	0.12	0.10	**LIQUEFACTION**
3000	0.13	33.83	-0.13	-0.11	0.12	0.10	**LIQUEFACTION**
3200	0.13	33.15	-0.13	-0.11	0.12	0.10	**LIQUEFACTION**
3400	0.14	26.56	-0.11	-0.09	0.10	0.08	**LIQUEFACTION**
3600	0.14	12.89	-0.06	-0.04	0.06	0.05	**LIQUEFACTION**
3800	0.14	7.77	-0.02	0.00	0.04	0.03	**LIQUEFACTION**
4000	0.14	6.61	0.00	0.01	0.03	0.03	**LIQUEFACTION**
4200	0.15	5.38	0.01	0.03	0.03	0.02	**LIQUEFACTION**
4400	0.15	5.29	0.02	0.03	0.03	0.02	**LIQUEFACTION**
4600	0.15	5.42	0.01	0.03	0.03	0.02	**LIQUEFACTION**
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.16	26.51	-0.12	-0.08	0.11	0.08	**LIQUEFACTION**
6200	0.16	10.91	-0.05	-0.02	0.05	0.04	**LIQUEFACTION**
6400	0.16	13.65	-0.07	-0.04	0.07	0.05	**LIQUEFACTION**
6600	0.16	18.41	-0.09	-0.06	0.08	0.06	**LIQUEFACTION**
6800	0.16	14.35	-0.08	-0.04	0.07	0.05	**LIQUEFACTION**
7000	0.16	16.02	-0.08	-0.05	0.07	0.05	**LIQUEFACTION**
7200	0.17	37.33	-0.14	-0.11	0.15	0.10	**LIQUEFACTION**
7400	0.17	19.07	-0.10	-0.06	0.09	0.06	**LIQUEFACTION**
7600	0.17	13.22	-0.07	-0.04	0.06	0.04	**LIQUEFACTION**
7800	0.17	15.58	-0.08	-0.05	0.07	0.05	**LIQUEFACTION**
8000	0.17	7.67	-0.03	0.00	0.04	0.03	**LIQUEFACTION**
8200	0.17	6.26	-0.01	0.02	0.03	0.02	**LIQUEFACTION**
8400	0.17	6.02	-0.01	0.02	0.03	0.02	**LIQUEFACTION**
8600	0.17	19.49	-0.09	-0.06	0.08	0.06	**LIQUEFACTION**
8800	0.17	14.07	-0.07	-0.04	0.06	0.04	**LIQUEFACTION**
9000	0.17	23.95	-0.10	-0.07	0.10	0.06	**LIQUEFACTION**

GRAPH
OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 7.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#1

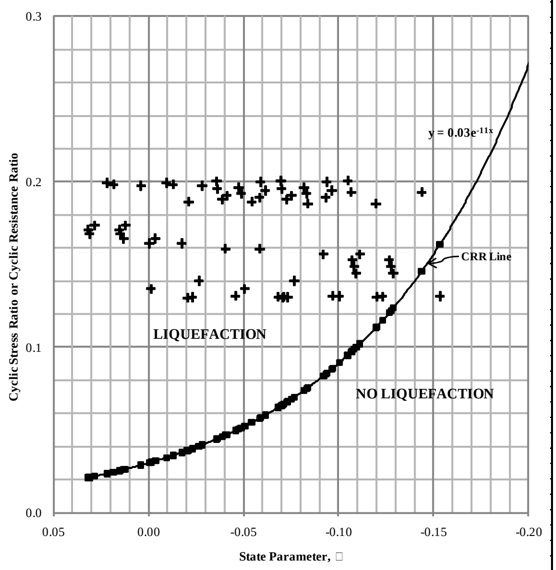
SHEET : 8 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=7.5**	**q_{c1N}**	**Ψ**		**$CRR_{M=7.5}$**		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.5
			BH#1	**BH#2**	**BH#1**	**BH#2**	
200							
400							
600							
800							
1000							
1200	0.13	30.81	-0.05	-0.10	0.05	0.09	**LIQUEFACTION**
1400	0.13	80.80	-0.10	-0.15	0.09	0.16	**NO LIQUEFACTION**
1600	0.13	51.90	-0.07	-0.12	0.07	0.12	**LIQUEFACTION**
1800	0.13	54.09	-0.07	-0.12	0.06	0.11	**LIQUEFACTION**
2000	0.13	26.71	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2200	0.13	27.57	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2400	0.14	20.98	0.00	-0.05	0.03	0.05	**LIQUEFACTION**
2600	0.14	30.88	-0.03	-0.08	0.04	0.07	**LIQUEFACTION**
2800	0.14	34.45	-0.13	-0.11	0.12	0.10	**LIQUEFACTION**
3000	0.15	33.83	-0.13	-0.11	0.12	0.10	**LIQUEFACTION**
3200	0.15	33.15	-0.13	-0.11	0.12	0.10	**LIQUEFACTION**
3400	0.16	26.56	-0.11	-0.09	0.10	0.08	**LIQUEFACTION**
3600	0.16	12.89	-0.06	-0.04	0.06	0.05	**LIQUEFACTION**
3800	0.16	7.77	-0.02	0.00	0.04	0.03	**LIQUEFACTION**
4000	0.17	6.61	0.00	0.01	0.03	0.03	**LIQUEFACTION**
4200	0.17	5.38	0.01	0.03	0.03	0.02	**LIQUEFACTION**
4400	0.17	5.29	0.02	0.03	0.03	0.02	**LIQUEFACTION**
4600	0.17	5.42	0.01	0.03	0.03	0.02	**LIQUEFACTION**
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.19	26.51	-0.12	-0.08	0.11	0.08	**LIQUEFACTION**
6200	0.19	10.91	-0.05	-0.02	0.05	0.04	**LIQUEFACTION**
6400	0.19	13.65	-0.07	-0.04	0.07	0.05	**LIQUEFACTION**
6600	0.19	18.41	-0.09	-0.06	0.08	0.06	**LIQUEFACTION**
6800	0.19	14.35	-0.08	-0.04	0.07	0.05	**LIQUEFACTION**
7000	0.19	16.02	-0.08	-0.05	0.07	0.05	**LIQUEFACTION**
7200	0.19	37.33	-0.14	-0.11	0.15	0.10	**LIQUEFACTION**
7400	0.19	19.07	-0.10	-0.06	0.09	0.06	**LIQUEFACTION**
7600	0.20	13.22	-0.07	-0.04	0.06	0.04	**LIQUEFACTION**
7800	0.20	15.58	-0.08	-0.05	0.07	0.05	**LIQUEFACTION**
8000	0.20	7.67	-0.03	0.00	0.04	0.03	**LIQUEFACTION**
8200	0.20	6.26	-0.01	0.02	0.03	0.02	**LIQUEFACTION**
8400	0.20	6.02	-0.01	0.02	0.03	0.02	**LIQUEFACTION**
8600	0.20	19.49	-0.09	-0.06	0.08	0.06	**LIQUEFACTION**
8800	0.20	14.07	-0.07	-0.04	0.06	0.04	**LIQUEFACTION**
9000	0.20	23.95	-0.10	-0.07	0.10	0.06	**LIQUEFACTION**

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#2

SHEET : 1 OF 8

INTERPRETATION USING SLOPE OF CSL TESTING @ BH#1

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m	
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan	
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan	
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa	

DEPTH (mm)	q_c (kPa)	f_s (kPa)	γ (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	Q	Qp	k	m	Ψ	$\lambda_{BH\#1}$	Remarks
200	5640	29.20	20.18	4.04	4.04											
400	7750	191.90	21.71	8.38	8.38											
600	9740	184.95	21.35	12.65	12.65											
800	6280	185.90	21.21	16.89	16.89											
1000	8590	179.00	20.97	21.08	21.08											
1200	5500	82.00	20.05	25.10	25.10	6.38	1.2	29.49	**28.02**	218	195.363	46.89	12.06	-0.118	0.019	DILATIVE
1400	7900	117.33	20.29	29.15	29.15	7.28	1.3	36.70	**34.18**	270	230.257	46.89	12.06	-0.132	0.019	DILATIVE
1600	5320	138.40	20.42	33.24	33.24	4.77	1.0	32.86	**32.99**	159	160.257	46.89	12.06	-0.102	0.019	DILATIVE
1800	2670	54.05	19.33	37.10	37.10	2.26	0.7	24.89	**28.96**	71	90.921	46.89	12.06	-0.055	0.019	DILATIVE
2000	3130	70.32	19.55	41.01	41.01	2.37	0.7	27.98	**32.32**	75	95.562	46.89	12.06	-0.059	0.019	DILATIVE
2200	660	37.95	18.47	44.71	44.71	0.20	0.2	10.79	**22.09**	14	27.848	46.89	12.06	0.043	0.019	CONTRACTIVE
2400	1050	22.80	18.03	48.31	46.35	0.47	0.3	15.47	**25.76**	22	38.878	46.89	12.06	0.016	0.019	CONTRACTIVE
2600	1470	15.65	17.65	51.84	47.92	0.77	0.4	19.47	**28.95**	30	48.979	46.89	12.06	-0.004	0.019	DILATIVE
2800	2080	16.89	17.74	55.39	49.51	1.18	0.5	24.13	**32.59**	41	62.126	16.97	11.11	-0.117	0.049	DILATIVE
3000	3000	20.80	17.94	58.98	51.13	1.75	0.6	29.75	**36.88**	58	79.752	16.97	11.11	-0.139	0.049	DILATIVE
3200	3030	25.60	18.12	62.60	52.80	1.70	0.6	30.26	**37.77**	56	78.566	16.97	11.11	-0.138	0.049	DILATIVE
3400	2360	23.65	17.98	66.20	54.43	1.22	0.5	26.73	**35.96**	42	63.785	16.97	11.11	-0.119	0.049	DILATIVE
3600	1110	14.05	17.24	69.65	55.92	0.37	0.3	16.77	**29.82**	19	34.892	16.97	11.11	-0.065	0.049	DILATIVE
3800	780	12.25	16.93	73.03	57.34	0.17	0.2	12.80	**27.65**	12	25.570	16.97	11.11	-0.037	0.049	DILATIVE
4000	800	10.65	16.76	76.38	58.73	0.17	0.2	13.11	**28.32**	12	25.552	16.97	11.11	-0.037	0.049	DILATIVE
4200	570	8.75	16.35	79.66	60.04	0.07	0.2	9.57	**26.40**	8	18.576	16.97	11.11	-0.008	0.049	DILATIVE
4400	580	9.32	16.40	82.94	61.36	0.07	0.2	9.74	**26.95**	8	18.444	16.97	11.11	-0.007	0.049	DILATIVE
4600	620	10.60	16.54	86.24	62.71	0.08	0.2	10.43	**27.86**	9	19.162	16.97	11.11	-0.011	0.049	DILATIVE
4800	630	11.10	16.57	89.56	64.06											
5000	630	10.50	16.48	92.85	65.39											
5200	640	8.10	16.18	96.09	66.67											
5400	620	9.68	16.33	99.35	67.97											
5600	910	11.05	16.61	102.68	69.33											
5800	1220	15.30	17.02	106.08	70.78											
6000	1760	51.37	18.39	109.76	72.49	0.54	0.3	24.46	**40.47**	23	40.775	15.45	10.96	-0.089	0.057	DILATIVE
6200	890	86.30	18.76	113.51	74.28	0.14	0.2	14.76	**34.60**	10	22.440	15.45	10.96	-0.034	0.057	DILATIVE
6400	8040	20.33	17.33	116.98	75.79	3.03	0.7	56.22	**62.74**	105	126.278	15.45	10.96	-0.192	0.057	DILATIVE
6600	8040	20.30	17.31	120.44	77.29	2.97	0.7	56.69	**63.55**	102	124.614	15.45	10.96	-0.190	0.057	DILATIVE
6800	1080	1.00	13.92	123.22	78.11	0.19	0.2	17.48	**37.69**	12	25.387	15.45	10.96	-0.045	0.057	DILATIVE
7000	3250	6.70	16.12	126.45	79.37	1.11	0.5	36.29	**50.65**	39	61.666	15.45	10.96	-0.126	0.057	DILATIVE
7200	2970	43.45	18.13	130.07	81.04	0.97	0.4	34.74	**50.17**	35	56.603	15.45	10.96	-0.118	0.057	DILATIVE
7400	1520	34.20	17.77	133.63	82.63	0.34	0.3	22.86	**42.78**	17	32.403	15.45	10.96	-0.068	0.057	DILATIVE
7600	1420	66.00	18.46	137.32	84.36	0.29	0.3	21.87	**42.70**	15	30.041	15.45	10.96	-0.061	0.057	DILATIVE
7800	910	17.55	16.88	140.69	85.77	0.10	0.2	15.27	**38.77**	9	19.843	15.45	10.96	-0.023	0.057	DILATIVE
8000	1410	8.15	16.15	143.92	87.04	0.27	0.3	21.92	**43.62**	15	29.022	15.45	10.96	-0.058	0.057	DILATIVE
8200	920	8.32	16.04	147.13	88.29	0.10	0.2	15.45	**39.73**	9	19.452	15.45	10.96	-0.021	0.057	DILATIVE
8400	780	8.65	16.00	150.33	89.53	0.06	0.1	13.22	**38.65**	7	16.290	15.45	10.96	-0.005	0.057	DILATIVE
8600	2960	65.30	18.44	154.02	91.25	0.82	0.4	36.05	**54.45**	31	51.531	15.45	10.96	-0.110	0.057	DILATIVE
8800	1900	62.32	18.34	157.69	92.96	0.41	0.3	27.43	**49.27**	19	35.359	15.45	10.96	-0.076	0.057	DILATIVE
9000	3030	77.70	18.60	161.41	94.72	0.81	0.4	36.99	**56.23**	30	51.011	15.45	10.96	-0.109	0.057	DILATIVE

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#2

SHEET : 2 OF 8

INTERPRETATION USING SLOPE OF CSL TESTING @ BH#2

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	γ (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	Q	Qp	k	m	Ψ	$\lambda_{BH\#2}$	Remarks
200	5640	29.20	20.18	4.04	4.04											
400	7750	191.90	21.71	8.38	8.38											
600	9740	184.95	21.35	12.65	12.65											
800	6280	185.90	21.21	16.89	16.89											
1000	8590	179.00	20.97	21.08	21.08											
1200	5500	82.00	20.05	25.10	25.10	6.38	1.2	29.49	**28.02**	218	195.363	26.42	11.64	-0.172	0.029	DILATIVE
1400	7900	117.33	20.29	29.15	29.15	7.28	1.3	36.70	**34.18**	270	230.257	26.42	11.64	-0.186	0.029	DILATIVE
1600	5320	138.40	20.42	33.24	33.24	4.77	1.0	32.86	**32.99**	159	160.257	26.42	11.64	-0.155	0.029	DILATIVE
1800	2670	54.05	19.33	37.10	37.10	2.26	0.7	24.89	**28.96**	71	90.921	26.42	11.64	-0.106	0.029	DILATIVE
2000	3130	70.32	19.55	41.01	41.01	2.37	0.7	27.98	**32.32**	75	95.562	26.42	11.64	-0.110	0.029	DILATIVE
2200	660	37.95	18.47	44.71	44.71	0.20	0.2	10.79	**22.09**	14	27.848	26.42	11.64	-0.005	0.029	DILATIVE
2400	1050	22.80	18.03	48.31	46.35	0.47	0.3	15.47	**25.76**	22	38.878	26.42	11.64	-0.033	0.029	DILATIVE
2600	1470	15.65	17.65	51.84	47.92	0.77	0.4	19.47	**28.95**	30	48.979	26.42	11.64	-0.053	0.029	DILATIVE
2800	2080	16.89	17.74	55.39	49.51	1.18	0.5	24.13	**32.59**	41	62.126	20.50	11.37	-0.098	0.038	DILATIVE
3000	3000	20.80	17.94	58.98	51.13	1.75	0.6	29.75	**36.88**	58	79.752	20.50	11.37	-0.120	0.038	DILATIVE
3200	3030	25.60	18.12	62.60	52.80	1.70	0.6	30.26	**37.77**	56	78.566	20.50	11.37	-0.118	0.038	DILATIVE
3400	2360	23.65	17.98	66.20	54.43	1.22	0.5	26.73	**35.96**	42	63.785	20.50	11.37	-0.100	0.038	DILATIVE
3600	1110	14.05	17.24	69.65	55.92	0.37	0.3	16.77	**29.82**	19	34.892	20.50	11.37	-0.047	0.038	DILATIVE
3800	780	12.25	16.93	73.03	57.34	0.17	0.2	12.80	**27.65**	12	25.570	20.50	11.37	-0.019	0.038	DILATIVE
4000	800	10.65	16.76	76.38	58.73	0.17	0.2	13.11	**28.32**	12	25.552	20.50	11.37	-0.019	0.038	DILATIVE
4200	570	8.75	16.35	79.66	60.04	0.07	0.2	9.57	**26.40**	8	18.576	20.50	11.37	0.009	0.038	CONTRACTIVE
4400	580	9.32	16.40	82.94	61.36	0.07	0.2	9.74	**26.95**	8	18.444	20.50	11.37	0.009	0.038	CONTRACTIVE
4600	620	10.60	16.54	86.24	62.71	0.08	0.2	10.43	**27.86**	9	19.162	20.50	11.37	0.006	0.038	CONTRACTIVE
4800	630	11.10	16.57	89.56	64.06											
5000	630	10.50	16.48	92.85	65.39											
5200	640	8.10	16.18	96.09	66.67											
5400	620	9.68	16.33	99.35	67.97											
5600	910	11.05	16.61	102.68	69.33											
5800	1220	15.30	17.02	106.08	70.78											
6000	1760	51.37	18.39	109.76	72.49	0.54	0.3	24.46	**40.47**	23	40.775	22.00	11.45	-0.054	0.035	DILATIVE
6200	890	86.30	18.76	113.51	74.28	0.14	0.2	14.76	**34.60**	10	22.440	22.00	11.45	-0.002	0.035	DILATIVE
6400	8040	20.33	17.33	116.98	75.79	3.03	0.7	56.22	**62.74**	105	126.278	22.00	11.45	-0.153	0.035	DILATIVE
6600	8040	20.30	17.31	120.44	77.29	2.97	0.7	56.69	**63.55**	102	124.614	22.00	11.45	-0.151	0.035	DILATIVE
6800	1080	1.00	13.92	123.22	78.11	0.19	0.2	17.48	**37.69**	12	25.387	22.00	11.45	-0.013	0.035	DILATIVE
7000	3250	6.70	16.12	126.45	79.37	1.11	0.5	36.29	**50.65**	39	61.666	22.00	11.45	-0.090	0.035	DILATIVE
7200	2970	43.45	18.13	130.07	81.04	0.97	0.4	34.74	**50.17**	35	56.603	22.00	11.45	-0.083	0.035	DILATIVE
7400	1520	34.20	17.77	133.63	82.63	0.34	0.3	22.86	**42.78**	17	32.403	22.00	11.45	-0.034	0.035	DILATIVE
7600	1420	66.00	18.46	137.32	84.36	0.29	0.3	21.87	**42.70**	15	30.041	22.00	11.45	-0.027	0.035	DILATIVE
7800	910	17.55	16.88	140.69	85.77	0.10	0.2	15.27	**38.77**	9	19.843	22.00	11.45	0.009	0.035	CONTRACTIVE
8000	1410	8.15	16.15	143.92	87.04	0.27	0.3	21.92	**43.62**	15	29.022	22.00	11.45	-0.024	0.035	DILATIVE
8200	920	8.32	16.04	147.13	88.29	0.10	0.2	15.45	**39.73**	9	19.452	22.00	11.45	0.011	0.035	CONTRACTIVE
8400	780	8.65	16.00	150.33	89.53	0.06	0.1	13.22	**38.65**	7	16.290	22.00	11.45	0.026	0.035	CONTRACTIVE
8600	2960	65.30	18.44	154.02	91.25	0.82	0.4	36.05	**54.45**	31	51.531	22.00	11.45	-0.074	0.035	DILATIVE
8800	1900	62.32	18.34	157.69	92.96	0.41	0.3	27.43	**49.27**	19	35.359	22.00	11.45	-0.041	0.035	DILATIVE
9000	3030	77.70	18.60	161.41	94.72	0.81	0.4	36.99	**56.23**	30	51.011	22.00	11.45	-0.073	0.035	DILATIVE

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#2

SHEET : 3 OF 8

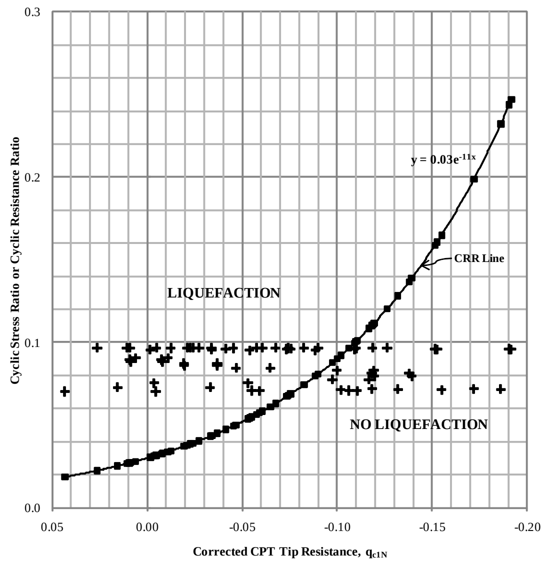
STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=5.0	q_{c1N}	Ψ		$CRR_{M=7.5}$		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0
			BH#1	BH#2	BH#1	BH#2	
200							
400							
600							
800							
1000							
1200	0.07	97.39	-0.12	-0.17	0.11	0.20	NO LIQUEFACTION
1400	0.07	124.93	-0.13	-0.19	0.13	0.23	NO LIQUEFACTION
1600	0.07	78.04	-0.10	-0.15	0.09	0.16	NO LIQUEFACTION
1800	0.07	42.82	-0.05	-0.11	0.05	0.10	NO LIQUEFACTION
2000	0.07	46.18	-0.06	-0.11	0.06	0.10	NO LIQUEFACTION
2200	0.07	11.82	0.04	0.00	0.02	0.03	LIQUEFACTION
2400	0.07	17.10	0.02	-0.03	0.03	0.04	LIQUEFACTION
2600	0.08	23.00	0.00	-0.05	0.03	0.05	LIQUEFACTION
2800	0.08	30.57	-0.12	-0.10	0.11	0.09	NO LIQUEFACTION
3000	0.08	41.44	-0.14	-0.12	0.14	0.11	NO LIQUEFACTION
3200	0.08	39.68	-0.14	-0.12	0.14	0.11	NO LIQUEFACTION
3400	0.08	30.11	-0.12	-0.10	0.11	0.09	NO LIQUEFACTION
3600	0.08	14.40	-0.06	-0.05	0.06	0.05	LIQUEFACTION
3800	0.09	10.00	-0.04	-0.02	0.05	0.04	LIQUEFACTION
4000	0.09	9.93	-0.04	-0.02	0.04	0.04	LIQUEFACTION
4200	0.09	6.99	-0.01	0.01	0.03	0.03	LIQUEFACTION
4400	0.09	6.84	-0.01	0.01	0.03	0.03	LIQUEFACTION
4600	0.09	7.03	-0.01	0.01	0.03	0.03	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.10	16.67	-0.09	-0.05	0.08	0.05	LIQUEFACTION
6200	0.10	8.23	-0.03	0.00	0.04	0.03	LIQUEFACTION
6400	0.10	71.94	-0.19	-0.15	0.25	0.16	NO LIQUEFACTION
6600	0.10	70.52	-0.19	-0.15	0.24	0.16	NO LIQUEFACTION
6800	0.10	8.47	-0.05	-0.01	0.05	0.03	LIQUEFACTION
7000	0.10	26.56	-0.13	-0.09	0.12	0.08	NO LIQUEFACTION
7200	0.10	25.81	-0.12	-0.08	0.11	0.07	NO LIQUEFACTION
7400	0.10	12.78	-0.07	-0.03	0.06	0.04	LIQUEFACTION
7600	0.10	11.99	-0.06	-0.03	0.06	0.04	LIQUEFACTION
7800	0.10	7.07	-0.02	0.01	0.04	0.03	LIQUEFACTION
8000	0.10	10.54	-0.06	-0.02	0.06	0.04	LIQUEFACTION
8200	0.10	6.69	-0.02	0.01	0.04	0.03	LIQUEFACTION
8400	0.10	5.53	0.00	0.03	0.03	0.02	LIQUEFACTION
8600	0.10	24.14	-0.11	-0.07	0.10	0.07	NO LIQUEFACTION
8800	0.10	15.11	-0.08	-0.04	0.07	0.05	LIQUEFACTION
9000	0.10	24.44	-0.11	-0.07	0.10	0.07	NO LIQUEFACTION

GRAPH

OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 5.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#2

SHEET : 4 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=5.5	q_{c1N}	Ψ		$CRR_{M=7.5}$		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.5
			BH#1	BH#2	BH#1	BH#2	
200							
400							
600							
800							
1000							
1200	0.08	97.39	-0.12	-0.17	0.11	0.20	NO LIQUEFACTION
1400	0.08	124.93	-0.13	-0.19	0.13	0.23	NO LIQUEFACTION
1600	0.08	78.04	-0.10	-0.15	0.09	0.16	NO LIQUEFACTION
1800	0.08	42.82	-0.05	-0.11	0.05	0.10	NO LIQUEFACTION
2000	0.08	46.18	-0.06	-0.11	0.06	0.10	NO LIQUEFACTION
2200	0.08	11.82	0.04	0.00	0.02	0.03	LIQUEFACTION
2400	0.08	17.10	0.02	-0.03	0.03	0.04	LIQUEFACTION
2600	0.08	23.00	0.00	-0.05	0.03	0.05	LIQUEFACTION
2800	0.08	30.57	-0.12	-0.10	0.11	0.09	NO LIQUEFACTION
3000	0.09	41.44	-0.14	-0.12	0.14	0.11	NO LIQUEFACTION
3200	0.09	39.68	-0.14	-0.12	0.14	0.11	NO LIQUEFACTION
3400	0.09	30.11	-0.12	-0.10	0.11	0.09	NO LIQUEFACTION
3600	0.09	14.40	-0.06	-0.05	0.06	0.05	LIQUEFACTION
3800	0.09	10.00	-0.04	-0.02	0.05	0.04	LIQUEFACTION
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4200	0.10	6.99	-0.01	0.01	0.03	0.03	LIQUEFACTION
4400	0.10	6.84	-0.01	0.01	0.03	0.03	LIQUEFACTION
4600	0.10	7.03	-0.01	0.01	0.03	0.03	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.10	16.67	-0.09	-0.05	0.08	0.05	LIQUEFACTION
6200	0.10	8.23	-0.03	0.00	0.04	0.03	LIQUEFACTION
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7400	0.11	12.78	-0.07	-0.03	0.06	0.04	LIQUEFACTION
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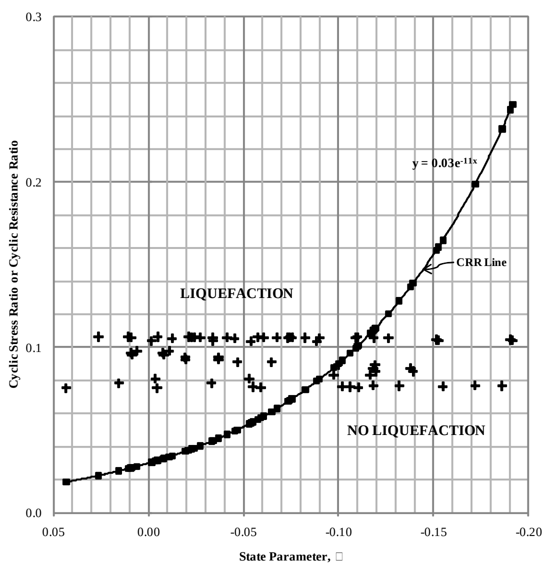
7800	0.11	7.07	-0.02	0.01	0.04	0.03	LIQUEFACTION
8000	0.11	10.54	-0.06	-0.02	0.06	0.04	LIQUEFACTION
8200	0.11	6.69	-0.02	0.01	0.04	0.03	LIQUEFACTION
8400	0.11	5.53	0.00	0.03	0.03	0.02	LIQUEFACTION
8600	0.11	24.14	-0.11	-0.07	0.10	0.07	LIQUEFACTION
8800	0.11	15.11	-0.08	-0.04	0.07	0.05	LIQUEFACTION
9000	0.11	24.44	-0.11	-0.07	0.10	0.07	LIQUEFACTION

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#2

SHEET : 5 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=6.0	q_{c1N}	Ψ BH#1	Ψ BH#2	$CRR_{M=7.5}$ BH#1	$CRR_{M=7.5}$ BH#2	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.0
200							
400							
600							
800							
1000							
1200	0.09	97.39	-0.12	-0.17	0.11	0.20	NO LIQUEFACTION
1400	0.09	124.93	-0.13	-0.19	0.13	0.23	NO LIQUEFACTION
1600	0.09	78.04	-0.10	-0.15	0.09	0.16	NO LIQUEFACTION
1800	0.09	42.82	-0.05	-0.11	0.05	0.10	NO LIQUEFACTION
2000	0.09	46.18	-0.06	-0.11	0.06	0.10	NO LIQUEFACTION
2200	0.09	11.82	0.04	0.00	0.02	0.03	LIQUEFACTION
2400	0.09	17.10	0.02	-0.03	0.03	0.04	LIQUEFACTION
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2800	0.10	30.57	-0.12	-0.10	0.11	0.09	NO LIQUEFACTION
3000	0.10	41.44	-0.14	-0.12	0.14	0.11	NO LIQUEFACTION
3200	0.10	39.68	-0.14	-0.12	0.14	0.11	NO LIQUEFACTION
3400	0.10	30.11	-0.12	-0.10	0.11	0.09	NO LIQUEFACTION
3600	0.10	14.40	-0.06	-0.05	0.06	0.05	LIQUEFACTION
3800	0.11	10.00	-0.04	-0.02	0.05	0.04	LIQUEFACTION
4000	0.11	9.93	-0.04	-0.02	0.04	0.04	LIQUEFACTION
4200	0.11	6.99	-0.01	0.01	0.03	0.03	LIQUEFACTION
4400	0.11	6.84	-0.01	0.01	0.03	0.03	LIQUEFACTION
4600	0.11	7.03	-0.01	0.01	0.03	0.03	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.12	16.67	-0.09	-0.05	0.08	0.05	LIQUEFACTION
6200	0.12	8.23	-0.03	0.00	0.04	0.03	LIQUEFACTION
6400	0.12	71.94	-0.19	-0.15	0.25	0.16	NO LIQUEFACTION
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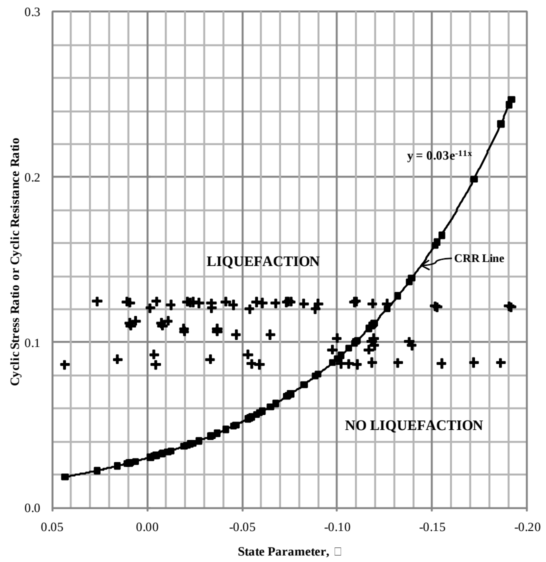
6800	0.12	8.47	-0.05	-0.01	0.05	0.03	LIQUEFACTION
7000	0.12	26.56	-0.13	-0.09	0.12	0.08	LIQUEFACTION
7200	0.12	25.81	-0.12	-0.08	0.11	0.07	LIQUEFACTION
7400	0.12	12.78	-0.07	-0.03	0.06	0.04	LIQUEFACTION
7600	0.12	11.99	-0.06	-0.03	0.06	0.04	LIQUEFACTION
7800	0.12	7.07	-0.02	0.01	0.04	0.03	LIQUEFACTION
8000	0.12	10.54	-0.06	-0.02	0.06	0.04	LIQUEFACTION
8200	0.12	6.69	-0.02	0.01	0.04	0.03	LIQUEFACTION
8400	0.12	5.53	0.00	0.03	0.03	0.02	LIQUEFACTION
8600	0.12	24.14	-0.11	-0.07	0.10	0.07	LIQUEFACTION
8800	0.12	15.11	-0.08	-0.04	0.07	0.05	LIQUEFACTION
9000	0.12	24.44	-0.11	-0.07	0.10	0.07	LIQUEFACTION

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 6.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#2

SHEET : 6 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=6.5**	**q_{c1N}**	**Ψ**		**$CRR_{M=7.5}$**		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.5
			BH#1	**BH#2**	**BH#1**	**BH#2**	
200							
400							
600							
800							
1000							
1200	0.10	97.39	-0.12	-0.17	0.11	0.20	**NO LIQUEFACTION**
1400	0.10	124.93	-0.13	-0.19	0.13	0.23	**NO LIQUEFACTION**
1600	0.10	78.04	-0.10	-0.15	0.09	0.16	**NO LIQUEFACTION**
1800	0.10	42.82	-0.05	-0.11	0.05	0.10	**LIQUEFACTION**
2000	0.10	46.18	-0.06	-0.11	0.06	0.10	**NO LIQUEFACTION**
2200	0.10	11.82	0.04	0.00	0.02	0.03	**LIQUEFACTION**
2400	0.10	17.10	0.02	-0.03	0.03	0.04	**LIQUEFACTION**
2600	0.11	23.00	0.00	-0.05	0.03	0.05	**LIQUEFACTION**
2800	0.11	30.57	-0.12	-0.10	0.11	0.09	**LIQUEFACTION**
3000	0.11	41.44	-0.14	-0.12	0.14	0.11	**NO LIQUEFACTION**
3200	0.12	39.68	-0.14	-0.12	0.14	0.11	**NO LIQUEFACTION**
3400	0.12	30.11	-0.12	-0.10	0.11	0.09	**LIQUEFACTION**
3600	0.12	14.40	-0.06	-0.05	0.06	0.05	**LIQUEFACTION**
3800	0.12	10.00	-0.04	-0.02	0.05	0.04	**LIQUEFACTION**
4000	0.12	9.93	-0.04	-0.02	0.04	0.04	**LIQUEFACTION**
4200	0.13	6.99	-0.01	0.01	0.03	0.03	**LIQUEFACTION**
4400	0.13	6.84	-0.01	0.01	0.03	0.03	**LIQUEFACTION**
4600	0.13	7.03	-0.01	0.01	0.03	0.03	**LIQUEFACTION**
4800							
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5200							
5400							
5600							
5800							
6000	0.14	16.67	-0.09	-0.05	0.08	0.05	**LIQUEFACTION**
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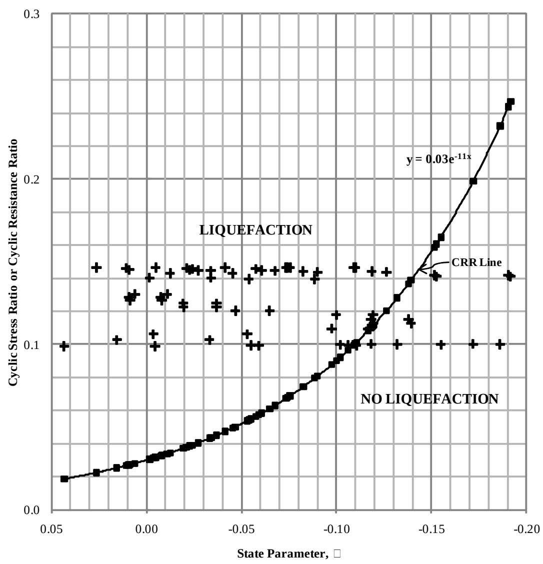
6800	0.14	8.47	-0.05	-0.01	0.05	0.03	**LIQUEFACTION**
7000	0.14	26.56	-0.13	-0.09	0.12	0.08	**LIQUEFACTION**
7200	0.14	25.81	-0.12	-0.08	0.11	0.07	**LIQUEFACTION**
7400	0.14	12.78	-0.07	-0.03	0.06	0.04	**LIQUEFACTION**
7600	0.14	11.99	-0.06	-0.03	0.06	0.04	**LIQUEFACTION**
7800	0.15	7.07	-0.02	0.01	0.04	0.03	**LIQUEFACTION**
8000	0.15	10.54	-0.06	-0.02	0.06	0.04	**LIQUEFACTION**
8200	0.15	6.69	-0.02	0.01	0.04	0.03	**LIQUEFACTION**
8400	0.15	5.53	0.00	0.03	0.03	0.02	**LIQUEFACTION**
8600	0.15	24.14	-0.11	-0.07	0.10	0.07	**LIQUEFACTION**
8800	0.15	15.11	-0.08	-0.04	0.07	0.05	**LIQUEFACTION**
9000	0.15	24.44	-0.11	-0.07	0.10	0.07	**LIQUEFACTION**

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#2

SHEET : 7 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=7.0	q_{c1N}	Ψ		$CRR_{M=7.5}$		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.0
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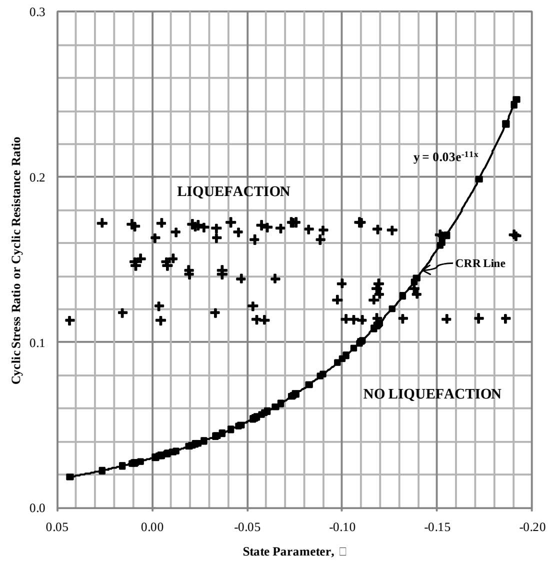
4200	0.15	6.99	-0.01	0.01	0.03	0.03	LIQUEFACTION
4400	0.15	6.84	-0.01	0.01	0.03	0.03	LIQUEFACTION
4600	0.15	7.03	-0.01	0.01	0.03	0.03	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.16	16.67	-0.09	-0.05	0.08	0.05	LIQUEFACTION
6200	0.16	8.23	-0.03	0.00	0.04	0.03	LIQUEFACTION
6400	0.16	71.94	-0.19	-0.15	0.25	0.16	NO LIQUEFACTION
6600	0.17	70.52	-0.19	-0.15	0.24	0.16	NO LIQUEFACTION
6800	0.17	8.47	-0.05	-0.01	0.05	0.03	LIQUEFACTION
7000	0.17	26.56	-0.13	-0.09	0.12	0.08	LIQUEFACTION
7200	0.17	25.81	-0.12	-0.08	0.11	0.07	LIQUEFACTION
7400	0.17	12.78	-0.07	-0.03	0.06	0.04	LIQUEFACTION
7600	0.17	11.99	-0.06	-0.03	0.06	0.04	LIQUEFACTION
7800	0.17	7.07	-0.02	0.01	0.04	0.03	LIQUEFACTION
8000	0.17	10.54	-0.06	-0.02	0.06	0.04	LIQUEFACTION
8200	0.17	6.69	-0.02	0.01	0.04	0.03	LIQUEFACTION
8400	0.17	5.53	0.00	0.03	0.03	0.02	LIQUEFACTION
8600	0.17	24.14	-0.11	-0.07	0.10	0.07	LIQUEFACTION
8800	0.17	15.11	-0.08	-0.04	0.07	0.05	LIQUEFACTION
9000	0.17	24.44	-0.11	-0.07	0.10	0.07	LIQUEFACTION

GRAPH
OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 7.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#2

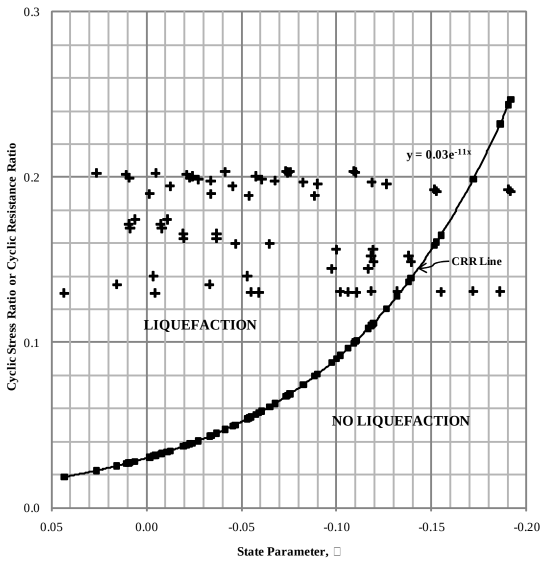
SHEET : 8 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=7.5**	**q_{c1N}**	**Ψ**		**$CRR_{M=7.5}$**		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.5
			BH#1	**BH#2**	**BH#1**	**BH#2**	
200							
400							
600							
800							
1000							
1200	0.13	97.39	-0.12	-0.17	0.11	0.20	NO LIQUEFACTION
1400	0.13	124.93	-0.13	-0.19	0.13	0.23	NO LIQUEFACTION
1600	0.13	78.04	-0.10	-0.15	0.09	0.16	NO LIQUEFACTION
1800	0.13	42.82	-0.05	-0.11	0.05	0.10	LIQUEFACTION
2000	0.13	46.18	-0.06	-0.11	0.06	0.10	LIQUEFACTION
2200	0.13	11.82	0.04	0.00	0.02	0.03	LIQUEFACTION
2400	0.14	17.10	0.02	-0.03	0.03	0.04	LIQUEFACTION
2600	0.14	23.00	0.00	-0.05	0.03	0.05	LIQUEFACTION
2800	0.14	30.57	-0.12	-0.10	0.11	0.09	LIQUEFACTION
3000	0.15	41.44	-0.14	-0.12	0.14	0.11	LIQUEFACTION
3200	0.15	39.68	-0.14	-0.12	0.14	0.11	LIQUEFACTION
3400	0.16	30.11	-0.12	-0.10	0.11	0.09	LIQUEFACTION
3600	0.16	14.40	-0.06	-0.05	0.06	0.05	LIQUEFACTION
3800	0.16	10.00	-0.04	-0.02	0.05	0.04	LIQUEFACTION
4000	0.17	9.93	-0.04	-0.02	0.04	0.04	LIQUEFACTION
4200	0.17	6.99	-0.01	0.01	0.03	0.03	LIQUEFACTION
4400	0.17	6.84	-0.01	0.01	0.03	0.03	LIQUEFACTION
4600	0.17	7.03	-0.01	0.01	0.03	0.03	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.19	16.67	-0.09	-0.05	0.08	0.05	LIQUEFACTION
6200	0.19	8.23	-0.03	0.00	0.04	0.03	LIQUEFACTION
6400	0.19	71.94	-0.19	-0.15	0.25	0.16	NO LIQUEFACTION
6600	0.19	70.52	-0.19	-0.15	0.24	0.16	NO LIQUEFACTION
6800	0.19	8.47	-0.05	-0.01	0.05	0.03	LIQUEFACTION
7000	0.20	26.56	-0.13	-0.09	0.12	0.08	LIQUEFACTION
7200	0.20	25.81	-0.12	-0.08	0.11	0.07	LIQUEFACTION
7400	0.20	12.78	-0.07	-0.03	0.06	0.04	LIQUEFACTION
7600	0.20	11.99	-0.06	-0.03	0.06	0.04	LIQUEFACTION
7800	0.20	7.07	-0.02	0.01	0.04	0.03	LIQUEFACTION
8000	0.20	10.54	-0.06	-0.02	0.06	0.04	LIQUEFACTION
8200	0.20	6.69	-0.02	0.01	0.04	0.03	LIQUEFACTION
8400	0.20	5.53	0.00	0.03	0.03	0.02	LIQUEFACTION
8600	0.20	24.14	-0.11	-0.07	0.10	0.07	LIQUEFACTION
8800	0.20	15.11	-0.08	-0.04	0.07	0.05	LIQUEFACTION
9000	0.20	24.44	-0.11	-0.07	0.10	0.07	LIQUEFACTION

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#3

SHEET : 1 OF 8

INTERPRETATION USING SLOPE OF CSL TESTING @ BH#1

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	γ (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	Q	Qp	k	m	Ψ	$\lambda_{BH\#1}$	Remarks
200	5920	67.70	21.09	4.22	4.22											
400	12040	251.25	21.92	8.60	8.60											
600	8650	209.00	21.50	12.90	12.90											
800	3560	139.60	20.93	17.09	17.09											
1000	2090	132.63	20.69	21.23	21.23											
1200	4630	133.05	20.59	25.35	25.35	5.52	1.1	27.50	**26.78**	182	171.943	46.89	12.06	-0.108	0.019	DILATIVE
1400	5930	220.42	21.01	29.55	29.55	5.81	1.1	32.73	**31.67**	200	186.312	46.89	12.06	-0.114	0.019	DILATIVE
1600	4080	167.30	20.64	33.68	33.68	3.77	0.9	29.34	**30.79**	120	131.425	46.89	12.06	-0.085	0.019	DILATIVE
1800	4320	77.85	19.73	37.62	37.62	3.53	0.8	31.52	**33.56**	114	127.621	46.89	12.06	-0.083	0.019	DILATIVE
2000	1090	69.40	19.38	41.50	41.50	0.60	0.4	15.47	**24.15**	25	43.423	46.89	12.06	0.006	0.019	CONTRACTIVE
2200	940	27.32	18.25	45.15	45.15	0.40	0.3	14.22	**24.53**	20	36.480	46.89	12.06	0.021	0.019	CONTRACTIVE
2400	970	19.10	17.82	48.71	46.75	0.40	0.3	14.65	**25.35**	20	36.341	46.89	12.06	0.021	0.019	CONTRACTIVE
2600	1960	16.95	17.79	52.27	48.34	1.13	0.5	23.14	**31.54**	39	60.479	46.89	12.06	-0.021	0.019	DILATIVE
2800	2370	23.20	18.09	55.89	50.00	1.37	0.5	26.03	**34.02**	46	68.018	16.97	11.11	-0.125	0.049	DILATIVE
3000	2690	23.05	18.05	59.50	51.65	1.52	0.5	28.17	**36.00**	51	73.070	16.97	11.11	-0.131	0.049	DILATIVE
3200	2625	29.85	18.28	63.15	53.34	1.43	0.5	28.14	**36.54**	48	70.109	16.97	11.11	-0.128	0.049	DILATIVE
3400	2640	30.37	18.26	66.80	55.04	1.38	0.5	28.54	**37.37**	47	68.857	16.97	11.11	-0.126	0.049	DILATIVE
3600	1800	32.10	18.24	70.45	56.72	0.80	0.4	23.15	**34.34**	30	50.369	16.97	11.11	-0.098	0.049	DILATIVE
3800	710	19.80	17.41	73.93	58.24	0.13	0.2	11.81	**27.29**	11	23.309	16.97	11.11	-0.029	0.049	DILATIVE
4000	660	10.68	16.68	77.27	59.62	0.10	0.2	11.07	**27.25**	10	21.385	16.97	11.11	-0.021	0.049	DILATIVE
4200	520	12.35	16.68	80.60	60.99	0.05	0.1	8.68	**26.12**	7	16.823	16.97	11.11	0.001	0.049	CONTRACTIVE
4400	310	14.95	16.49	83.90	62.33	0.01	0.1	4.29	**23.64**	4	9.565	16.97	11.11	0.052	0.049	CONTRACTIVE
4600	170	12.70	15.65	87.03	63.50	0.00003	0.0	0.98	**21.82**	1	3.803	16.97	11.11	0.135	0.049	CONTRACTIVE
4800	190	17.35	16.10	90.25	64.75											
5000	150	11.00	15.27	93.31	65.85											
5200	220	10.05	15.62	96.43	67.01											
5400	100	14.16	14.82	99.39	68.01											
5600	330	14.45	16.34	102.66	69.32											
5800	940	29.10	17.64	106.19	70.88											
6000	620	96.60	18.75	109.94	72.67	0.05	0.1	10.43	**31.17**	7	16.361	15.45	10.96	-0.005	0.057	DILATIVE
6200	10250	39.28	18.03	113.54	74.32	3.81	0.8	62.24	**66.27**	136	152.961	15.45	10.96	-0.209	0.057	DILATIVE
6400	10250	39.28	18.00	117.15	75.96	3.73	0.8	62.84	**67.21**	133	150.764	15.45	10.96	-0.208	0.057	DILATIVE
6600	14620	55.40	18.28	120.80	77.65	4.86	1.0	74.10	**75.28**	187	192.600	15.45	10.96	-0.230	0.057	DILATIVE
6800	15800	199.90	19.64	124.73	79.62	5.05	1.0	77.46	**78.18**	197	200.504	15.45	10.96	-0.234	0.057	DILATIVE
7000	13180	220.85	19.76	128.68	81.61	4.29	0.9	72.45	**75.50**	160	172.856	15.45	10.96	-0.220	0.057	DILATIVE
7200	12370	168.21	19.46	132.58	83.54	3.99	0.9	71.20	**75.31**	146	162.488	15.45	10.96	-0.215	0.057	DILATIVE
7400	11530	145.65	19.30	136.44	85.44	3.69	0.8	69.70	**74.94**	133	152.026	15.45	10.96	-0.209	0.057	DILATIVE
7600	11300	94.10	18.81	140.20	87.24	3.55	0.8	69.66	**75.52**	128	147.766	15.45	10.96	-0.206	0.057	DILATIVE
7800	8470	126.79	19.17	144.03	89.11	2.70	0.7	61.64	**70.80**	93	117.604	15.45	10.96	-0.185	0.057	DILATIVE
8000	4850	92.15	18.86	147.80	90.92	1.50	0.5	47.21	**61.78**	52	76.114	15.45	10.96	-0.145	0.057	DILATIVE
8200	4520	29.05	17.60	151.32	92.48	1.36	0.5	45.81	**61.36**	47	71.193	15.45	10.96	-0.139	0.057	DILATIVE
8400	2970	33.42	17.73	154.87	94.07	0.79	0.4	36.48	**55.68**	30	50.560	15.45	10.96	-0.108	0.057	DILATIVE
8600	4180	27.30	17.50	158.37	95.61	1.20	0.5	44.46	**61.51**	42	65.386	15.45	10.96	-0.132	0.057	DILATIVE
8800	6430	109.79	18.96	162.16	97.44	1.88	0.6	55.94	**69.78**	64	89.829	15.45	10.96	-0.161	0.057	DILATIVE
9000	1250	78.58	18.50	165.86	99.17	0.16	0.2	20.40	**46.66**	11	23.235	15.45	10.96	-0.037	0.057	DILATIVE

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#3

SHEET : 2 OF 8

INTERPRETATION USING SLOPE OF CSL TESTING @ BH#2

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	γ (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	OCR	K_o	σ'_h (kN/m^2)	σ'_{mean} (kN/m^2)	Q	Qp	k	m	Ψ	$\lambda_{BH\#2}$	Remarks
200	5920	67.70	21.09	4.22	4.22											
400	12040	251.25	21.92	8.60	8.60											
600	8650	209.00	21.50	12.90	12.90											
800	3560	139.60	20.93	17.09	17.09											
1000	2090	132.63	20.69	21.23	21.23											
1200	4630	133.05	20.59	25.35	25.35	5.52	1.1	27.50	**26.78**	182	171.943	26.42	11.64	-0.161	0.029	DILATIVE
1400	5930	220.42	21.01	29.55	29.55	5.81	1.1	32.73	**31.67**	200	186.312	26.42	11.64	-0.168	0.029	DILATIVE
1600	4080	167.30	20.64	33.68	33.68	3.77	0.9	29.34	**30.79**	120	131.425	26.42	11.64	-0.138	0.029	DILATIVE
1800	4320	77.85	19.73	37.62	37.62	3.53	0.8	31.52	**33.56**	114	127.621	26.42	11.64	-0.135	0.029	DILATIVE
2000	1090	69.40	19.38	41.50	41.50	0.60	0.4	15.47	**24.15**	25	43.423	26.42	11.64	-0.043	0.029	DILATIVE
2200	940	27.32	18.25	45.15	45.15	0.40	0.3	14.22	**24.53**	20	36.480	26.42	11.64	-0.028	0.029	DILATIVE
2400	970	19.10	17.82	48.71	46.75	0.40	0.3	14.65	**25.35**	20	36.341	26.42	11.64	-0.027	0.029	DILATIVE
2600	1960	16.95	17.79	52.27	48.34	1.13	0.5	23.14	**31.54**	39	60.479	26.42	11.64	-0.071	0.029	DILATIVE
2800	2370	23.20	18.09	55.89	50.00	1.37	0.5	26.03	**34.02**	46	68.018	20.50	11.37	-0.106	0.038	DILATIVE
3000	2690	23.05	18.05	59.50	51.65	1.52	0.5	28.17	**36.00**	51	73.070	20.50	11.37	-0.112	0.038	DILATIVE
3200	2625	29.85	18.28	63.15	53.34	1.43	0.5	28.14	**36.54**	48	70.109	20.50	11.37	-0.108	0.038	DILATIVE
3400	2640	30.37	18.26	66.80	55.04	1.38	0.5	28.54	**37.37**	47	68.857	20.50	11.37	-0.107	0.038	DILATIVE
3600	1800	32.10	18.24	70.45	56.72	0.80	0.4	23.15	**34.34**	30	50.369	20.50	11.37	-0.079	0.038	DILATIVE
3800	710	19.80	17.41	73.93	58.24	0.13	0.2	11.81	**27.29**	11	23.309	20.50	11.37	-0.011	0.038	DILATIVE
4000	660	10.68	16.68	77.27	59.62	0.10	0.2	11.07	**27.25**	10	21.385	20.50	11.37	-0.004	0.038	DILATIVE
4200	520	12.35	16.68	80.60	60.99	0.05	0.1	8.68	**26.12**	7	16.823	20.50	11.37	0.017	0.038	CONTRACTIVE
4400	310	14.95	16.49	83.90	62.33	0.01	0.1	4.29	**23.64**	4	9.565	20.50	11.37	0.067	0.038	CONTRACTIVE
4600	170	12.70	15.65	87.03	63.50	0.00003	0.0	0.98	**21.82**	1	3.803	20.50	11.37	0.148	0.038	CONTRACTIVE
4800	190	17.35	16.10	90.25	64.75											
5000	150	11.00	15.27	93.31	65.85											
5200	220	10.05	15.62	96.43	67.01											
5400	100	14.16	14.82	99.39	68.01											
5600	330	14.45	16.34	102.66	69.32											
5800	940	29.10	17.64	106.19	70.88											
6000	620	96.60	18.75	109.94	72.67	0.05	0.1	10.43	**31.17**	7	16.361	22.00	11.45	0.026	0.035	CONTRACTIVE
6200	10250	39.28	18.03	113.54	74.32	3.81	0.8	62.24	**66.27**	136	152.961	22.00	11.45	-0.169	0.035	DILATIVE
6400	10250	39.28	18.00	117.15	75.96	3.73	0.8	62.84	**67.21**	133	150.764	22.00	11.45	-0.168	0.035	DILATIVE
6600	14620	55.40	18.28	120.80	77.65	4.86	1.0	74.10	**75.28**	187	192.600	22.00	11.45	-0.190	0.035	DILATIVE
6800	15800	199.90	19.64	124.73	79.62	5.05	1.0	77.46	**78.18**	197	200.504	22.00	11.45	-0.193	0.035	DILATIVE
7000	13180	220.85	19.76	128.68	81.61	4.29	0.9	72.45	**75.50**	160	172.856	22.00	11.45	-0.180	0.035	DILATIVE
7200	12370	168.21	19.46	132.58	83.54	3.99	0.9	71.20	**75.31**	146	162.488	22.00	11.45	-0.175	0.035	DILATIVE
7400	11530	145.65	19.30	136.44	85.44	3.69	0.8	69.70	**74.94**	133	152.026	22.00	11.45	-0.169	0.035	DILATIVE
7600	11300	94.10	18.81	140.20	87.24	3.55	0.8	69.66	**75.52**	128	147.766	22.00	11.45	-0.166	0.035	DILATIVE
7800	8470	126.79	19.17	144.03	89.11	2.70	0.7	61.64	**70.80**	93	117.604	22.00	11.45	-0.146	0.035	DILATIVE
8000	4850	92.15	18.86	147.80	90.92	1.50	0.5	47.21	**61.78**	52	76.114	22.00	11.45	-0.108	0.035	DILATIVE
8200	4520	29.05	17.60	151.32	92.48	1.36	0.5	45.81	**61.36**	47	71.193	22.00	11.45	-0.103	0.035	DILATIVE
8400	2970	33.42	17.73	154.87	94.07	0.79	0.4	36.48	**55.68**	30	50.560	22.00	11.45	-0.073	0.035	DILATIVE
8600	4180	27.30	17.50	158.37	95.61	1.20	0.5	44.46	**61.51**	42	65.386	22.00	11.45	-0.095	0.035	DILATIVE
8800	6430	109.79	18.96	162.16	97.44	1.88	0.6	55.94	**69.78**	64	89.829	22.00	11.45	-0.123	0.035	DILATIVE
9000	1250	78.58	18.50	165.86	99.17	0.16	0.2	20.40	**46.66**	11	23.235	22.00	11.45	-0.005	0.035	DILATIVE

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#3

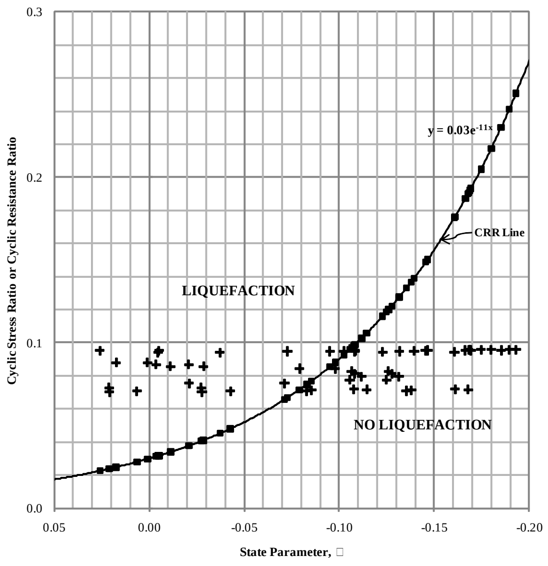
SHEET : 3 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=5.0	q_{c1N}	Ψ BH#1	Ψ BH#2	$CRR_{M=7.5}$ BH#1	$CRR_{M=7.5}$ BH#2	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0
200							
400							
600							
800							
1000							
1200	0.07	75.40	-0.11	-0.16	0.10	0.18	NO LIQUEFACTION
1400	0.07	85.37	-0.11	-0.17	0.11	0.19	NO LIQUEFACTION
1600	0.07	58.57	-0.09	-0.14	0.08	0.14	NO LIQUEFACTION
1800	0.07	64.99	-0.08	-0.14	0.07	0.13	NO LIQUEFACTION
2000	0.07	17.56	0.01	-0.04	0.03	0.05	LIQUEFACTION
2200	0.07	16.00	0.02	-0.03	0.02	0.04	LIQUEFACTION
2400	0.07	16.10	0.02	-0.03	0.02	0.04	LIQUEFACTION
2600	0.08	29.95	-0.02	-0.07	0.04	0.07	LIQUEFACTION
2800	0.08	33.55	-0.12	-0.11	0.12	0.10	NO LIQUEFACTION
3000	0.08	36.63	-0.13	-0.11	0.13	0.10	NO LIQUEFACTION
3200	0.08	33.85	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3400	0.08	32.94	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3600	0.08	21.88	-0.10	-0.08	0.09	0.07	NO LIQUEFACTION
3800	0.09	8.93	-0.03	-0.01	0.04	0.03	LIQUEFACTION
4000	0.09	8.20	-0.02	0.00	0.04	0.03	LIQUEFACTION
4200	0.09	6.30	0.00	0.02	0.03	0.02	LIQUEFACTION
4400	0.09	3.79	0.05	0.07	0.02	0.01	LIQUEFACTION
4600	0.09	2.18	0.13	0.15	0.01	0.01	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.10	5.79	-0.01	0.03	0.03	0.02	LIQUEFACTION
6200	0.10	94.85	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
6400	0.10	93.19	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
6600	0.10	131.44	-0.23	-0.19	0.38	0.24	NO LIQUEFACTION
6800	0.10	145.43	-0.23	-0.19	0.39	0.25	NO LIQUEFACTION
7000	0.10	120.59	-0.22	-0.18	0.34	0.22	NO LIQUEFACTION
7200	0.10	111.21	-0.21	-0.17	0.32	0.20	NO LIQUEFACTION
7400	0.10	102.16	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
7600	0.10	97.24	-0.21	-0.17	0.29	0.19	NO LIQUEFACTION
7800	0.10	73.38	-0.19	-0.15	0.23	0.15	NO LIQUEFACTION
8000	0.10	41.10	-0.15	-0.11	0.15	0.10	NO LIQUEFACTION
8200	0.09	35.46	-0.14	-0.10	0.14	0.09	NO LIQUEFACTION
8400	0.09	23.25	-0.11	-0.07	0.10	0.07	NO LIQUEFACTION
8600	0.09	31.83	-0.13	-0.10	0.13	0.09	NO LIQUEFACTION
8800	0.09	52.99	-0.16	-0.12	0.18	0.12	NO LIQUEFACTION
9000	0.09	9.58	-0.04	0.00	0.05	0.03	LIQUEFACTION

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 5.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#3

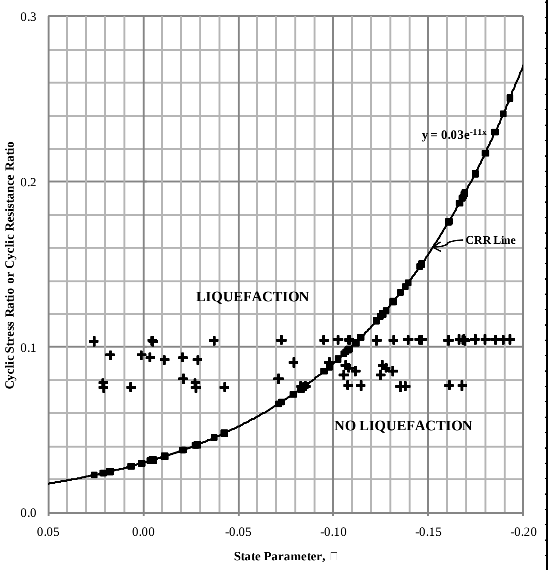
SHEET : 4 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=5.5**	**q_{c1N}**	**Ψ**		**$CRR_{M=7.5}$**		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.5
			BH#1	**BH#2**	**BH#1**	**BH#2**	
200							
400							
600							
800							
1000							
1200	0.08	75.40	-0.11	-0.16	0.10	0.18	**NO LIQUEFACTION**
1400	0.08	85.37	-0.11	-0.17	0.11	0.19	**NO LIQUEFACTION**
1600	0.08	58.57	-0.09	-0.14	0.08	0.14	**NO LIQUEFACTION**
1800	0.08	64.99	-0.08	-0.14	0.07	0.13	**NO LIQUEFACTION**
2000	0.08	17.56	0.01	-0.04	0.03	0.05	**LIQUEFACTION**
2200	0.08	16.00	0.02	-0.03	0.02	0.04	**LIQUEFACTION**
2400	0.08	16.10	0.02	-0.03	0.02	0.04	**LIQUEFACTION**
2600	0.08	29.95	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2800	0.08	33.55	-0.12	-0.11	0.12	0.10	**NO LIQUEFACTION**
3000	0.09	36.63	-0.13	-0.11	0.13	0.10	**NO LIQUEFACTION**
3200	0.09	33.85	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3400	0.09	32.94	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3600	0.09	21.88	-0.10	-0.08	0.09	0.07	**LIQUEFACTION**
3800	0.09	8.93	-0.03	-0.01	0.04	0.03	**LIQUEFACTION**
4000	0.09	8.20	-0.02	0.00	0.04	0.03	**LIQUEFACTION**
4200	0.10	6.30	0.00	0.02	0.03	0.02	**LIQUEFACTION**
4400	0.10	3.79	0.05	0.07	0.02	0.01	**LIQUEFACTION**
4600	0.10	2.18	0.13	0.15	0.01	0.01	**LIQUEFACTION**
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.10	5.79	-0.01	0.03	0.03	0.02	**LIQUEFACTION**
6200	0.10	94.85	-0.21	-0.17	0.30	0.19	**NO LIQUEFACTION**
6400	0.10	93.19	-0.21	-0.17	0.30	0.19	**NO LIQUEFACTION**
6600	0.10	131.44	-0.23	-0.19	0.38	0.24	**NO LIQUEFACTION**
6800	0.10	145.43	-0.23	-0.19	0.39	0.25	**NO LIQUEFACTION**
7000	0.10	120.59	-0.22	-0.18	0.34	0.22	**NO LIQUEFACTION**
7200	0.10	111.21	-0.21	-0.17	0.32	0.20	**NO LIQUEFACTION**
7400	0.10	102.16	-0.21	-0.17	0.30	0.19	**NO LIQUEFACTION**
7600	0.10	97.24	-0.21	-0.17	0.29	0.19	**NO LIQUEFACTION**
7800	0.10	73.38	-0.19	-0.15	0.23	0.15	**NO LIQUEFACTION**
8000	0.10	41.10	-0.15	-0.11	0.15	0.10	**NO LIQUEFACTION**
8200	0.10	35.46	-0.14	-0.10	0.14	0.09	**NO LIQUEFACTION**
8400	0.10	23.25	-0.11	-0.07	0.10	0.07	**LIQUEFACTION**
8600	0.10	31.83	-0.13	-0.10	0.13	0.09	**NO LIQUEFACTION**
8800	0.10	52.99	-0.16	-0.12	0.18	0.12	**NO LIQUEFACTION**
9000	0.10	9.58	-0.04	0.00	0.05	0.03	**LIQUEFACTION**

GRAPH
OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#3

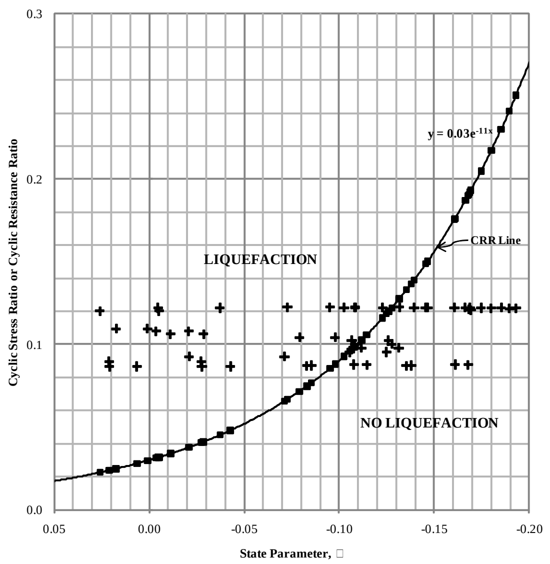
SHEET : 5 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=6.0	q_{c1N}	Ψ BH#1	Ψ BH#2	$CRR_{M=7.5}$ BH#1	$CRR_{M=7.5}$ BH#2	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.0
200							
400							
600							
800							
1000							
1200	0.09	75.40	-0.11	-0.16	0.10	0.18	NO LIQUEFACTION
1400	0.09	85.37	-0.11	-0.17	0.11	0.19	NO LIQUEFACTION
1600	0.09	58.57	-0.09	-0.14	0.08	0.14	NO LIQUEFACTION
1800	0.09	64.99	-0.08	-0.14	0.07	0.13	NO LIQUEFACTION
2000	0.09	17.56	0.01	-0.04	0.03	0.05	LIQUEFACTION
2200	0.09	16.00	0.02	-0.03	0.02	0.04	LIQUEFACTION
2400	0.09	16.10	0.02	-0.03	0.02	0.04	LIQUEFACTION
2600	0.09	29.95	-0.02	-0.07	0.04	0.07	LIQUEFACTION
2800	0.10	33.55	-0.12	-0.11	0.12	0.10	NO LIQUEFACTION
3000	0.10	36.63	-0.13	-0.11	0.13	0.10	NO LIQUEFACTION
3200	0.10	33.85	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3400	0.10	32.94	-0.13	-0.11	0.12	0.10	NO LIQUEFACTION
3600	0.10	21.88	-0.10	-0.08	0.09	0.07	LIQUEFACTION
3800	0.11	8.93	-0.03	-0.01	0.04	0.03	LIQUEFACTION
4000	0.11	8.20	-0.02	0.00	0.04	0.03	LIQUEFACTION
4200	0.11	6.30	0.00	0.02	0.03	0.02	LIQUEFACTION
4400	0.11	3.79	0.05	0.07	0.02	0.01	LIQUEFACTION
4600	0.11	2.18	0.13	0.15	0.01	0.01	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.12	5.79	-0.01	0.03	0.03	0.02	LIQUEFACTION
6200	0.12	94.85	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
6400	0.12	93.19	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
6600	0.12	131.44	-0.23	-0.19	0.38	0.24	NO LIQUEFACTION
6800	0.12	145.43	-0.23	-0.19	0.39	0.25	NO LIQUEFACTION
7000	0.12	120.59	-0.22	-0.18	0.34	0.22	NO LIQUEFACTION
7200	0.12	111.21	-0.21	-0.17	0.32	0.20	NO LIQUEFACTION
7400	0.12	102.16	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
7600	0.12	97.24	-0.21	-0.17	0.29	0.19	NO LIQUEFACTION
7800	0.12	73.38	-0.19	-0.15	0.23	0.15	NO LIQUEFACTION
8000	0.12	41.10	-0.15	-0.11	0.15	0.10	NO LIQUEFACTION
8200	0.12	35.46	-0.14	-0.10	0.14	0.09	NO LIQUEFACTION
8400	0.12	23.25	-0.11	-0.07	0.10	0.07	LIQUEFACTION
8600	0.12	31.83	-0.13	-0.10	0.13	0.09	NO LIQUEFACTION
8800	0.12	52.99	-0.16	-0.12	0.18	0.12	NO LIQUEFACTION
9000	0.12	9.58	-0.04	0.00	0.05	0.03	LIQUEFACTION

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 6.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#3

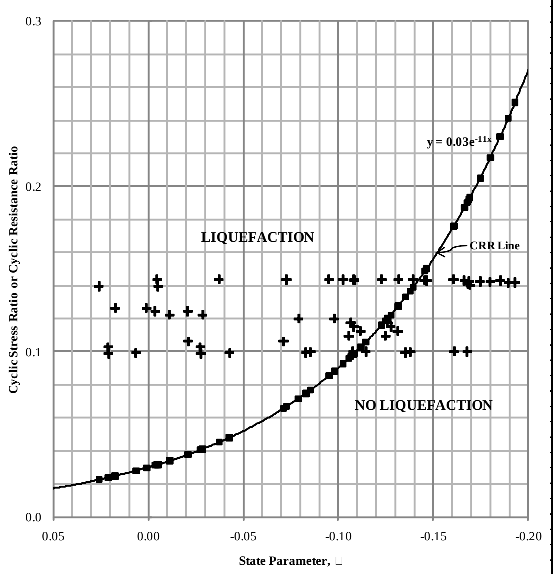
SHEET : 6 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=6.5**	**q_{c1N}**	**Ψ**		**$CRR_{M=7.5}$**		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.5
			BH#1	**BH#2**	**BH#1**	**BH#2**	
200							
400							
600							
800							
1000							
1200	0.10	75.40	-0.11	-0.16	0.10	0.18	**NO LIQUEFACTION**
1400	0.10	85.37	-0.11	-0.17	0.11	0.19	**NO LIQUEFACTION**
1600	0.10	58.57	-0.09	-0.14	0.08	0.14	**NO LIQUEFACTION**
1800	0.10	64.99	-0.08	-0.14	0.07	0.13	**NO LIQUEFACTION**
2000	0.10	17.56	0.01	-0.04	0.03	0.05	**LIQUEFACTION**
2200	0.10	16.00	0.02	-0.03	0.02	0.04	**LIQUEFACTION**
2400	0.10	16.10	0.02	-0.03	0.02	0.04	**LIQUEFACTION**
2600	0.11	29.95	-0.02	-0.07	0.04	0.07	**LIQUEFACTION**
2800	0.11	33.55	-0.12	-0.11	0.12	0.10	**NO LIQUEFACTION**
3000	0.11	36.63	-0.13	-0.11	0.13	0.10	**NO LIQUEFACTION**
3200	0.12	33.85	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3400	0.12	32.94	-0.13	-0.11	0.12	0.10	**NO LIQUEFACTION**
3600	0.12	21.88	-0.10	-0.08	0.09	0.07	**LIQUEFACTION**
3800	0.12	8.93	-0.03	-0.01	0.04	0.03	**LIQUEFACTION**
4000	0.12	8.20	-0.02	0.00	0.04	0.03	**LIQUEFACTION**
4200	0.13	6.30	0.00	0.02	0.03	0.02	**LIQUEFACTION**
4400	0.13	3.79	0.05	0.07	0.02	0.01	**LIQUEFACTION**
4600	0.13	2.18	0.13	0.15	0.01	0.01	**LIQUEFACTION**
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.14	5.79	-0.01	0.03	0.03	0.02	**LIQUEFACTION**
6200	0.14	94.85	-0.21	-0.17	0.30	0.19	**NO LIQUEFACTION**
6400	0.14	93.19	-0.21	-0.17	0.30	0.19	**NO LIQUEFACTION**
6600	0.14	131.44	-0.23	-0.19	0.38	0.24	**NO LIQUEFACTION**
6800	0.14	145.43	-0.23	-0.19	0.39	0.25	**NO LIQUEFACTION**
7000	0.14	120.59	-0.22	-0.18	0.34	0.22	**NO LIQUEFACTION**
7200	0.14	111.21	-0.21	-0.17	0.32	0.20	**NO LIQUEFACTION**
7400	0.14	102.16	-0.21	-0.17	0.30	0.19	**NO LIQUEFACTION**
7600	0.14	97.24	-0.21	-0.17	0.29	0.19	**NO LIQUEFACTION**
7800	0.14	73.38	-0.19	-0.15	0.23	0.15	**NO LIQUEFACTION**
8000	0.14	41.10	-0.15	-0.11	0.15	0.10	**NO LIQUEFACTION**
8200	0.14	35.46	-0.14	-0.10	0.14	0.09	**LIQUEFACTION**
8400	0.14	23.25	-0.11	-0.07	0.10	0.07	**LIQUEFACTION**
8600	0.14	31.83	-0.13	-0.10	0.13	0.09	**LIQUEFACTION**
8800	0.14	52.99	-0.16	-0.12	0.18	0.12	**NO LIQUEFACTION**
9000	0.14	9.58	-0.04	0.00	0.05	0.03	**LIQUEFACTION**

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#3

SHEET : 7 OF 8

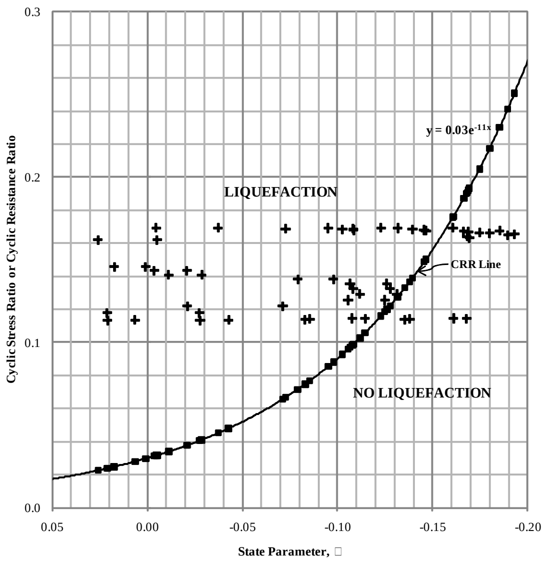
STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=7.0	q_{c1N}	Ψ BH#1	Ψ BH#2	$CRR_{M=7.5}$ BH#1	$CRR_{M=7.5}$ BH#2	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.0
200							
400							
600							
800							
1000							
1200	0.11	75.40	-0.11	-0.16	0.10	0.18	NO LIQUEFACTION
1400	0.11	85.37	-0.11	-0.17	0.11	0.19	NO LIQUEFACTION
1600	0.11	58.57	-0.09	-0.14	0.08	0.14	NO LIQUEFACTION
1800	0.11	64.99	-0.08	-0.14	0.07	0.13	NO LIQUEFACTION
2000	0.11	17.56	0.01	-0.04	0.03	0.05	LIQUEFACTION
2200	0.11	16.00	0.02	-0.03	0.02	0.04	LIQUEFACTION
2400	0.12	16.10	0.02	-0.03	0.02	0.04	LIQUEFACTION
2600	0.12	29.95	-0.02	-0.07	0.04	0.07	LIQUEFACTION
2800	0.13	33.55	-0.12	-0.11	0.12	0.10	LIQUEFACTION
3000	0.13	36.63	-0.13	-0.11	0.13	0.10	LIQUEFACTION
3200	0.13	33.85	-0.13	-0.11	0.12	0.10	LIQUEFACTION
3400	0.14	32.94	-0.13	-0.11	0.12	0.10	LIQUEFACTION
3600	0.14	21.88	-0.10	-0.08	0.09	0.07	LIQUEFACTION
3800	0.14	8.93	-0.03	-0.01	0.04	0.03	LIQUEFACTION
4000	0.14	8.20	-0.02	0.00	0.04	0.03	LIQUEFACTION
4200	0.15	6.30	0.00	0.02	0.03	0.02	LIQUEFACTION
4400	0.15	3.79	0.05	0.07	0.02	0.01	LIQUEFACTION
4600	0.15	2.18	0.13	0.15	0.01	0.01	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.16	5.79	-0.01	0.03	0.03	0.02	LIQUEFACTION
6200	0.16	94.85	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
6400	0.16	93.19	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
6600	0.16	131.44	-0.23	-0.19	0.38	0.24	NO LIQUEFACTION
6800	0.17	145.43	-0.23	-0.19	0.39	0.25	NO LIQUEFACTION
7000	0.17	120.59	-0.22	-0.18	0.34	0.22	NO LIQUEFACTION
7200	0.17	111.21	-0.21	-0.17	0.32	0.20	NO LIQUEFACTION
7400	0.17	102.16	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
7600	0.17	97.24	-0.21	-0.17	0.29	0.19	NO LIQUEFACTION
7800	0.17	73.38	-0.19	-0.15	0.23	0.15	NO LIQUEFACTION
8000	0.17	41.10	-0.15	-0.11	0.15	0.10	LIQUEFACTION
8200	0.17	35.46	-0.14	-0.10	0.14	0.09	LIQUEFACTION
8400	0.17	23.25	-0.11	-0.07	0.10	0.07	LIQUEFACTION
8600	0.17	31.83	-0.13	-0.10	0.13	0.09	LIQUEFACTION
8800	0.17	52.99	-0.16	-0.12	0.18	0.12	NO LIQUEFACTION
9000	0.17	9.58	-0.04	0.00	0.05	0.03	LIQUEFACTION

GRAPH

OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 7.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

STATE PARAMETER ESTIMATION USING JEFFERIES & BEEN (2006)

CPT#3

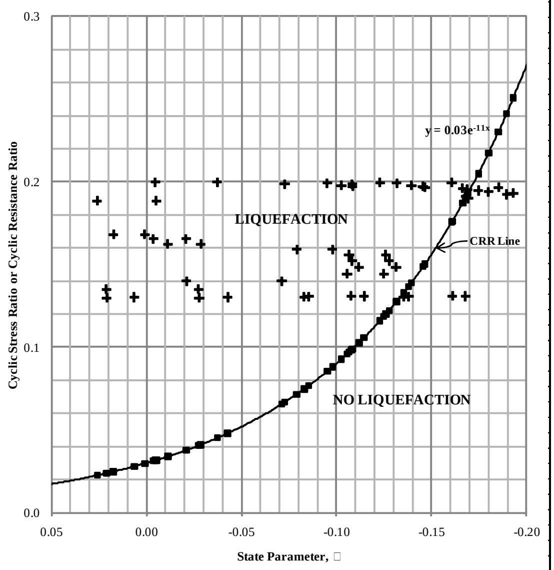
SHEET : 8 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=7.5**	**q_{c1N}**	**Ψ**		**$CRR_{M=7.5}$**		DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.5
			BH#1	**BH#2**	**BH#1**	**BH#2**	
200							
400							
600							
800							
1000							
1200	0.13	75.40	-0.11	-0.16	0.10	0.18	NO LIQUEFACTION
1400	0.13	85.37	-0.11	-0.17	0.11	0.19	NO LIQUEFACTION
1600	0.13	58.57	-0.09	-0.14	0.08	0.14	NO LIQUEFACTION
1800	0.13	64.99	-0.08	-0.14	0.07	0.13	NO LIQUEFACTION
2000	0.13	17.56	0.01	-0.04	0.03	0.05	LIQUEFACTION
2200	0.13	16.00	0.02	-0.03	0.02	0.04	LIQUEFACTION
2400	0.14	16.10	0.02	-0.03	0.02	0.04	LIQUEFACTION
2600	0.14	29.95	-0.02	-0.07	0.04	0.07	LIQUEFACTION
2800	0.14	33.55	-0.12	-0.11	0.12	0.10	LIQUEFACTION
3000	0.15	36.63	-0.13	-0.11	0.13	0.10	LIQUEFACTION
3200	0.15	33.85	-0.13	-0.11	0.12	0.10	LIQUEFACTION
3400	0.16	32.94	-0.13	-0.11	0.12	0.10	LIQUEFACTION
3600	0.16	21.88	-0.10	-0.08	0.09	0.07	LIQUEFACTION
3800	0.16	8.93	-0.03	-0.01	0.04	0.03	LIQUEFACTION
4000	0.17	8.20	-0.02	0.00	0.04	0.03	LIQUEFACTION
4200	0.17	6.30	0.00	0.02	0.03	0.02	LIQUEFACTION
4400	0.17	3.79	0.05	0.07	0.02	0.01	LIQUEFACTION
4600	0.17	2.18	0.13	0.15	0.01	0.01	LIQUEFACTION
4800							
5000							
5200							
5400							
5600							
5800							
6000	0.19	5.79	-0.01	0.03	0.03	0.02	LIQUEFACTION
6200	0.19	94.85	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
6400	0.19	93.19	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
6600	0.19	131.44	-0.23	-0.19	0.38	0.24	NO LIQUEFACTION
6800	0.19	145.43	-0.23	-0.19	0.39	0.25	NO LIQUEFACTION
7000	0.19	120.59	-0.22	-0.18	0.34	0.22	NO LIQUEFACTION
7200	0.19	111.21	-0.21	-0.17	0.32	0.20	NO LIQUEFACTION
7400	0.20	102.16	-0.21	-0.17	0.30	0.19	NO LIQUEFACTION
7600	0.20	97.24	-0.21	-0.17	0.29	0.19	NO LIQUEFACTION
7800	0.20	73.38	-0.19	-0.15	0.23	0.15	NO LIQUEFACTION
8000	0.20	41.10	-0.15	-0.11	0.15	0.10	LIQUEFACTION
8200	0.20	35.46	-0.14	-0.10	0.14	0.09	LIQUEFACTION
8400	0.20	23.25	-0.11	-0.07	0.10	0.07	LIQUEFACTION
8600	0.20	31.83	-0.13	-0.10	0.13	0.09	LIQUEFACTION
8800	0.20	52.99	-0.16	-0.12	0.18	0.12	LIQUEFACTION
9000	0.20	9.58	-0.04	0.00	0.05	0.03	LIQUEFACTION

GRAPH
OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

APPENDIX I

INTERPRETING IN-SITU STATE PARAMETER FROM DMT DATA

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FLAT DILATOMETER TEST (DMT)
STATE PARAMETER ESTIMATION

DMT#1

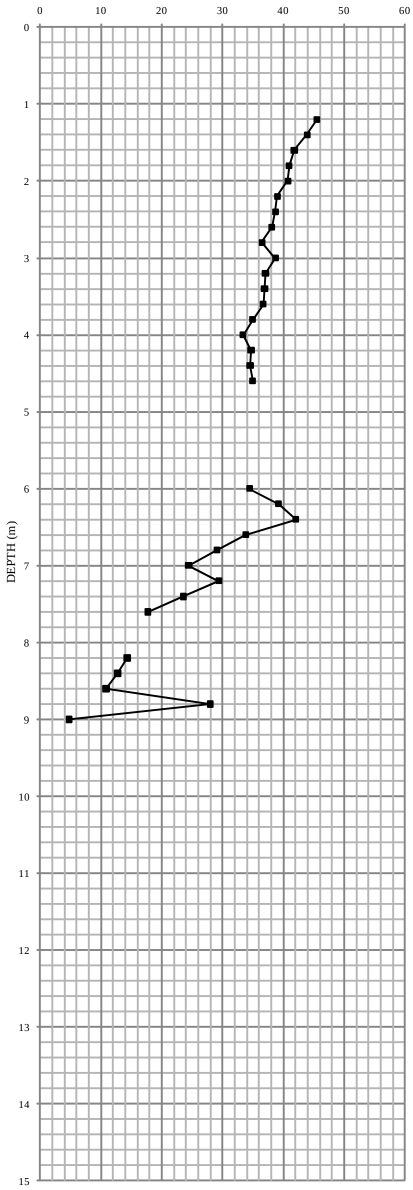
SHEET : 1 OF 8

FRICTION ANGLE & COEFFICIENT AT REST

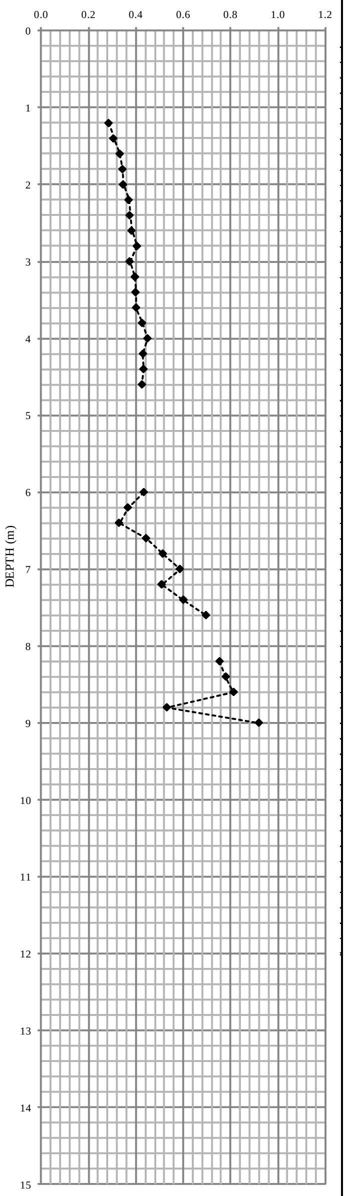
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	K_D	DMT FRICTION ANGLE (Marchetti, 2001)	K_o (Jacky's equation)
200			
400			
600			
800			
1000			
1200	35.12	45.55	0.29
1400	22.56	43.91	0.31
1600	13.53	41.83	0.33
1800	11.07	40.96	0.34
2000	10.57	40.75	0.35
2200	7.29	39.03	0.37
2400	6.84	38.72	0.37
2600	6.04	38.12	0.38
2800	4.37	36.49	0.41
3000	6.84	38.73	0.37
3200	4.91	37.08	0.40
3400	4.73	36.90	0.40
3600	4.56	36.71	0.40
3800	3.27	34.95	0.43
4000	2.46	33.38	0.45
4200	3.11	34.68	0.43
4400	3.02	34.53	0.43
4600	3.28	34.98	0.43
4800			
5000			
5200			
5400			
5600			
5800			
6000	2.97	34.44	0.43
6200	7.63	39.25	0.37
6400	14.32	42.07	0.33
6600	2.64	33.79	0.44
6800	1.19	29.08	0.51
7000	0.58	24.45	0.59
7200	1.25	29.38	0.51
7400	0.51	23.52	0.60
7600	0.23	17.72	0.70
7800	-0.06	28.00	0.53
8000	-0.08	28.00	0.53
8200	0.15	14.31	0.75
8400	0.12	12.76	0.78
8600	0.09	10.85	0.81
8800	0.99	27.96	0.53
9000	0.05	4.72	0.92

DMT PROFILE FOR FRICTION ANGLE (DEGREE)



DMT PROFILE FOR COEFFICIENT AT REST (K_o)



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
STATE PARAMETER ESTIMATION

DMT#1

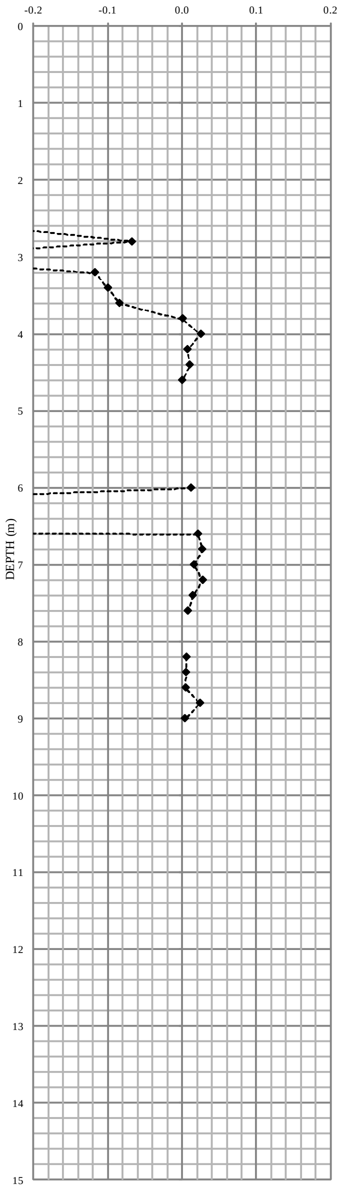
SHEET : 2 OF 8

RESULTS OF SOIL BEHAVIOUR ASSESSMENT

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	K_D	K_o	Ψ	Soil behaviour assessment	REMARKS
200					
400					
600					
800					
1000					
1200	35.12	0.29	-28.29	DILATIVE	1st COARSE GRAINED LAYER
1400	22.56	0.31	-9.73	DILATIVE	
1600	13.53	0.33	-2.69	DILATIVE	
1800	11.07	0.34	-1.58	DILATIVE	
2000	10.57	0.35	-1.39	DILATIVE	
2200	7.29	0.37	-0.48	DILATIVE	
2400	6.84	0.37	-0.39	DILATIVE	
2600	6.04	0.38	-0.26	DILATIVE	
2800	4.37	0.41	-0.07	DILATIVE	2nd COARSE GRAINED LAYER
3000	6.84	0.37	-0.39	DILATIVE	
3200	4.91	0.40	-0.12	DILATIVE	
3400	4.73	0.40	-0.10	DILATIVE	
3600	4.56	0.40	-0.08	DILATIVE	
3800	3.27	0.43	0.00	CONTRACTIVE	
4000	2.46	0.45	0.02	CONTRACTIVE	
4200	3.11	0.43	0.01	CONTRACTIVE	
4400	3.02	0.43	0.01	CONTRACTIVE	
4600	3.28	0.43	0.00	DILATIVE	
4800					
5000					
5200					
5400					
5600					
5800					
6000	2.97	0.43	0.01	CONTRACTIVE	3rd COARSE GRAINED LAYER
6200	7.63	0.37	-0.55	DILATIVE	
6400	14.32	0.33	-3.11	DILATIVE	
6600	2.64	0.44	0.02	CONTRACTIVE	
6800	1.19	0.51	0.03	CONTRACTIVE	
7000	0.58	0.59	0.02	CONTRACTIVE	
7200	1.25	0.51	0.03	CONTRACTIVE	
7400	0.51	0.60	0.01	CONTRACTIVE	
7600	0.23	0.70	0.01	CONTRACTIVE	
7800	-0.06	0.53	0.00	DILATIVE	
8000	-0.08	0.53	0.00	DILATIVE	
8200	0.15	0.75	0.01	CONTRACTIVE	
8400	0.12	0.78	0.00	CONTRACTIVE	
8600	0.09	0.81	0.00	CONTRACTIVE	
8800	0.99	0.53	0.02	CONTRACTIVE	
9000	0.05	0.92	0.00	CONTRACTIVE	

DMT PROFILE
FOR STATE PARAMETER (Ψ)



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
STATE PARAMETER ESTIMATION

DMT#1

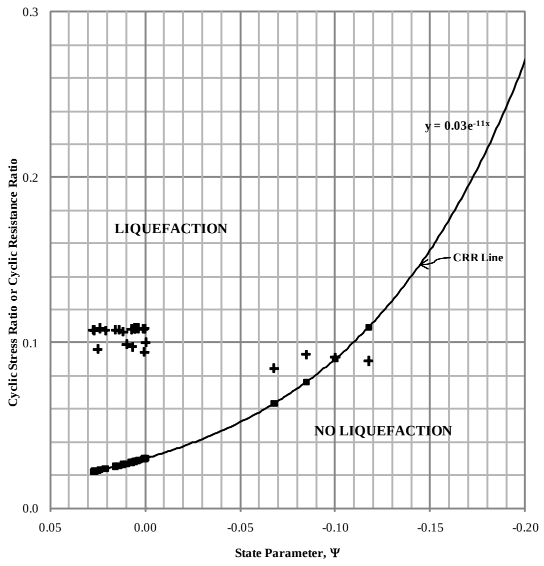
SHEET : 3 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=5.0	K_D	Ψ	$CRR_{M=7.5}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0
200					
400					
600					
800					
1000					
1200	0.08	35.12	-28.29	Very high CRR values	**NO LIQUEFACTION**
1400	0.08	22.56	-9.73		**NO LIQUEFACTION**
1600	0.08	13.53	-2.69		**NO LIQUEFACTION**
1800	0.08	11.07	-1.58		**NO LIQUEFACTION**
2000	0.08	10.57	-1.39		**NO LIQUEFACTION**
2200	0.08	7.29	-0.48	5.70	**NO LIQUEFACTION**
2400	0.08	6.84	-0.39	2.20	**NO LIQUEFACTION**
2600	0.08	6.04	-0.26	0.52	**NO LIQUEFACTION**
2800	0.08	4.37	-0.07	0.06	**LIQUEFACTION**
3000	0.09	6.84	-0.39	2.20	**NO LIQUEFACTION**
3200	0.09	4.91	-0.12	0.11	**NO LIQUEFACTION**
3400	0.09	4.73	-0.10	0.09	**LIQUEFACTION**
3600	0.09	4.56	-0.08	0.08	**LIQUEFACTION**
3800	0.09	3.27	0.00	0.03	**LIQUEFACTION**
4000	0.10	2.46	0.02	0.02	**LIQUEFACTION**
4200	0.10	3.11	0.01	0.03	**LIQUEFACTION**
4400	0.10	3.02	0.01	0.03	**LIQUEFACTION**
4600	0.10	3.28	0.00	0.03	**LIQUEFACTION**
4800					
5000					
5200					
5400					
5600					
5800					
6000	0.11	2.97	0.01	0.03	**LIQUEFACTION**
6200	0.11	7.63	-0.55	12.53	**NO LIQUEFACTION**
6400	0.11	14.32	-3.11	Very high CRR values	**NO LIQUEFACTION**
6600	0.11	2.64	0.02	0.02	**LIQUEFACTION**
6800	0.11	1.19	0.03	0.02	**LIQUEFACTION**
7000	0.11	0.58	0.02	0.03	**LIQUEFACTION**
7200	0.11	1.25	0.03	0.02	**LIQUEFACTION**
7400	0.11	0.51	0.01	0.03	**LIQUEFACTION**
7600	0.11	0.23	0.01	0.03	**LIQUEFACTION**
7800	0.11	-0.06	0.00	0.03	**LIQUEFACTION**
8000	0.11	-0.08	0.00	0.03	**LIQUEFACTION**
8200	0.11	0.15	0.01	0.03	**LIQUEFACTION**
8400	0.11	0.12	0.00	0.03	**LIQUEFACTION**
8600	0.11	0.09	0.00	0.03	**LIQUEFACTION**
8800	0.11	0.99	0.02	0.02	**LIQUEFACTION**
9000	0.11	0.05	0.00	0.03	**LIQUEFACTION**

GRAPH
OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 5.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
STATE PARAMETER ESTIMATION

DMT#1

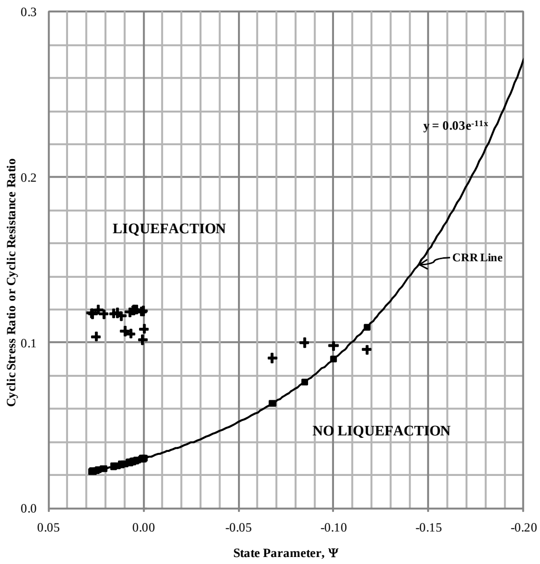
SHEET : 4 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=5.5	K_D	Ψ	$CRR_{M=7.5}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0
200					
400					
600					
800					
1000					
1200	0.08	35.12	-28.29		NO LIQUEFACTION
1400	0.08	22.56	-9.73		NO LIQUEFACTION
1600	0.08	13.53	-2.69	Very high CRR values	NO LIQUEFACTION
1800	0.08	11.07	-1.58		NO LIQUEFACTION
2000	0.08	10.57	-1.39		NO LIQUEFACTION
2200	0.08	7.29	-0.48	5.70	NO LIQUEFACTION
2400	0.08	6.84	-0.39	2.20	NO LIQUEFACTION
2600	0.09	6.04	-0.26	0.52	NO LIQUEFACTION
2800	0.09	4.37	-0.07	0.06	LIQUEFACTION
3000	0.09	6.84	-0.39	2.20	NO LIQUEFACTION
3200	0.10	4.91	-0.12	0.11	NO LIQUEFACTION
3400	0.10	4.73	-0.10	0.09	LIQUEFACTION
3600	0.10	4.56	-0.08	0.08	LIQUEFACTION
3800	0.10	3.27	0.00	0.03	LIQUEFACTION
4000	0.10	2.46	0.02	0.02	LIQUEFACTION
4200	0.11	3.11	0.01	0.03	LIQUEFACTION
4400	0.11	3.02	0.01	0.03	LIQUEFACTION
4600	0.11	3.28	0.00	0.03	LIQUEFACTION
4800					
5000					
5200					
5400					
5600					
5800					
6000	0.12	2.97	0.01	0.03	LIQUEFACTION
6200	0.12	7.63	-0.55	12.53	NO LIQUEFACTION
6400	0.12	14.32	-3.11	Very high CRR values	NO LIQUEFACTION
6600	0.12	2.64	0.02	0.02	LIQUEFACTION
6800	0.12	1.19	0.03	0.02	LIQUEFACTION
7000	0.12	0.58	0.02	0.03	LIQUEFACTION
7200	0.12	1.25	0.03	0.02	LIQUEFACTION
7400	0.12	0.51	0.01	0.03	LIQUEFACTION
7600	0.12	0.23	0.01	0.03	LIQUEFACTION
7800	0.12	-0.06	0.00	0.03	LIQUEFACTION
8000	0.12	-0.08	0.00	0.03	LIQUEFACTION
8200	0.12	0.15	0.01	0.03	LIQUEFACTION
8400	0.12	0.12	0.00	0.03	LIQUEFACTION
8600	0.12	0.09	0.00	0.03	LIQUEFACTION
8800	0.12	0.99	0.02	0.02	LIQUEFACTION
9000	0.12	0.05	0.00	0.03	LIQUEFACTION

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
STATE PARAMETER ESTIMATION

DMT#1

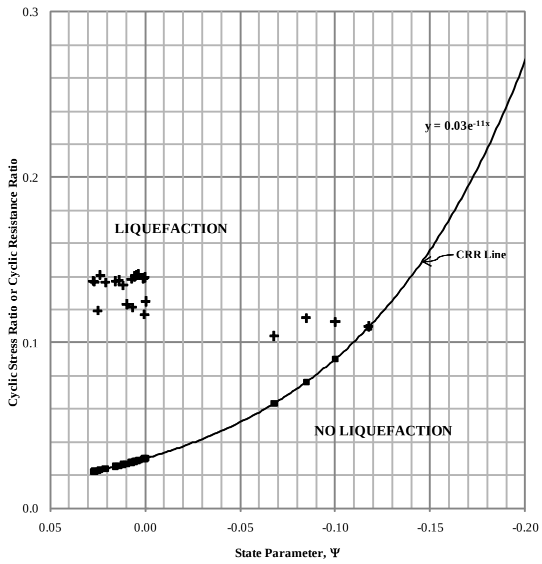
SHEET : 5 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.5}$ FOR M=6.0	K_D	Ψ	$CRR_{M=7.5}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0
200					
400					
600					
800					
1000					
1200	0.09	35.12	-28.29	Very high CRR values	NO LIQUEFACTION
1400	0.09	22.56	-9.73		NO LIQUEFACTION
1600	0.09	13.53	-2.69		NO LIQUEFACTION
1800	0.09	11.07	-1.58		NO LIQUEFACTION
2000	0.09	10.57	-1.39		NO LIQUEFACTION
2200	0.09	7.29	-0.48	5.70	NO LIQUEFACTION
2400	0.10	6.84	-0.39	2.20	NO LIQUEFACTION
2600	0.10	6.04	-0.26	0.52	NO LIQUEFACTION
2800	0.10	4.37	-0.07	0.06	LIQUEFACTION
3000	0.11	6.84	-0.39	2.20	NO LIQUEFACTION
3200	0.11	4.91	-0.12	0.11	LIQUEFACTION
3400	0.11	4.73	-0.10	0.09	LIQUEFACTION
3600	0.11	4.56	-0.08	0.08	LIQUEFACTION
3800	0.12	3.27	0.00	0.03	LIQUEFACTION
4000	0.12	2.46	0.02	0.02	LIQUEFACTION
4200	0.12	3.11	0.01	0.03	LIQUEFACTION
4400	0.12	3.02	0.01	0.03	LIQUEFACTION
4600	0.13	3.28	0.00	0.03	LIQUEFACTION
4800					
5000					
5200					
5400					
5600					
5800					
6000	0.13	2.97	0.01	0.03	LIQUEFACTION
6200	0.14	7.63	-0.55	12.53	NO LIQUEFACTION
6400	0.14	14.32	-3.11	Very high CRR values	NO LIQUEFACTION
6600	0.14	2.64	0.02	0.02	LIQUEFACTION
6800	0.14	1.19	0.03	0.02	LIQUEFACTION
7000	0.14	0.58	0.02	0.03	LIQUEFACTION
7200	0.14	1.25	0.03	0.02	LIQUEFACTION
7400	0.14	0.51	0.01	0.03	LIQUEFACTION
7600	0.14	0.23	0.01	0.03	LIQUEFACTION
7800	0.14	-0.06	0.00	0.03	LIQUEFACTION
8000	0.14	-0.08	0.00	0.03	LIQUEFACTION
8200	0.14	0.15	0.01	0.03	LIQUEFACTION
8400	0.14	0.12	0.00	0.03	LIQUEFACTION
8600	0.14	0.09	0.00	0.03	LIQUEFACTION
8800	0.14	0.99	0.02	0.02	LIQUEFACTION
9000	0.14	0.05	0.00	0.03	LIQUEFACTION

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 6.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
STATE PARAMETER ESTIMATION

DMT#1

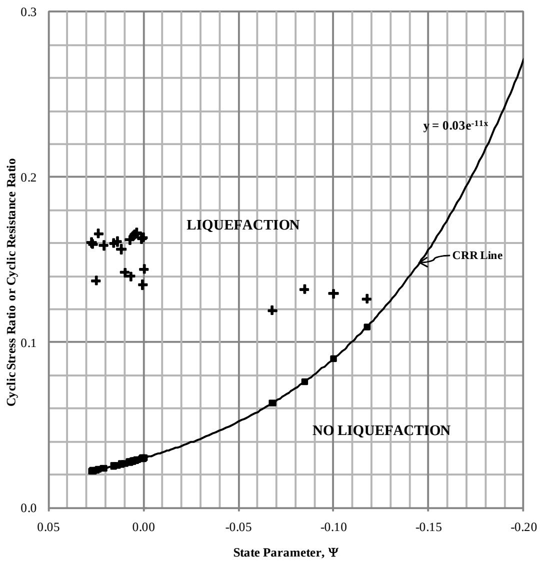
SHEET : 6 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=6.5**	**K_D**	**Ψ**	**$CRR_{M=7.5}$**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0
200					
400					
600					
800					
1000					
1200	0.11	35.12	-28.29	Very high CRR values	**NO LIQUEFACTION**
1400	0.11	22.56	-9.73		**NO LIQUEFACTION**
1600	0.11	13.53	-2.69		**NO LIQUEFACTION**
1800	0.11	11.07	-1.58		**NO LIQUEFACTION**
2000	0.11	10.57	-1.39		**NO LIQUEFACTION**
2200	0.11	7.29	-0.48	5.70	**NO LIQUEFACTION**
2400	0.11	6.84	-0.39	2.20	**NO LIQUEFACTION**
2600	0.12	6.04	-0.26	0.52	**NO LIQUEFACTION**
2800	0.12	4.37	-0.07	0.06	**LIQUEFACTION**
3000	0.12	6.84	-0.39	2.20	**NO LIQUEFACTION**
3200	0.13	4.91	-0.12	0.11	**LIQUEFACTION**
3400	0.13	4.73	-0.10	0.09	**LIQUEFACTION**
3600	0.13	4.56	-0.08	0.08	**LIQUEFACTION**
3800	0.13	3.27	0.00	0.03	**LIQUEFACTION**
4000	0.14	2.46	0.02	0.02	**LIQUEFACTION**
4200	0.14	3.11	0.01	0.03	**LIQUEFACTION**
4400	0.14	3.02	0.01	0.03	**LIQUEFACTION**
4600	0.14	3.28	0.00	0.03	**LIQUEFACTION**
4800					
5000					
5200					
5400					
5600					
5800					
6000	0.16	2.97	0.01	0.03	**LIQUEFACTION**
6200	0.16	7.63	-0.55	12.53	**NO LIQUEFACTION**
6400	0.16	14.32	-3.11	Very high CRR values	**NO LIQUEFACTION**
6600	0.16	2.64	0.02	0.02	**LIQUEFACTION**
6800	0.16	1.19	0.03	0.02	**LIQUEFACTION**
7000	0.16	0.58	0.02	0.03	**LIQUEFACTION**
7200	0.16	1.25	0.03	0.02	**LIQUEFACTION**
7400	0.16	0.51	0.01	0.03	**LIQUEFACTION**
7600	0.16	0.23	0.01	0.03	**LIQUEFACTION**
7800	0.16	-0.06	0.00	0.03	**LIQUEFACTION**
8000	0.16	-0.08	0.00	0.03	**LIQUEFACTION**
8200	0.16	0.15	0.01	0.03	**LIQUEFACTION**
8400	0.16	0.12	0.00	0.03	**LIQUEFACTION**
8600	0.17	0.09	0.00	0.03	**LIQUEFACTION**
8800	0.17	0.99	0.02	0.02	**LIQUEFACTION**
9000	0.17	0.05	0.00	0.03	**LIQUEFACTION**

GRAPH
OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
STATE PARAMETER ESTIMATION

DMT#1

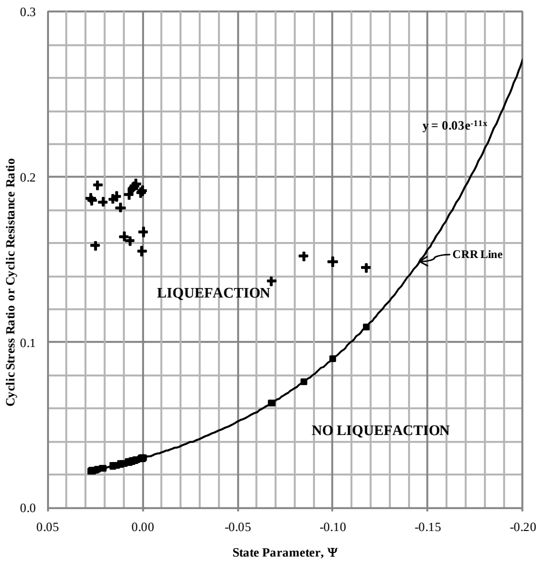
SHEET : 7 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=7.0**	**K_D**	**Ψ**	**$CRR_{M=7.5}$**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0
200					
400					
600					
800					
1000					
1200	0.12	35.12	-28.29	Very high CRR values	**NO LIQUEFACTION**
1400	0.12	22.56	-9.73		**NO LIQUEFACTION**
1600	0.12	13.53	-2.69		**NO LIQUEFACTION**
1800	0.12	11.07	-1.58		**NO LIQUEFACTION**
2000	0.12	10.57	-1.39		**NO LIQUEFACTION**
2200	0.12	7.29	-0.48	5.70	**NO LIQUEFACTION**
2400	0.13	6.84	-0.39	2.20	**NO LIQUEFACTION**
2600	0.13	6.04	-0.26	0.52	**NO LIQUEFACTION**
2800	0.14	4.37	-0.07	0.06	**LIQUEFACTION**
3000	0.14	6.84	-0.39	2.20	**NO LIQUEFACTION**
3200	0.15	4.91	-0.12	0.11	**LIQUEFACTION**
3400	0.15	4.73	-0.10	0.09	**LIQUEFACTION**
3600	0.15	4.56	-0.08	0.08	**LIQUEFACTION**
3800	0.16	3.27	0.00	0.03	**LIQUEFACTION**
4000	0.16	2.46	0.02	0.02	**LIQUEFACTION**
4200	0.16	3.11	0.01	0.03	**LIQUEFACTION**
4400	0.16	3.02	0.01	0.03	**LIQUEFACTION**
4600	0.17	3.28	0.00	0.03	**LIQUEFACTION**
4800					
5000					
5200					
5400					
5600					
5800					
6000	0.18	2.97	0.01	0.03	**LIQUEFACTION**
6200	0.18	7.63	-0.55	12.53	**NO LIQUEFACTION**
6400	0.18	14.32	-3.11	Very high CRR values	**NO LIQUEFACTION**
6600	0.18	2.64	0.02	0.02	**LIQUEFACTION**
6800	0.19	1.19	0.03	0.02	**LIQUEFACTION**
7000	0.19	0.58	0.02	0.03	**LIQUEFACTION**
7200	0.19	1.25	0.03	0.02	**LIQUEFACTION**
7400	0.19	0.51	0.01	0.03	**LIQUEFACTION**
7600	0.19	0.23	0.01	0.03	**LIQUEFACTION**
7800	0.19	-0.06	0.00	0.03	**LIQUEFACTION**
8000	0.19	-0.08	0.00	0.03	**LIQUEFACTION**
8200	0.19	0.15	0.01	0.03	**LIQUEFACTION**
8400	0.19	0.12	0.00	0.03	**LIQUEFACTION**
8600	0.19	0.09	0.00	0.03	**LIQUEFACTION**
8800	0.20	0.99	0.02	0.02	**LIQUEFACTION**
9000	0.20	0.05	0.00	0.03	**LIQUEFACTION**

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 7.0

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
STATE PARAMETER ESTIMATION

DMT#1

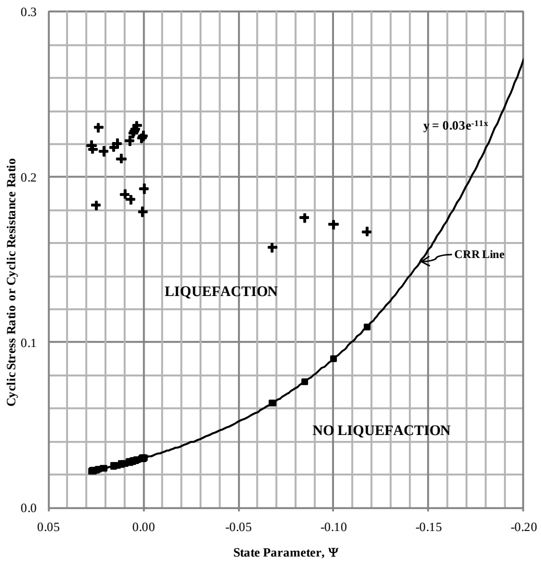
SHEET : 8 OF 8

STATE PARAMETER FOR LIQUEFACTION ASSESSMENT IF M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.5}$ FOR M=7.5**	**K_D**	**Ψ**	**$CRR_{M=7.5}$**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0
200					
400					
600					
800					
1000					
1200	0.14	35.12	-28.29		**NO LIQUEFACTION**
1400	0.14	22.56	-9.73		**NO LIQUEFACTION**
1600	0.14	13.53	-2.69	Very high CRR values	**NO LIQUEFACTION**
1800	0.14	11.07	-1.58		**NO LIQUEFACTION**
2000	0.14	10.57	-1.39		**NO LIQUEFACTION**
2200	0.14	7.29	-0.48	5.70	**NO LIQUEFACTION**
2400	0.15	6.84	-0.39	2.20	**NO LIQUEFACTION**
2600	0.15	6.04	-0.26	0.52	**NO LIQUEFACTION**
2800	0.16	4.37	-0.07	0.06	**LIQUEFACTION**
3000	0.16	6.84	-0.39	2.20	**NO LIQUEFACTION**
3200	0.17	4.91	-0.12	0.11	**LIQUEFACTION**
3400	0.17	4.73	-0.10	0.09	**LIQUEFACTION**
3600	0.18	4.56	-0.08	0.08	**LIQUEFACTION**
3800	0.18	3.27	0.00	0.03	**LIQUEFACTION**
4000	0.18	2.46	0.02	0.02	**LIQUEFACTION**
4200	0.19	3.11	0.01	0.03	**LIQUEFACTION**
4400	0.19	3.02	0.01	0.03	**LIQUEFACTION**
4600	0.19	3.28	0.00	0.03	**LIQUEFACTION**
4800					
5000					
5200					
5400					
5600					
5800					
6000	0.21	2.97	0.01	0.03	**LIQUEFACTION**
6200	0.21	7.63	-0.55	12.53	**NO LIQUEFACTION**
6400	0.21	14.32	-3.11	Very high CRR values	**NO LIQUEFACTION**
6600	0.22	2.64	0.02	0.02	**LIQUEFACTION**
6800	0.22	1.19	0.03	0.02	**LIQUEFACTION**
7000	0.22	0.58	0.02	0.03	**LIQUEFACTION**
7200	0.22	1.25	0.03	0.02	**LIQUEFACTION**
7400	0.22	0.51	0.01	0.03	**LIQUEFACTION**
7600	0.22	0.23	0.01	0.03	**LIQUEFACTION**
7800	0.22	-0.06	0.00	0.03	**LIQUEFACTION**
8000	0.23	-0.08	0.00	0.03	**LIQUEFACTION**
8200	0.23	0.15	0.01	0.03	**LIQUEFACTION**
8400	0.23	0.12	0.00	0.03	**LIQUEFACTION**
8600	0.23	0.09	0.00	0.03	**LIQUEFACTION**
8800	0.23	0.99	0.02	0.02	**LIQUEFACTION**
9000	0.23	0.05	0.00	0.03	**LIQUEFACTION**

GRAPH OF LIQUEFACTION ASSESSMENT AS SUGGESTED BY JEFFERIES & BEEN (2006)



Graph 1. Liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

APPENDIX J

CPT LIQUEFACTION ASSESSMENT RESULTS

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CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

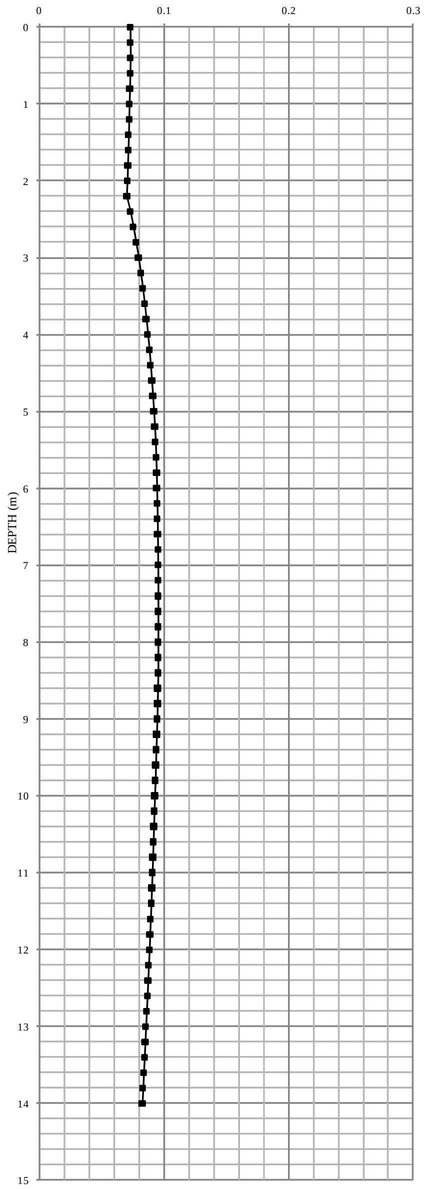
SHEET : 1 OF 14

CYCLIC STRESS RATIO FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.60	20.60	4.12	4.12	1.00	0.202	1.80	**0.073**
400	21.28	21.28	8.38	8.38	1.00	0.202	1.80	**0.073**
600	20.93	20.93	12.56	12.56	1.00	0.202	1.80	**0.073**
800	20.90	20.90	16.74	16.74	0.99	0.202	1.80	**0.073**
1000	20.67	20.67	20.88	20.88	0.99	0.202	1.80	**0.072**
1200	20.00	20.00	24.88	24.88	0.99	0.202	1.80	**0.072**
1400	19.59	19.59	28.79	28.79	0.98	0.202	1.80	**0.072**
1600	19.58	19.58	32.71	32.71	0.98	0.202	1.80	**0.071**
1800	19.15	19.15	36.54	36.54	0.97	0.202	1.80	**0.071**
2000	19.34	19.34	40.41	40.41	0.97	0.202	1.80	**0.071**
2200	18.85	18.85	44.18	44.18	0.96	0.202	1.80	**0.070**
2400	18.51	8.70	47.88	45.92	0.96	0.202	1.80	**0.073**
2600	18.34	8.53	51.55	47.62	0.95	0.202	1.80	**0.075**
2800	18.40	8.59	55.23	49.34	0.95	0.202	1.80	**0.078**
3000	18.32	8.51	58.89	51.04	0.94	0.202	1.80	**0.080**
3200	18.30	8.50	62.55	52.74	0.94	0.202	1.80	**0.081**
3400	18.16	8.35	66.18	54.41	0.93	0.202	1.80	**0.083**
3600	17.90	8.10	69.76	56.03	0.93	0.202	1.80	**0.084**
3800	17.62	7.82	73.29	57.60	0.92	0.202	1.80	**0.086**
4000	17.40	7.59	76.77	59.11	0.92	0.202	1.80	**0.087**
4200	17.29	7.48	80.22	60.61	0.91	0.202	1.80	**0.088**
4400	17.25	7.44	83.67	62.10	0.91	0.202	1.80	**0.089**
4600	17.12	7.31	87.10	63.56	0.90	0.202	1.80	**0.090**
4800	17.32	7.52	90.56	65.06	0.90	0.202	1.80	**0.091**
5000	17.09	7.29	93.98	66.52	0.89	0.202	1.80	**0.092**
5200	16.96	7.15	97.37	67.95	0.89	0.202	1.80	**0.093**
5400	17.24	7.43	100.82	69.44	0.88	0.202	1.80	**0.093**
5600	18.15	8.35	104.45	71.11	0.87	0.202	1.80	**0.094**
5800	18.06	8.25	108.06	72.76	0.87	0.202	1.80	**0.094**
6000	19.46	9.66	111.96	74.69	0.86	0.202	1.80	**0.094**
6200	19.08	9.28	115.77	76.54	0.86	0.202	1.80	**0.094**
6400	17.53	7.72	119.28	78.09	0.85	0.202	1.80	**0.095**
6600	18.26	8.45	122.93	79.78	0.84	0.202	1.80	**0.095**
6800	17.88	8.07	126.50	81.39	0.84	0.202	1.80	**0.095**
7000	17.81	8.00	130.07	82.99	0.83	0.202	1.80	**0.095**
7200	17.74	7.93	133.62	84.58	0.83	0.202	1.80	**0.095**
7400	17.43	7.62	137.10	86.11	0.82	0.202	1.80	**0.095**
7600	17.10	7.29	140.52	87.56	0.81	0.202	1.80	**0.095**
7800	17.23	7.42	143.97	89.05	0.81	0.202	1.80	**0.095**
8000	16.78	6.97	147.32	90.44	0.80	0.202	1.80	**0.095**
8200	16.29	6.49	150.58	91.74	0.80	0.202	1.80	**0.095**
8400	16.31	6.51	153.84	93.04	0.79	0.202	1.80	**0.095**
8600	18.14	8.33	157.47	94.71	0.78	0.202	1.80	**0.095**
8800	18.01	8.20	161.07	96.35	0.78	0.202	1.80	**0.095**
9000	18.85	9.05	164.85	98.16	0.77	0.202	1.80	**0.094**
9200	18.94	9.13	168.63	99.98	0.77	0.202	1.80	**0.094**
9400	18.70	8.90	172.37	101.76	0.76	0.202	1.80	**0.094**
9600	18.47	8.66	176.07	103.49	0.75	0.202	1.80	**0.093**
9800	18.38	8.57	179.74	105.21	0.75	0.202	1.80	**0.093**
10000	19.01	9.20	183.54	107.05	0.74	0.202	1.80	**0.093**
10200	18.77	8.96	187.30	108.84	0.73	0.202	1.80	**0.092**
10400	17.01	7.20	190.70	110.28	0.73	0.202	1.80	**0.092**
10600	17.78	7.98	194.26	111.88	0.72	0.202	1.80	**0.091**
10800	18.07	8.27	197.87	113.53	0.72	0.202	1.80	**0.091**
11000	18.12	8.32	201.50	115.19	0.71	0.202	1.80	**0.091**
11200	18.29	8.48	205.15	116.89	0.70	0.202	1.80	**0.090**
11400	17.70	7.90	208.69	118.47	0.70	0.202	1.80	**0.090**
11600	18.07	8.26	212.31	120.12	0.69	0.202	1.80	**0.089**
11800	17.92	8.11	215.89	121.74	0.69	0.202	1.80	**0.089**
12000	18.40	8.60	219.57	123.46	0.68	0.202	1.80	**0.088**
12200	18.74	8.94	223.32	125.25	0.67	0.202	1.80	**0.088**
12400	18.97	9.16	227.11	127.08	0.67	0.202	1.80	**0.087**
12600	18.90	9.09	230.89	128.90	0.66	0.202	1.80	**0.087**
12800	18.50	8.69	234.59	130.64	0.66	0.202	1.80	**0.086**
13000	19.25	9.45	238.44	132.53	0.65	0.202	1.80	**0.086**
13200	19.26	9.46	242.30	134.42	0.65	0.202	1.80	**0.085**
13400	18.68	8.87	246.03	136.19	0.64	0.202	1.80	**0.084**
13600	19.68	9.87	249.97	138.17	0.63	0.202	1.80	**0.084**
13800	19.81	10.00	253.93	140.17	0.63	0.202	1.80	**0.083**
14000	19.58	9.77	257.85	142.12	0.62	0.202	1.80	**0.083**

CPT PROFILE FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

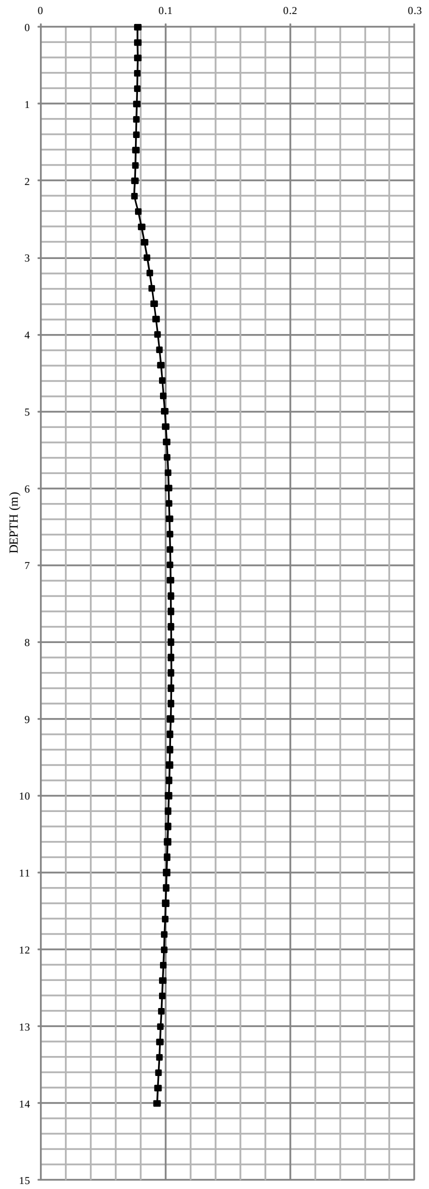
SHEET : 2 OF 14

CYCLIC STRESS RATIO FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.60	20.60	4.12	4.12	1.00	0.202	1.69	**0.078**
400	21.28	21.28	8.38	8.38	1.00	0.202	1.69	**0.078**
600	20.93	20.93	12.56	12.56	1.00	0.202	1.69	**0.078**
800	20.90	20.90	16.74	16.74	1.00	0.202	1.69	**0.078**
1000	20.67	20.67	20.88	20.88	0.99	0.202	1.69	**0.077**
1200	20.00	20.00	24.88	24.88	0.99	0.202	1.69	**0.077**
1400	19.59	19.59	28.79	28.79	0.98	0.202	1.69	**0.077**
1600	19.58	19.58	32.71	32.71	0.98	0.202	1.69	**0.076**
1800	19.15	19.15	36.54	36.54	0.98	0.202	1.69	**0.076**
2000	19.34	19.34	40.41	40.41	0.97	0.202	1.69	**0.076**
2200	18.85	18.85	44.18	44.18	0.97	0.202	1.69	**0.075**
2400	18.51	8.70	47.88	45.92	0.96	0.202	1.69	**0.078**
2600	18.34	8.53	51.55	47.62	0.96	0.202	1.69	**0.081**
2800	18.40	8.59	55.23	49.34	0.96	0.202	1.69	**0.083**
3000	18.32	8.51	58.89	51.04	0.95	0.202	1.69	**0.086**
3200	18.30	8.50	62.55	52.74	0.95	0.202	1.69	**0.087**
3400	18.16	8.35	66.18	54.41	0.94	0.202	1.69	**0.089**
3600	17.90	8.10	69.76	56.03	0.94	0.202	1.69	**0.091**
3800	17.62	7.82	73.29	57.60	0.93	0.202	1.69	**0.093**
4000	17.40	7.59	76.77	59.11	0.93	0.202	1.69	**0.094**
4200	17.29	7.48	80.22	60.61	0.92	0.202	1.69	**0.095**
4400	17.25	7.44	83.67	62.10	0.92	0.202	1.69	**0.096**
4600	17.12	7.31	87.10	63.56	0.91	0.202	1.69	**0.098**
4800	17.32	7.52	90.56	65.06	0.91	0.202	1.69	**0.099**
5000	17.09	7.29	93.98	66.52	0.90	0.202	1.69	**0.099**
5200	16.96	7.15	97.37	67.95	0.90	0.202	1.69	**0.100**
5400	17.24	7.43	100.82	69.44	0.89	0.202	1.69	**0.101**
5600	18.15	8.35	104.45	71.11	0.89	0.202	1.69	**0.102**
5800	18.06	8.25	108.06	72.76	0.88	0.202	1.69	**0.102**
6000	19.46	9.66	111.96	74.69	0.88	0.202	1.69	**0.103**
6200	19.08	9.28	115.77	76.54	0.87	0.202	1.69	**0.103**
6400	17.53	7.72	119.28	78.09	0.87	0.202	1.69	**0.103**
6600	18.26	8.45	122.93	79.78	0.86	0.202	1.69	**0.104**
6800	17.88	8.07	126.50	81.39	0.86	0.202	1.69	**0.104**
7000	17.81	8.00	130.07	82.99	0.85	0.202	1.69	**0.104**
7200	17.74	7.93	133.62	84.58	0.85	0.202	1.69	**0.104**
7400	17.43	7.62	137.10	86.11	0.84	0.202	1.69	**0.104**
7600	17.10	7.29	140.52	87.56	0.84	0.202	1.69	**0.104**
7800	17.23	7.42	143.97	89.05	0.83	0.202	1.69	**0.105**
8000	16.78	6.97	147.32	90.44	0.82	0.202	1.69	**0.105**
8200	16.29	6.49	150.58	91.74	0.82	0.202	1.69	**0.105**
8400	16.31	6.51	153.84	93.04	0.81	0.202	1.69	**0.105**
8600	18.14	8.33	157.47	94.71	0.81	0.202	1.69	**0.105**
8800	18.01	8.20	161.07	96.35	0.80	0.202	1.69	**0.104**
9000	18.85	9.05	164.85	98.16	0.80	0.202	1.69	**0.104**
9200	18.94	9.13	168.63	99.98	0.79	0.202	1.69	**0.104**
9400	18.70	8.90	172.37	101.76	0.79	0.202	1.69	**0.104**
9600	18.47	8.66	176.07	103.49	0.78	0.202	1.69	**0.103**
9800	18.38	8.57	179.74	105.21	0.77	0.202	1.69	**0.103**
10000	19.01	9.20	183.54	107.05	0.77	0.202	1.69	**0.103**
10200	18.77	8.96	187.30	108.84	0.76	0.202	1.69	**0.102**
10400	17.01	7.20	190.70	110.28	0.76	0.202	1.69	**0.102**
10600	17.78	7.98	194.26	111.88	0.75	0.202	1.69	**0.102**
10800	18.07	8.27	197.87	113.53	0.75	0.202	1.69	**0.101**
11000	18.12	8.32	201.50	115.19	0.74	0.202	1.69	**0.101**
11200	18.29	8.48	205.15	116.89	0.74	0.202	1.69	**0.101**
11400	17.70	7.90	208.69	118.47	0.73	0.202	1.69	**0.100**
11600	18.07	8.26	212.31	120.12	0.73	0.202	1.69	**0.100**
11800	17.92	8.11	215.89	121.74	0.72	0.202	1.69	**0.099**
12000	18.40	8.60	219.57	123.46	0.71	0.202	1.69	**0.099**
12200	18.74	8.94	223.32	125.25	0.71	0.202	1.69	**0.098**
12400	18.97	9.16	227.11	127.08	0.70	0.202	1.69	**0.098**
12600	18.90	9.09	230.89	128.90	0.70	0.202	1.69	**0.097**
12800	18.50	8.69	234.59	130.64	0.69	0.202	1.69	**0.097**
13000	19.25	9.45	238.44	132.53	0.69	0.202	1.69	**0.096**
13200	19.26	9.46	242.30	134.42	0.68	0.202	1.69	**0.096**
13400	18.68	8.87	246.03	136.19	0.68	0.202	1.69	**0.095**
13600	19.68	9.87	249.97	138.17	0.67	0.202	1.69	**0.095**
13800	19.81	10.00	253.93	140.17	0.67	0.202	1.69	**0.094**
14000	19.58	9.77	257.85	142.12	0.66	0.202	1.69	**0.093**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

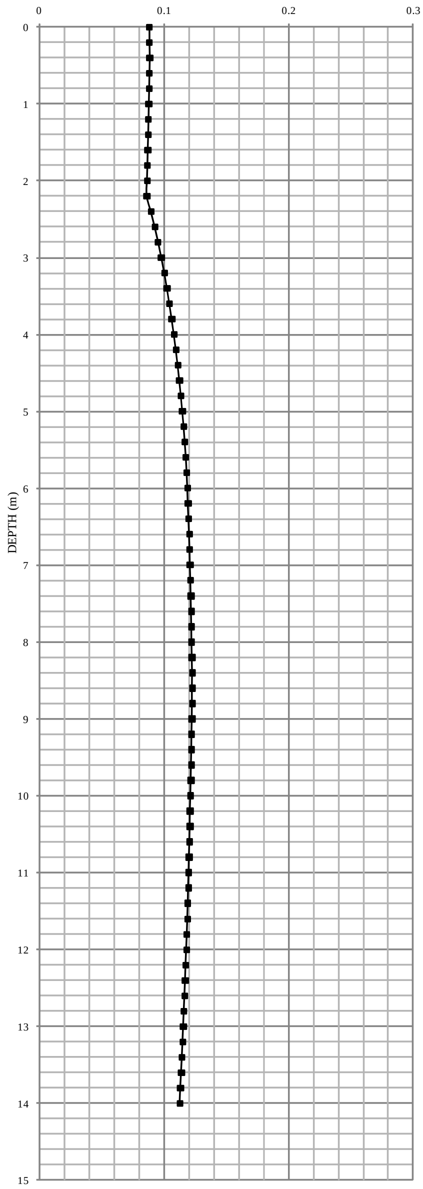
SHEET : 3 OF 14

CYCLIC STRESS RATIO FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.60	20.60	4.12	4.12	1.00	0.202	1.48	**0.089**
400	21.28	21.28	8.38	8.38	1.00	0.202	1.48	**0.089**
600	20.93	20.93	12.56	12.56	1.00	0.202	1.48	**0.089**
800	20.90	20.90	16.74	16.74	1.00	0.202	1.48	**0.088**
1000	20.67	20.67	20.88	20.88	0.99	0.202	1.48	**0.088**
1200	20.00	20.00	24.88	24.88	0.99	0.202	1.48	**0.088**
1400	19.59	19.59	28.79	28.79	0.99	0.202	1.48	**0.088**
1600	19.58	19.58	32.71	32.71	0.98	0.202	1.48	**0.087**
1800	19.15	19.15	36.54	36.54	0.98	0.202	1.48	**0.087**
2000	19.34	19.34	40.41	40.41	0.98	0.202	1.48	**0.087**
2200	18.85	18.85	44.18	44.18	0.97	0.202	1.48	**0.086**
2400	18.51	8.70	47.88	45.92	0.97	0.202	1.48	**0.090**
2600	18.34	8.53	51.55	47.62	0.97	0.202	1.48	**0.093**
2800	18.40	8.59	55.23	49.34	0.96	0.202	1.48	**0.096**
3000	18.32	8.51	58.89	51.04	0.96	0.202	1.48	**0.098**
3200	18.30	8.50	62.55	52.74	0.96	0.202	1.48	**0.100**
3400	18.16	8.35	66.18	54.41	0.95	0.202	1.48	**0.103**
3600	17.90	8.10	69.76	56.03	0.95	0.202	1.48	**0.105**
3800	17.62	7.82	73.29	57.60	0.94	0.202	1.48	**0.106**
4000	17.40	7.59	76.77	59.11	0.94	0.202	1.48	**0.108**
4200	17.29	7.48	80.22	60.61	0.94	0.202	1.48	**0.110**
4400	17.25	7.44	83.67	62.10	0.93	0.202	1.48	**0.111**
4600	17.12	7.31	87.10	63.56	0.93	0.202	1.48	**0.113**
4800	17.32	7.52	90.56	65.06	0.92	0.202	1.48	**0.114**
5000	17.09	7.29	93.98	66.52	0.92	0.202	1.48	**0.115**
5200	16.96	7.15	97.37	67.95	0.91	0.202	1.48	**0.116**
5400	17.24	7.43	100.82	69.44	0.91	0.202	1.48	**0.117**
5600	18.15	8.35	104.45	71.11	0.91	0.202	1.48	**0.118**
5800	18.06	8.25	108.06	72.76	0.90	0.202	1.48	**0.119**
6000	19.46	9.66	111.96	74.69	0.90	0.202	1.48	**0.119**
6200	19.08	9.28	115.77	76.54	0.89	0.202	1.48	**0.119**
6400	17.53	7.72	119.28	78.09	0.89	0.202	1.48	**0.120**
6600	18.26	8.45	122.93	79.78	0.88	0.202	1.48	**0.120**
6800	17.88	8.07	126.50	81.39	0.88	0.202	1.48	**0.121**
7000	17.81	8.00	130.07	82.99	0.87	0.202	1.48	**0.121**
7200	17.74	7.93	133.62	84.58	0.87	0.202	1.48	**0.121**
7400	17.43	7.62	137.10	86.11	0.86	0.202	1.48	**0.122**
7600	17.10	7.29	140.52	87.56	0.86	0.202	1.48	**0.122**
7800	17.23	7.42	143.97	89.05	0.85	0.202	1.48	**0.122**
8000	16.78	6.97	147.32	90.44	0.85	0.202	1.48	**0.122**
8200	16.29	6.49	150.58	91.74	0.84	0.202	1.48	**0.123**
8400	16.31	6.51	153.84	93.04	0.84	0.202	1.48	**0.123**
8600	18.14	8.33	157.47	94.71	0.83	0.202	1.48	**0.123**
8800	18.01	8.20	161.07	96.35	0.83	0.202	1.48	**0.123**
9000	18.85	9.05	164.85	98.16	0.82	0.202	1.48	**0.123**
9200	18.94	9.13	168.63	99.98	0.82	0.202	1.48	**0.122**
9400	18.70	8.90	172.37	101.76	0.81	0.202	1.48	**0.122**
9600	18.47	8.66	176.07	103.49	0.81	0.202	1.48	**0.122**
9800	18.38	8.57	179.74	105.21	0.80	0.202	1.48	**0.122**
10000	19.01	9.20	183.54	107.05	0.80	0.202	1.48	**0.121**
10200	18.77	8.96	187.30	108.84	0.79	0.202	1.48	**0.121**
10400	17.01	7.20	190.70	110.28	0.79	0.202	1.48	**0.121**
10600	17.78	7.98	194.26	111.88	0.78	0.202	1.48	**0.121**
10800	18.07	8.27	197.87	113.53	0.78	0.202	1.48	**0.120**
11000	18.12	8.32	201.50	115.19	0.77	0.202	1.48	**0.120**
11200	18.29	8.48	205.15	116.89	0.77	0.202	1.48	**0.120**
11400	17.70	7.90	208.69	118.47	0.76	0.202	1.48	**0.119**
11600	18.07	8.26	212.31	120.12	0.76	0.202	1.48	**0.119**
11800	17.92	8.11	215.89	121.74	0.75	0.202	1.48	**0.119**
12000	18.40	8.60	219.57	123.46	0.75	0.202	1.48	**0.118**
12200	18.74	8.94	223.32	125.25	0.74	0.202	1.48	**0.118**
12400	18.97	9.16	227.11	127.08	0.74	0.202	1.48	**0.117**
12600	18.90	9.09	230.89	128.90	0.74	0.202	1.48	**0.117**
12800	18.50	8.69	234.59	130.64	0.73	0.202	1.48	**0.116**
13000	19.25	9.45	238.44	132.53	0.73	0.202	1.48	**0.116**
13200	19.26	9.46	242.30	134.42	0.72	0.202	1.48	**0.115**
13400	18.68	8.87	246.03	136.19	0.72	0.202	1.48	**0.115**
13600	19.68	9.87	249.97	138.17	0.71	0.202	1.48	**0.114**
13800	19.81	10.00	253.93	140.17	0.71	0.202	1.48	**0.113**
14000	19.58	9.77	257.85	142.12	0.70	0.202	1.48	**0.113**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

SHEET : 4 OF 14

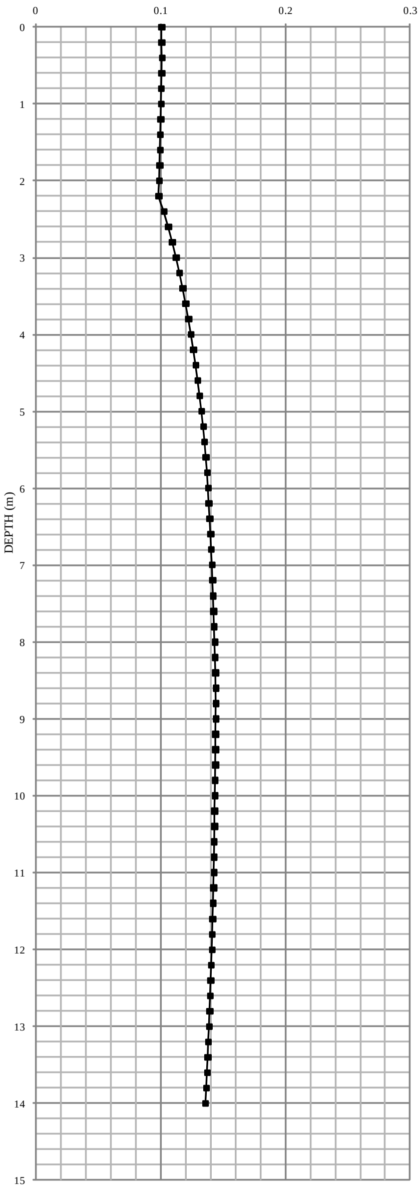
CYCLIC STRESS RATIO FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.60	20.60	4.12	4.12	1.00	0.202	1.30	**0.101**
400	21.28	21.28	8.38	8.38	1.00	0.202	1.30	**0.101**
600	20.93	20.93	12.56	12.56	1.00	0.202	1.30	**0.101**
800	20.90	20.90	16.74	16.74	1.00	0.202	1.30	**0.101**
1000	20.67	20.67	20.88	20.88	1.00	0.202	1.30	**0.101**
1200	20.00	20.00	24.88	24.88	0.99	0.202	1.30	**0.100**
1400	19.59	19.59	28.79	28.79	0.99	0.202	1.30	**0.100**
1600	19.58	19.58	32.71	32.71	0.99	0.202	1.30	**0.100**
1800	19.15	19.15	36.54	36.54	0.98	0.202	1.30	**0.099**
2000	19.34	19.34	40.41	40.41	0.98	0.202	1.30	**0.099**
2200	18.85	18.85	44.18	44.18	0.98	0.202	1.30	**0.099**
2400	18.51	8.70	47.88	45.92	0.98	0.202	1.30	**0.103**
2600	18.34	8.53	51.55	47.62	0.97	0.202	1.30	**0.106**
2800	18.40	8.59	55.23	49.34	0.97	0.202	1.30	**0.110**
3000	18.32	8.51	58.89	51.04	0.97	0.202	1.30	**0.113**
3200	18.30	8.50	62.55	52.74	0.96	0.202	1.30	**0.115**
3400	18.16	8.35	66.18	54.41	0.96	0.202	1.30	**0.118**
3600	17.90	8.10	69.76	56.03	0.96	0.202	1.30	**0.120**
3800	17.62	7.82	73.29	57.60	0.95	0.202	1.30	**0.122**
4000	17.40	7.59	76.77	59.11	0.95	0.202	1.30	**0.125**
4200	17.29	7.48	80.22	60.61	0.95	0.202	1.30	**0.126**
4400	17.25	7.44	83.67	62.10	0.94	0.202	1.30	**0.128**
4600	17.12	7.31	87.10	63.56	0.94	0.202	1.30	**0.130**
4800	17.32	7.52	90.56	65.06	0.94	0.202	1.30	**0.132**
5000	17.09	7.29	93.98	66.52	0.93	0.202	1.30	**0.133**
5200	16.96	7.15	97.37	67.95	0.93	0.202	1.30	**0.134**
5400	17.24	7.43	100.82	69.44	0.92	0.202	1.30	**0.136**
5600	18.15	8.35	104.45	71.11	0.92	0.202	1.30	**0.137**
5800	18.06	8.25	108.06	72.76	0.92	0.202	1.30	**0.138**
6000	19.46	9.66	111.96	74.69	0.91	0.202	1.30	**0.138**
6200	19.08	9.28	115.77	76.54	0.91	0.202	1.30	**0.139**
6400	17.53	7.72	119.28	78.09	0.91	0.202	1.30	**0.140**
6600	18.26	8.45	122.93	79.78	0.90	0.202	1.30	**0.140**
6800	17.88	8.07	126.50	81.39	0.90	0.202	1.30	**0.141**
7000	17.81	8.00	130.07	82.99	0.89	0.202	1.30	**0.141**
7200	17.74	7.93	133.62	84.58	0.89	0.202	1.30	**0.142**
7400	17.43	7.62	137.10	86.11	0.89	0.202	1.30	**0.142**
7600	17.10	7.29	140.52	87.56	0.88	0.202	1.30	**0.143**
7800	17.23	7.42	143.97	89.05	0.88	0.202	1.30	**0.143**
8000	16.78	6.97	147.32	90.44	0.87	0.202	1.30	**0.144**
8200	16.29	6.49	150.58	91.74	0.87	0.202	1.30	**0.144**
8400	16.31	6.51	153.84	93.04	0.86	0.202	1.30	**0.144**
8600	18.14	8.33	157.47	94.71	0.86	0.202	1.30	**0.144**
8800	18.01	8.20	161.07	96.35	0.86	0.202	1.30	**0.144**
9000	18.85	9.05	164.85	98.16	0.85	0.202	1.30	**0.144**
9200	18.94	9.13	168.63	99.98	0.85	0.202	1.30	**0.144**
9400	18.70	8.90	172.37	101.76	0.84	0.202	1.30	**0.144**
9600	18.47	8.66	176.07	103.49	0.84	0.202	1.30	**0.144**
9800	18.38	8.57	179.74	105.21	0.83	0.202	1.30	**0.144**
10000	19.01	9.20	183.54	107.05	0.83	0.202	1.30	**0.144**
10200	18.77	8.96	187.30	108.84	0.83	0.202	1.30	**0.143**
10400	17.01	7.20	190.70	110.28	0.82	0.202	1.30	**0.143**
10600	17.78	7.98	194.26	111.88	0.82	0.202	1.30	**0.143**
10800	18.07	8.27	197.87	113.53	0.81	0.202	1.30	**0.143**
11000	18.12	8.32	201.50	115.19	0.81	0.202	1.30	**0.143**
11200	18.29	8.48	205.15	116.89	0.80	0.202	1.30	**0.143**
11400	17.70	7.90	208.69	118.47	0.80	0.202	1.30	**0.142**
11600	18.07	8.26	212.31	120.12	0.80	0.202	1.30	**0.142**
11800	17.92	8.11	215.89	121.74	0.79	0.202	1.30	**0.142**
12000	18.40	8.60	219.57	123.46	0.79	0.202	1.30	**0.141**
12200	18.74	8.94	223.32	125.25	0.78	0.202	1.30	**0.141**
12400	18.97	9.16	227.11	127.08	0.78	0.202	1.30	**0.140**
12600	18.90	9.09	230.89	128.90	0.77	0.202	1.30	**0.140**
12800	18.50	8.69	234.59	130.64	0.77	0.202	1.30	**0.140**
13000	19.25	9.45	238.44	132.53	0.77	0.202	1.30	**0.139**
13200	19.26	9.46	242.30	134.42	0.76	0.202	1.30	**0.139**
13400	18.68	8.87	246.03	136.19	0.76	0.202	1.30	**0.138**
13600	19.68	9.87	249.97	138.17	0.75	0.202	1.30	**0.137**
13800	19.81	10.00	253.93	140.17	0.75	0.202	1.30	**0.137**
14000	19.58	9.77	257.85	142.12	0.74	0.202	1.30	**0.136**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

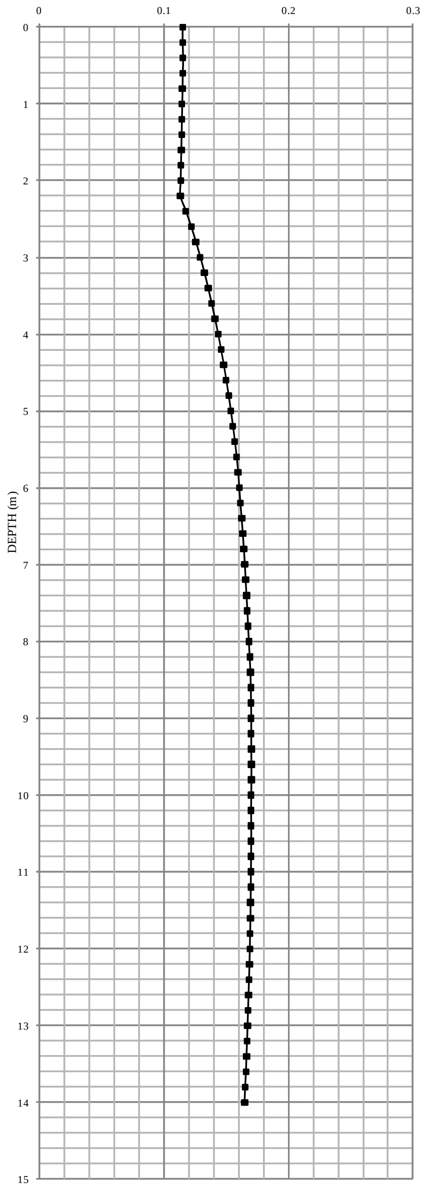
SHEET : 5 OF 14

CYCLIC STRESS RATIO FOR M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.60	20.60	4.12	4.12	1.00	0.202	1.14	**0.115**
400	21.28	21.28	8.38	8.38	1.00	0.202	1.14	**0.115**
600	20.93	20.93	12.56	12.56	1.00	0.202	1.14	**0.115**
800	20.90	20.90	16.74	16.74	1.00	0.202	1.14	**0.115**
1000	20.67	20.67	20.88	20.88	1.00	0.202	1.14	**0.115**
1200	20.00	20.00	24.88	24.88	1.00	0.202	1.14	**0.115**
1400	19.59	19.59	28.79	28.79	0.99	0.202	1.14	**0.114**
1600	19.58	19.58	32.71	32.71	0.99	0.202	1.14	**0.114**
1800	19.15	19.15	36.54	36.54	0.99	0.202	1.14	**0.114**
2000	19.34	19.34	40.41	40.41	0.99	0.202	1.14	**0.114**
2200	18.85	18.85	44.18	44.18	0.98	0.202	1.14	**0.113**
2400	18.51	8.70	47.88	45.92	0.98	0.202	1.14	**0.118**
2600	18.34	8.53	51.55	47.62	0.98	0.202	1.14	**0.122**
2800	18.40	8.59	55.23	49.34	0.98	0.202	1.14	**0.126**
3000	18.32	8.51	58.89	51.04	0.97	0.202	1.14	**0.129**
3200	18.30	8.50	62.55	52.74	0.97	0.202	1.14	**0.133**
3400	18.16	8.35	66.18	54.41	0.97	0.202	1.14	**0.136**
3600	17.90	8.10	69.76	56.03	0.97	0.202	1.14	**0.138**
3800	17.62	7.82	73.29	57.60	0.96	0.202	1.14	**0.141**
4000	17.40	7.59	76.77	59.11	0.96	0.202	1.14	**0.144**
4200	17.29	7.48	80.22	60.61	0.96	0.202	1.14	**0.146**
4400	17.25	7.44	83.67	62.10	0.96	0.202	1.14	**0.148**
4600	17.12	7.31	87.10	63.56	0.95	0.202	1.14	**0.150**
4800	17.32	7.52	90.56	65.06	0.95	0.202	1.14	**0.152**
5000	17.09	7.29	93.98	66.52	0.95	0.202	1.14	**0.154**
5200	16.96	7.15	97.37	67.95	0.94	0.202	1.14	**0.156**
5400	17.24	7.43	100.82	69.44	0.94	0.202	1.14	**0.157**
5600	18.15	8.35	104.45	71.11	0.94	0.202	1.14	**0.158**
5800	18.06	8.25	108.06	72.76	0.93	0.202	1.14	**0.160**
6000	19.46	9.66	111.96	74.69	0.93	0.202	1.14	**0.161**
6200	19.08	9.28	115.77	76.54	0.93	0.202	1.14	**0.161**
6400	17.53	7.72	119.28	78.09	0.92	0.202	1.14	**0.163**
6600	18.26	8.45	122.93	79.78	0.92	0.202	1.14	**0.163**
6800	17.88	8.07	126.50	81.39	0.92	0.202	1.14	**0.164**
7000	17.81	8.00	130.07	82.99	0.91	0.202	1.14	**0.165**
7200	17.74	7.93	133.62	84.58	0.91	0.202	1.14	**0.166**
7400	17.43	7.62	137.10	86.11	0.91	0.202	1.14	**0.166**
7600	17.10	7.29	140.52	87.56	0.90	0.202	1.14	**0.167**
7800	17.23	7.42	143.97	89.05	0.90	0.202	1.14	**0.168**
8000	16.78	6.97	147.32	90.44	0.90	0.202	1.14	**0.168**
8200	16.29	6.49	150.58	91.74	0.89	0.202	1.14	**0.169**
8400	16.31	6.51	153.84	93.04	0.89	0.202	1.14	**0.170**
8600	18.14	8.33	157.47	94.71	0.89	0.202	1.14	**0.170**
8800	18.01	8.20	161.07	96.35	0.88	0.202	1.14	**0.170**
9000	18.85	9.05	164.85	98.16	0.88	0.202	1.14	**0.170**
9200	18.94	9.13	168.63	99.98	0.88	0.202	1.14	**0.170**
9400	18.70	8.90	172.37	101.76	0.87	0.202	1.14	**0.170**
9600	18.47	8.66	176.07	103.49	0.87	0.202	1.14	**0.170**
9800	18.38	8.57	179.74	105.21	0.87	0.202	1.14	**0.170**
10000	19.01	9.20	183.54	107.05	0.86	0.202	1.14	**0.170**
10200	18.77	8.96	187.30	108.84	0.86	0.202	1.14	**0.170**
10400	17.01	7.20	190.70	110.28	0.86	0.202	1.14	**0.170**
10600	17.78	7.98	194.26	111.88	0.85	0.202	1.14	**0.170**
10800	18.07	8.27	197.87	113.53	0.85	0.202	1.14	**0.170**
11000	18.12	8.32	201.50	115.19	0.84	0.202	1.14	**0.170**
11200	18.29	8.48	205.15	116.89	0.84	0.202	1.14	**0.170**
11400	17.70	7.90	208.69	118.47	0.84	0.202	1.14	**0.170**
11600	18.07	8.26	212.31	120.12	0.83	0.202	1.14	**0.170**
11800	17.92	8.11	215.89	121.74	0.83	0.202	1.14	**0.169**
12000	18.40	8.60	219.57	123.46	0.83	0.202	1.14	**0.169**
12200	18.74	8.94	223.32	125.25	0.82	0.202	1.14	**0.169**
12400	18.97	9.16	227.11	127.08	0.82	0.202	1.14	**0.168**
12600	18.90	9.09	230.89	128.90	0.82	0.202	1.14	**0.168**
12800	18.50	8.69	234.59	130.64	0.81	0.202	1.14	**0.168**
13000	19.25	9.45	238.44	132.53	0.81	0.202	1.14	**0.167**
13200	19.26	9.46	242.30	134.42	0.80	0.202	1.14	**0.167**
13400	18.68	8.87	246.03	136.19	0.80	0.202	1.14	**0.166**
13600	19.68	9.87	249.97	138.17	0.80	0.202	1.14	**0.166**
13800	19.81	10.00	253.93	140.17	0.79	0.202	1.14	**0.165**
14000	19.58	9.77	257.85	142.12	0.79	0.202	1.14	**0.165**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

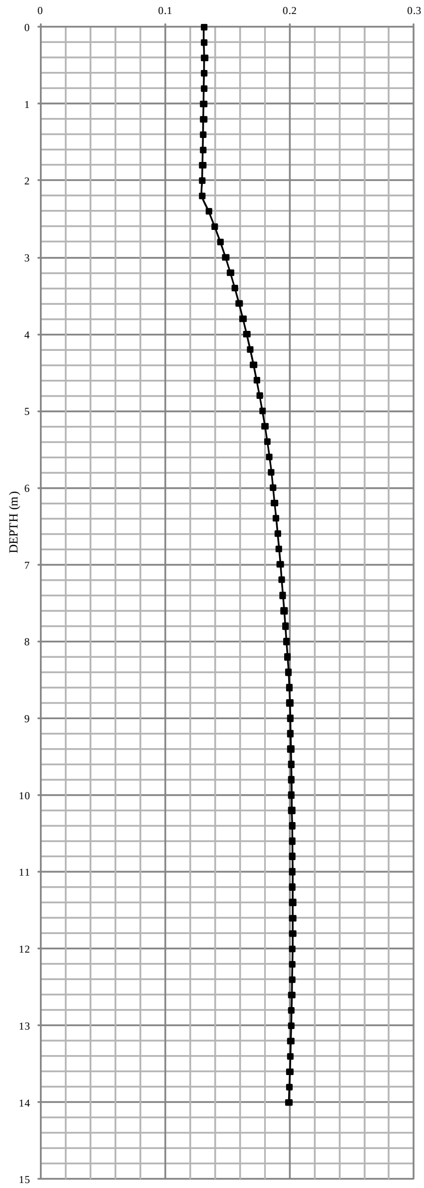
SHEET : 6 OF 14

CYCLIC STRESS RATIO FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.60	20.60	4.12	4.12	1.00	0.202	1	**0.131**
400	21.28	21.28	8.38	8.38	1.00	0.202	1	**0.132**
600	20.93	20.93	12.56	12.56	1.00	0.202	1	**0.132**
800	20.90	20.90	16.74	16.74	1.00	0.202	1	**0.131**
1000	20.67	20.67	20.88	20.88	1.00	0.202	1	**0.131**
1200	20.00	20.00	24.88	24.88	1.00	0.202	1	**0.131**
1400	19.59	19.59	28.79	28.79	1.00	0.202	1	**0.131**
1600	19.58	19.58	32.71	32.71	0.99	0.202	1	**0.131**
1800	19.15	19.15	36.54	36.54	0.99	0.202	1	**0.130**
2000	19.34	19.34	40.41	40.41	0.99	0.202	1	**0.130**
2200	18.85	18.85	44.18	44.18	0.99	0.202	1	**0.130**
2400	18.51	8.70	47.88	45.92	0.99	0.202	1	**0.135**
2600	18.34	8.53	51.55	47.62	0.99	0.202	1	**0.140**
2800	18.40	8.59	55.23	49.34	0.98	0.202	1	**0.145**
3000	18.32	8.51	58.89	51.04	0.98	0.202	1	**0.149**
3200	18.30	8.50	62.55	52.74	0.98	0.202	1	**0.153**
3400	18.16	8.35	66.18	54.41	0.98	0.202	1	**0.156**
3600	17.90	8.10	69.76	56.03	0.98	0.202	1	**0.160**
3800	17.62	7.82	73.29	57.60	0.97	0.202	1	**0.163**
4000	17.40	7.59	76.77	59.11	0.97	0.202	1	**0.166**
4200	17.29	7.48	80.22	60.61	0.97	0.202	1	**0.169**
4400	17.25	7.44	83.67	62.10	0.97	0.202	1	**0.171**
4600	17.12	7.31	87.10	63.56	0.97	0.202	1	**0.174**
4800	17.32	7.52	90.56	65.06	0.96	0.202	1	**0.176**
5000	17.09	7.29	93.98	66.52	0.96	0.202	1	**0.178**
5200	16.96	7.15	97.37	67.95	0.96	0.202	1	**0.180**
5400	17.24	7.43	100.82	69.44	0.96	0.202	1	**0.182**
5600	18.15	8.35	104.45	71.11	0.95	0.202	1	**0.184**
5800	18.06	8.25	108.06	72.76	0.95	0.202	1	**0.186**
6000	19.46	9.66	111.96	74.69	0.95	0.202	1	**0.187**
6200	19.08	9.28	115.77	76.54	0.95	0.202	1	**0.188**
6400	17.53	7.72	119.28	78.09	0.94	0.202	1	**0.189**
6600	18.26	8.45	122.93	79.78	0.94	0.202	1	**0.191**
6800	17.88	8.07	126.50	81.39	0.94	0.202	1	**0.192**
7000	17.81	8.00	130.07	82.99	0.94	0.202	1	**0.193**
7200	17.74	7.93	133.62	84.58	0.93	0.202	1	**0.194**
7400	17.43	7.62	137.10	86.11	0.93	0.202	1	**0.195**
7600	17.10	7.29	140.52	87.56	0.93	0.202	1	**0.196**
7800	17.23	7.42	143.97	89.05	0.93	0.202	1	**0.197**
8000	16.78	6.97	147.32	90.44	0.92	0.202	1	**0.198**
8200	16.29	6.49	150.58	91.74	0.92	0.202	1	**0.198**
8400	16.31	6.51	153.84	93.04	0.92	0.202	1	**0.199**
8600	18.14	8.33	157.47	94.71	0.92	0.202	1	**0.200**
8800	18.01	8.20	161.07	96.35	0.91	0.202	1	**0.200**
9000	18.85	9.05	164.85	98.16	0.91	0.202	1	**0.201**
9200	18.94	9.13	168.63	99.98	0.91	0.202	1	**0.201**
9400	18.70	8.90	172.37	101.76	0.90	0.202	1	**0.201**
9600	18.47	8.66	176.07	103.49	0.90	0.202	1	**0.201**
9800	18.38	8.57	179.74	105.21	0.90	0.202	1	**0.202**
10000	19.01	9.20	183.54	107.05	0.90	0.202	1	**0.202**
10200	18.77	8.96	187.30	108.84	0.89	0.202	1	**0.202**
10400	17.01	7.20	190.70	110.28	0.89	0.202	1	**0.202**
10600	17.78	7.98	194.26	111.88	0.89	0.202	1	**0.202**
10800	18.07	8.27	197.87	113.53	0.88	0.202	1	**0.202**
11000	18.12	8.32	201.50	115.19	0.88	0.202	1	**0.203**
11200	18.29	8.48	205.15	116.89	0.88	0.202	1	**0.203**
11400	17.70	7.90	208.69	118.47	0.88	0.202	1	**0.203**
11600	18.07	8.26	212.31	120.12	0.87	0.202	1	**0.203**
11800	17.92	8.11	215.89	121.74	0.87	0.202	1	**0.203**
12000	18.40	8.60	219.57	123.46	0.87	0.202	1	**0.202**
12200	18.74	8.94	223.32	125.25	0.86	0.202	1	**0.202**
12400	18.97	9.16	227.11	127.08	0.86	0.202	1	**0.202**
12600	18.90	9.09	230.89	128.90	0.86	0.202	1	**0.202**
12800	18.50	8.69	234.59	130.64	0.86	0.202	1	**0.202**
13000	19.25	9.45	238.44	132.53	0.85	0.202	1	**0.201**
13200	19.26	9.46	242.30	134.42	0.85	0.202	1	**0.201**
13400	18.68	8.87	246.03	136.19	0.85	0.202	1	**0.201**
13600	19.68	9.87	249.97	138.17	0.84	0.202	1	**0.200**
13800	19.81	10.00	253.93	140.17	0.84	0.202	1	**0.200**
14000	19.58	9.77	257.85	142.12	0.84	0.202	1	**0.199**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

SHEET : 7 OF 14

SOIL BEHAVIOUR TYPE INDEX CORRECTION

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	γ (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	F	$Q_{(1)}$	$I_{c(1)}$	1st Screening	$Q_{(0.5)}$	$C_{Q(0.5)}$	$I_{c(0.5)}$	2nd Screening	$I_{c(3)}$	q_{c1N}
200	6140	43.15	20.60	4.12	4.12	0.01	1489.32	0.98	to the next step	300.3	1.7	1.4	<------------------------Use the Ic(2)	---------------	103.0
400	6610	127.25	21.28	8.38	8.38	0.02	788.17	0.76	to the next step	226.6	1.7	1.2	<------------------------Use the Ic(2)	---------------	110.9
600	9080	124.85	20.93	12.56	12.56	0.01	721.79	0.89	to the next step	254.1	1.7	1.2	<------------------------Use the Ic(2)	---------------	152.3
800	4720	137.10	20.90	16.74	16.74	0.03	280.91	1.07	to the next step	114.2	1.7	1.4	<------------------------Use the Ic(2)	---------------	79.2
1000	2630	127.47	20.67	20.88	20.88	0.05	124.98	1.38	to the next step	56.7	1.7	1.7	<------------------------Use the Ic(2)	---------------	44.1
1200	1600	81.35	20.00	24.88	24.88	0.05	63.32	1.67	to the next step	31.4	1.7	2.0	<------------------------Use the Ic(2)	---------------	26.8
1400	4570	58.50	19.59	28.79	28.79	0.01	157.71	1.44	to the next step	84.1	1.7	1.7	<------------------------Use the Ic(2)	---------------	76.7
1600	3130	62.65	19.58	32.71	32.71	0.02	94.69	1.57	to the next step	53.8	1.7	1.8	<------------------------Use the Ic(2)	---------------	52.5
1800	3290	45.45	19.15	36.54	36.54	0.01	89.04	1.65	to the next step	53.5	1.7	1.9	<------------------------Use the Ic(2)	---------------	54.1
2000	1710	61.26	19.34	40.41	40.41	0.04	41.32	1.87	to the next step	26.1	1.6	2.1	<------------------------Use the Ic(2)	---------------	26.7
2200	1780	41.05	18.85	44.18	44.18	0.02	39.29	1.92	to the next step	25.9	1.5	2.1	<------------------------Use the Ic(2)	---------------	26.6
2400	1360	33.25	18.51	47.88	47.88	0.03	27.41	2.07	to the next step	18.8	1.5	2.2	<------------------------Use the Ic(2)	---------------	19.5
2600	2110	27.95	18.34	51.55	51.55	0.01	39.93	1.98	to the next step	28.5	1.4	2.1	<------------------------Use the Ic(2)	---------------	29.2
2800	2480	30.60	18.40	55.23	55.23	0.01	43.91	1.95	to the next step	32.4	1.4	2.1	<------------------------Use the Ic(2)	---------------	33.2
3000	2520	29.74	18.32	58.89	58.89	0.01	41.79	1.98	to the next step	31.9	1.3	2.1	<------------------------Use the Ic(2)	---------------	32.6
3200	2560	30.53	18.30	62.55	62.55	0.01	39.93	1.99	to the next step	31.4	1.3	2.1	<------------------------Use the Ic(2)	---------------	32.2
3400	2100	28.15	18.16	66.18	66.18	0.01	30.73	2.08	to the next step	24.8	1.2	2.2	<------------------------Use the Ic(2)	---------------	25.6
3600	1020	26.50	17.90	69.76	69.76	0.03	13.62	2.36	to the next step	11.3	1.2	2.4	<------------------------Use the Ic(2)	---------------	12.1
3800	610	25.65	17.62	73.29	73.29	0.05	7.32	2.61	Lab check		1.4				8.3
4000	530	23.05	17.40	76.77	76.77	0.05	5.90	2.70	Lab check		1.3				6.9
4200	440	23.89	17.29	80.22	80.22	0.07	4.48	2.82	Lab check		1.3				5.5
4400	450	23.40	17.25	83.67	83.67	0.06	4.38	2.83	Lab check		1.2				5.4
4600	480	20.50	17.12	87.10	87.10	0.05	4.51	2.82	Lab check		1.2				5.5
4800	500	24.95	17.32	90.56	90.56	0.06	4.52	2.81	Lab check		1.1				5.5
5000	430	22.60	17.09	93.98	93.98	0.07	3.58	2.92	Lab check		1.1				4.6
5200	460	19.63	16.96	97.37	97.37	0.05	3.72	2.90	Lab check		1.0				4.7
5400	550	23.70	17.24	100.82	100.82	0.05	4.46	2.82	Lab check		1.0				5.5
5600	1670	39.85	18.15	104.45	104.45	0.03	14.99	2.32	to the next step	15.2	1.0	2.3	<------------------------Use the Ic(2)	---------------	16.2
5800	1960	36.63	18.06	108.06	108.06	0.02	17.14	2.29	to the next step	17.7	1.0	2.3	<------------------------Use the Ic(2)	---------------	18.7
6000	2790	132.95	19.46	111.96	111.96	0.05	23.92	2.09	to the next step	25.1	1.0	2.1	<------------------------Use the Ic(2)	---------------	26.2
6200	1180	107.55	19.08	115.77	115.77	0.10	9.19	2.52	to the next step	9.8	0.9	2.5	<------------------------Use the Ic(2)	---------------	10.9
6400	1530	24.85	17.53	119.28	119.28	0.02	11.83	2.46	to the next step	12.8	0.9	2.4	<------------------------Use the Ic(2)	---------------	13.9
6600	2060	47.42	18.26	122.93	122.93	0.02	15.76	2.31	to the next step	17.4	0.9	2.3	<------------------------Use the Ic(2)	---------------	18.5
6800	1650	35.10	17.88	126.50	126.50	0.02	12.04	2.43	to the next step	13.5	0.9	2.4	<------------------------Use the Ic(2)	---------------	14.6
7000	1870	33.05	17.81	130.07	130.07	0.02	13.38	2.40	to the next step	15.2	0.9	2.3	<------------------------Use the Ic(2)	---------------	16.3
7200	4420	30.47	17.74	133.62	133.62	0.01	32.08	2.17	to the next step	36.8	0.9	2.1	<------------------------Use the Ic(2)	---------------	38.0
7400	2320	23.60	17.43	137.10	137.10	0.01	15.92	2.39	to the next step	18.5	0.9	2.3	<------------------------Use the Ic(2)	---------------	19.7
7600	1660	18.35	17.10	140.52	140.52	0.01	10.81	2.53	to the next step	12.7	0.8	2.5	<------------------------Use the Ic(2)	---------------	13.9
7800	1970	20.60	17.23	143.97	143.97	0.01	12.68	2.48	to the next step	15.1	0.8	2.4	<------------------------Use the Ic(2)	---------------	16.3
8000	1020	15.75	16.78	147.32	147.32	0.02	5.92	2.75	Lab check		0.7				6.9
8200	870	10.74	16.29	150.58	150.58	0.01	4.78	2.86	Lab check		0.7				5.8
8400	850	11.20	16.31	153.84	153.84	0.02	4.53	2.87	Lab check		0.7				5.5
8600	2460	49.75	18.14	157.47	157.47	0.02	14.62	2.35	to the next step	18.2	0.8	2.3	<------------------------Use the Ic(2)	---------------	19.5
8800	1820	46.10	18.01	161.07	161.07	0.03	10.30	2.48	to the next step	13.0	0.8	2.4	<------------------------Use the Ic(2)	---------------	14.2
9000	2960	98.16	18.85	164.85	164.85	0.04	16.96	2.25	to the next step	21.6	0.8	2.1	<------------------------Use the Ic(2)	---------------	22.9
9200	2380	108.55	18.94	168.63	168.63	0.05	13.11	2.35	to the next step	16.9	0.8	2.2	<------------------------Use the Ic(2)	---------------	18.2
9400	2080	90.00	18.70	172.37	172.37	0.05	11.07	2.43	to the next step	14.4	0.8	2.3	<------------------------Use the Ic(2)	---------------	15.7
9600	1820	74.40	18.47	176.07	176.07	0.05	9.34	2.50	to the next step	12.3	0.8	2.4	<------------------------Use the Ic(2)	---------------	13.6
9800	2010	68.60	18.38	179.74	179.74	0.04	10.18	2.47	to the next step	13.6	0.8	2.3	<------------------------Use the Ic(2)	---------------	14.9
10000	3190	120.90	19.01	183.54	183.54	0.04	16.38	2.26	to the next step	22.0	0.7	2.1	<------------------------Use the Ic(2)	---------------	23.4
10200	2200	100.17	18.77	187.30	187.30	0.05	10.75	2.44	to the next step	14.6	0.7	2.3	<------------------------Use the Ic(2)	---------------	16.0
10400	2130	20.10	17.01	190.70	190.70	0.01	10.17	2.58	to the next step	14.0	0.7	2.4	<------------------------Use the Ic(2)	---------------	15.3
10600	1890	42.05	17.78	194.26	194.26	0.02	8.73	2.56	to the next step	12.1	0.7	2.4	<------------------------Use the Ic(2)	---------------	13.5
10800	2120	54.90	18.07	197.87	197.87	0.03	9.71	2.50	to the next step	13.6	0.7	2.4	<------------------------Use the Ic(2)	---------------	15.0
11000	2460	57.50	18.12	201.50	201.50	0.03	11.21	2.45	to the next step	15.8	0.7	2.3	<------------------------Use the Ic(2)	---------------	17.2
11200	2460	67.68	18.29	205.15	205.15	0.03	10.99	2.45	to the next step	15.6	0.7	2.3	<------------------------Use the Ic(2)	---------------	17.1
11400	2440	39.95	17.70	208.69	208.69	0.02	10.69	2.50	to the next step	15.3	0.7	2.3	<------------------------Use the Ic(2)	---------------	16.8
11600	2020	57.50	18.07	212.31	212.31	0.03	8.51	2.55	to the next step	12.3	0.7	2.4	<------------------------Use the Ic(2)	---------------	13.8
11800	2230	50.16	17.92	215.89	215.89	0.02	9.33	2.53	to the next step	13.6	0.7	2.4	<------------------------Use the Ic(2)	---------------	15.1
12000	2330	79.10	18.40	219.57	219.57	0.04	9.61	2.50	to the next step	14.1	0.7	2.3	<------------------------Use the Ic(2)	---------------	15.6
12200	2720	108.16	18.74	223.32	223.32	0.04	11.18	2.43	to the next step	16.6	0.7	2.3	<------------------------Use the Ic(2)	---------------	18.1
12400	3060	134.25	18.97	227.11	227.11	0.05	12.47	2.38	to the next step	18.7	0.7	2.2	<------------------------Use the Ic(2)	---------------	20.2
12600	3570	126.75	18.90	230.89	230.89	0.04	14.46	2.32	to the next step	21.8	0.7	2.1	<------------------------Use the Ic(2)	---------------	23.3
12800	4000	88.42	18.50	234.59	234.59	0.02	16.05	2.30	to the next step	24.4	0.7	2.1	<------------------------Use the Ic(2)	---------------	25.9
13000	4790	180.90	19.25	238.44	238.44	0.04	19.09	2.20	to the next step	29.3	0.7	2.0	<------------------------Use the Ic(2)	---------------	30.8
13200	3900	182.79	19.26	242.30	242.30	0.05	15.10	2.29	to the next step	23.3	0.6	2.1	<------------------------Use the Ic(2)	---------------	24.9
13400	5900	110.16	18.68	246.03	246.03	0.02	22.98	2.16	to the next step	35.8	0.6	2.0	<------------------------Use the Ic(2)	---------------	37.4
13600	7570	286.55	19.68	249.97	249.97	0.04	29.28	2.01	to the next step	46.0	0.6	1.8	<------------------------Use the Ic(2)	---------------	47.6
13800	4340	313.05	19.81	253.93	253.93	0.08	16.09	2.27	to the next step	25.5	0.6	2.1	<------------------------Use the Ic(2)	---------------	27.1
14000	6270	261.80	19.58	257.85	257.85	0.04	23.32	2.11	to the next step	37.2	0.6	1.9	<------------------------Use the Ic(2)	---------------	38.8

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

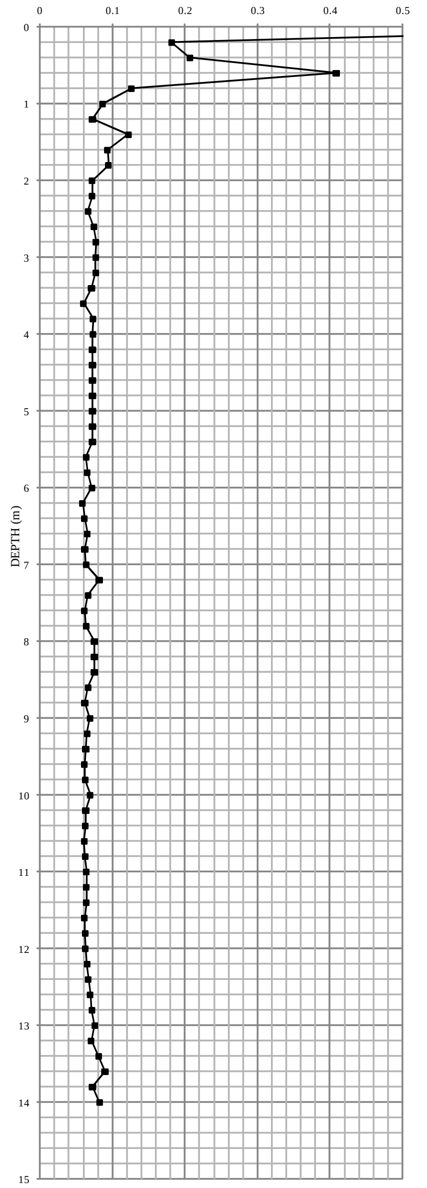
SHEET : 8 OF 14

CYCLIC RESISTANCE RATIO

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (MPa)	σ'_v (kN/m^2)	P_a (kN/m^2)	q_{c1N}	I_c	K_c	q_{c1Ncs}	$CRR_{M=7.5}$
200	6.14	4.12	101.325	103.02	1.36	1.00	**103.02**	**0.18**
400	6.61	8.38	101.325	110.90	1.22	1.00	**110.90**	**0.21**
600	9.08	12.56	101.325	152.34	1.24	1.00	**152.34**	**0.41**
800	4.72	16.74	101.325	79.19	1.45	1.00	**79.19**	**0.13**
1000	2.63	20.88	101.325	44.13	1.72	1.00	**44.13**	**0.09**
1200	1.6	24.88	101.325	26.84	1.97	1.00	**26.84**	**0.07**
1400	4.57	28.79	101.325	76.67	1.68	1.00	**76.67**	**0.12**
1600	3.13	32.71	101.325	52.51	1.80	1.00	**52.51**	**0.09**
1800	3.29	36.54	101.325	54.07	1.85	1.00	**54.07**	**0.09**
2000	1.71	40.41	101.325	26.72	2.06	1.00	**26.72**	**0.07**
2200	1.78	44.18	101.325	26.60	2.10	1.00	**26.60**	**0.07**
2400	1.36	45.92	101.325	19.53	2.23	1.00	**19.53**	**0.07**
2600	2.11	47.62	101.325	29.20	2.12	1.00	**29.20**	**0.07**
2800	2.48	49.34	101.325	33.15	2.07	1.00	**33.15**	**0.08**
3000	2.52	51.04	101.325	32.62	2.09	1.00	**32.62**	**0.08**
3200	2.56	52.74	101.325	32.16	2.09	1.00	**32.16**	**0.08**
3400	2.1	54.41	101.325	25.64	2.17	1.00	**25.64**	**0.07**
3600	1.02	56.03	101.325	12.13	2.44	1.00	**12.13**	**0.06**
3800	0.61	57.60	101.325	8.32	2.61	3.37	**28.06**	**0.07**
4000	0.53	59.11	101.325	6.90	2.70	3.99	**27.58**	**0.07**
4200	0.44	60.61	101.325	5.48	2.82	4.94	**27.12**	**0.07**
4400	0.45	62.10	101.325	5.38	2.83	5.03	**27.08**	**0.07**
4600	0.48	63.56	101.325	5.51	2.82	4.93	**27.14**	**0.07**
4800	0.5	65.06	101.325	5.52	2.81	4.91	**27.11**	**0.07**
5000	0.43	66.52	101.325	4.58	2.92	5.87	**26.85**	**0.07**
5200	0.46	67.95	101.325	4.72	2.90	5.69	**26.89**	**0.07**
5400	0.55	69.44	101.325	5.46	2.82	4.97	**27.12**	**0.07**
5600	1.67	71.11	101.325	16.23	2.32	1.00	**16.23**	**0.06**
5800	1.96	72.76	101.325	18.73	2.27	1.00	**18.73**	**0.07**
6000	2.79	74.69	101.325	26.20	2.07	1.00	**26.20**	**0.07**
6200	1.18	76.54	101.325	10.89	2.49	1.00	**10.89**	**0.06**
6400	1.53	78.09	101.325	13.92	2.42	1.00	**13.92**	**0.06**
6600	2.06	79.78	101.325	18.46	2.26	1.00	**18.46**	**0.07**
6800	1.65	81.39	101.325	14.57	2.38	1.00	**14.57**	**0.06**
7000	1.87	82.99	101.325	16.29	2.34	1.00	**16.29**	**0.06**
7200	4.42	84.58	101.325	37.99	2.12	1.00	**37.99**	**0.08**
7400	2.32	86.11	101.325	19.68	2.33	1.00	**19.68**	**0.07**
7600	1.66	87.56	101.325	13.91	2.47	1.00	**13.91**	**0.06**
7800	1.97	89.05	101.325	16.31	2.40	1.00	**16.31**	**0.06**
8000	1.02	90.44	101.325	6.92	2.75	4.36	**30.17**	**0.08**
8200	0.87	91.74	101.325	5.78	2.86	5.28	**30.50**	**0.08**
8400	0.85	93.04	101.325	5.53	2.87	5.43	**30.01**	**0.07**
8600	2.46	94.71	101.325	19.47	2.25	1.00	**19.47**	**0.07**
8800	1.82	96.35	101.325	14.25	2.38	1.00	**14.25**	**0.06**
9000	2.96	98.16	101.325	22.90	2.15	1.00	**22.90**	**0.07**
9200	2.38	99.98	101.325	18.21	2.24	1.00	**18.21**	**0.07**
9400	2.08	101.76	101.325	15.74	2.31	1.00	**15.74**	**0.06**
9600	1.82	103.49	101.325	13.63	2.38	1.00	**13.63**	**0.06**
9800	2.01	105.21	101.325	14.89	2.35	1.00	**14.89**	**0.06**
10000	3.19	107.05	101.325	23.39	2.13	1.00	**23.39**	**0.07**
10200	2.2	108.84	101.325	15.97	2.31	1.00	**15.97**	**0.06**
10400	2.13	110.28	101.325	15.32	2.45	1.00	**15.32**	**0.06**
10600	1.89	111.88	101.325	13.47	2.42	1.00	**13.47**	**0.06**
10800	2.12	113.53	101.325	14.97	2.36	1.00	**14.97**	**0.06**
11000	2.46	115.19	101.325	17.22	2.30	1.00	**17.22**	**0.06**
11200	2.46	116.89	101.325	17.06	2.30	1.00	**17.06**	**0.06**
11400	2.44	118.47	101.325	16.78	2.34	1.00	**16.78**	**0.06**
11600	2.02	120.12	101.325	13.77	2.40	1.00	**13.77**	**0.06**
11800	2.23	121.74	101.325	15.08	2.37	1.00	**15.08**	**0.06**
12000	2.33	123.46	101.325	15.62	2.33	1.00	**15.62**	**0.06**
12200	2.72	125.25	101.325	18.08	2.25	1.00	**18.08**	**0.07**
12400	3.06	127.08	101.325	20.17	2.20	1.00	**20.17**	**0.07**
12600	3.57	128.90	101.325	23.34	2.14	1.00	**23.34**	**0.07**
12800	4	130.64	101.325	25.94	2.12	1.00	**25.94**	**0.07**
13000	4.79	132.53	101.325	30.82	2.01	1.00	**30.82**	**0.08**
13200	3.9	134.42	101.325	24.89	2.10	1.00	**24.89**	**0.07**
13400	5.9	136.19	101.325	37.37	1.98	1.00	**37.37**	**0.08**
13600	7.57	138.17	101.325	47.57	1.82	1.00	**47.57**	**0.09**
13800	4.34	140.17	101.325	27.06	2.07	1.00	**27.06**	**0.07**
14000	6.27	142.12	101.325	38.79	1.90	1.00	**38.79**	**0.08**

CPT PROFILE
FOR CYCLIC RESISTANCE



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

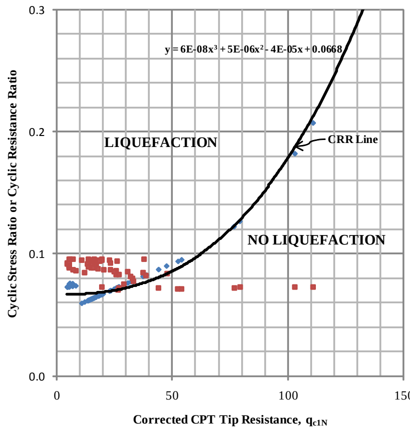
SHEET : 9 OF 14

ASSESSMENT RESULTS FOR M=5.0 & 5.5

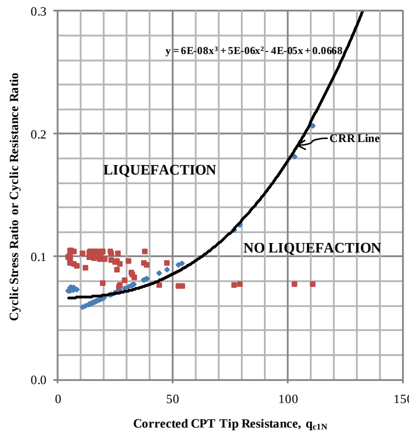
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=5.0}$**	**$CSR_{M=5.5}$**	**$CRR_{M=7.5}$**	**q_{c1N}**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.5
200	0.07	0.08	0.18	103.02	NO LIQUEFACTION	NO LIQUEFACTION
400	0.07	0.08	0.21	110.90	NO LIQUEFACTION	NO LIQUEFACTION
600	0.07	0.08	0.41	152.34	NO LIQUEFACTION	NO LIQUEFACTION
800	0.07	0.08	0.13	79.19	NO LIQUEFACTION	NO LIQUEFACTION
1000	0.07	0.08	0.09	44.13	NO LIQUEFACTION	NO LIQUEFACTION
1200	0.07	0.08	0.07	26.84	LIQUEFACTION	NO LIQUEFACTION
1400	0.07	0.08	0.12	76.67	NO LIQUEFACTION	NO LIQUEFACTION
1600	0.07	0.08	0.09	52.51	NO LIQUEFACTION	NO LIQUEFACTION
1800	0.07	0.08	0.09	54.07	NO LIQUEFACTION	NO LIQUEFACTION
2000	0.07	0.08	0.07	26.72	LIQUEFACTION	NO LIQUEFACTION
2200	0.07	0.08	0.07	26.60	NO LIQUEFACTION	NO LIQUEFACTION
2400	0.07	0.08	0.07	19.53	LIQUEFACTION	LIQUEFACTION
2600	0.08	0.08	0.07	29.20	LIQUEFACTION	LIQUEFACTION
2800	0.08	0.08	0.08	33.15	LIQUEFACTION	LIQUEFACTION
3000	0.08	0.09	0.08	32.62	LIQUEFACTION	LIQUEFACTION
3200	0.08	0.09	0.08	32.16	LIQUEFACTION	LIQUEFACTION
3400	0.08	0.09	0.07	25.64	LIQUEFACTION	LIQUEFACTION
3600	0.08	0.09	0.06	12.13	LIQUEFACTION	LIQUEFACTION
3800	0.09	0.09	0.07	8.32	LIQUEFACTION	LIQUEFACTION
4000	0.09	0.09	0.07	6.90	LIQUEFACTION	LIQUEFACTION
4200	0.09	0.10	0.07	5.48	LIQUEFACTION	LIQUEFACTION
4400	0.09	0.10	0.07	5.38	LIQUEFACTION	LIQUEFACTION
4600	0.09	0.10	0.07	5.51	LIQUEFACTION	LIQUEFACTION
4800	0.09	0.10	0.07	5.52	LIQUEFACTION	LIQUEFACTION
5000	0.09	0.10	0.07	4.58	LIQUEFACTION	LIQUEFACTION
5200	0.09	0.10	0.07	4.72	LIQUEFACTION	LIQUEFACTION
5400	0.09	0.10	0.07	5.46	LIQUEFACTION	LIQUEFACTION
5600	0.09	0.10	0.06	16.23	LIQUEFACTION	LIQUEFACTION
5800	0.09	0.10	0.07	18.73	LIQUEFACTION	LIQUEFACTION
6000	0.09	0.10	0.07	26.20	LIQUEFACTION	LIQUEFACTION
6200	0.09	0.10	0.06	10.89	LIQUEFACTION	LIQUEFACTION
6400	0.09	0.10	0.06	13.92	LIQUEFACTION	LIQUEFACTION
6600	0.09	0.10	0.07	18.46	LIQUEFACTION	LIQUEFACTION
6800	0.10	0.10	0.06	14.57	LIQUEFACTION	LIQUEFACTION
7000	0.10	0.10	0.06	16.29	LIQUEFACTION	LIQUEFACTION
7200	0.10	0.10	0.08	37.99	LIQUEFACTION	LIQUEFACTION
7400	0.10	0.10	0.07	19.68	LIQUEFACTION	LIQUEFACTION
7600	0.10	0.10	0.06	13.91	LIQUEFACTION	LIQUEFACTION
7800	0.10	0.10	0.06	16.31	LIQUEFACTION	LIQUEFACTION
8000	0.10	0.10	0.08	6.92	LIQUEFACTION	LIQUEFACTION
8200	0.10	0.10	0.08	5.78	LIQUEFACTION	LIQUEFACTION
8400	0.10	0.10	0.07	5.53	LIQUEFACTION	LIQUEFACTION
8600	0.10	0.10	0.07	19.47	LIQUEFACTION	LIQUEFACTION
8800	0.09	0.10	0.06	14.25	LIQUEFACTION	LIQUEFACTION
9000	0.09	0.10	0.07	22.90	LIQUEFACTION	LIQUEFACTION
9200	0.09	0.10	0.07	18.21	LIQUEFACTION	LIQUEFACTION
9400	0.09	0.10	0.06	15.74	LIQUEFACTION	LIQUEFACTION
9600	0.09	0.10	0.06	13.63	LIQUEFACTION	LIQUEFACTION
9800	0.09	0.10	0.06	14.89	LIQUEFACTION	LIQUEFACTION
10000	0.09	0.10	0.07	23.39	LIQUEFACTION	LIQUEFACTION
10200	0.09	0.10	0.06	15.97	LIQUEFACTION	LIQUEFACTION
10400	0.09	0.10	0.06	15.32	LIQUEFACTION	LIQUEFACTION
10600	0.09	0.10	0.06	13.47	LIQUEFACTION	LIQUEFACTION
10800	0.09	0.10	0.06	14.97	LIQUEFACTION	LIQUEFACTION
11000	0.09	0.10	0.06	17.22	LIQUEFACTION	LIQUEFACTION
11200	0.09	0.10	0.06	17.06	LIQUEFACTION	LIQUEFACTION
11400	0.09	0.10	0.06	16.78	LIQUEFACTION	LIQUEFACTION
11600	0.09	0.10	0.06	13.77	LIQUEFACTION	LIQUEFACTION
11800	0.09	0.10	0.06	15.08	LIQUEFACTION	LIQUEFACTION
12000	0.09	0.10	0.06	15.62	LIQUEFACTION	LIQUEFACTION
12200	0.09	0.10	0.07	18.08	LIQUEFACTION	LIQUEFACTION
12400	0.09	0.10	0.07	20.17	LIQUEFACTION	LIQUEFACTION
12600	0.09	0.10	0.07	23.34	LIQUEFACTION	LIQUEFACTION
12800	0.09	0.10	0.07	25.94	LIQUEFACTION	LIQUEFACTION
13000	0.09	0.10	0.08	30.82	LIQUEFACTION	LIQUEFACTION
13200	0.08	0.10	0.07	24.89	LIQUEFACTION	LIQUEFACTION
13400	0.08	0.10	0.08	37.37	LIQUEFACTION	LIQUEFACTION
13600	0.08	0.09	0.09	47.57	LIQUEFACTION	LIQUEFACTION
13800	0.08	0.09	0.07	27.06	LIQUEFACTION	LIQUEFACTION
14000	0.08	0.09	0.08	38.79	LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 5.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

SHEET : 10 OF 14

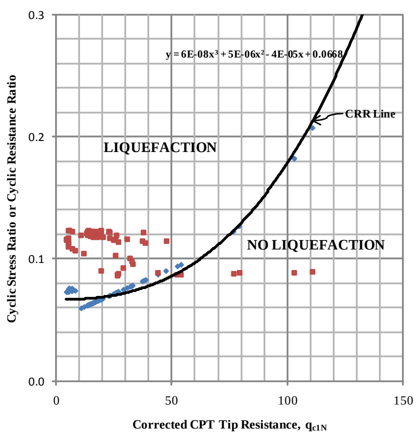
ASSESSMENT RESULTS FOR M=6.0 & 6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

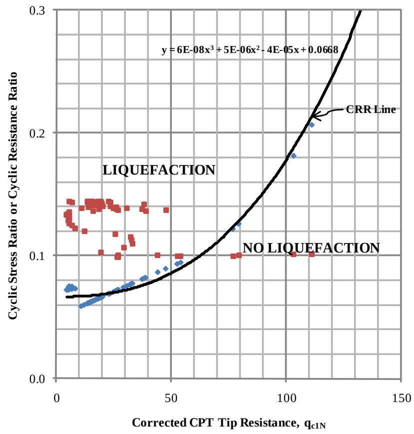
REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=6.0}$**	**$CSR_{M=6.5}$**	**$CRR_{M=7.5}$**	**q_{c1N}**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.5
200	0.09	0.10	0.18	103.02	**NO LIQUEFACTION**	**NO LIQUEFACTION**
400	0.09	0.10	0.21	110.90	**NO LIQUEFACTION**	**NO LIQUEFACTION**
600	0.09	0.10	0.41	152.34	**NO LIQUEFACTION**	**NO LIQUEFACTION**
800	0.09	0.10	0.13	79.19	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1000	0.09	0.10	0.09	44.13	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1200	0.09	0.10	0.07	26.84	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1400	0.09	0.10	0.12	76.67	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1600	0.09	0.10	0.09	52.51	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1800	0.09	0.10	0.09	54.07	**NO LIQUEFACTION**	**NO LIQUEFACTION**
2000	0.09	0.10	0.07	26.72	**NO LIQUEFACTION**	**NO LIQUEFACTION**
2200	0.09	0.10	0.07	26.60	**NO LIQUEFACTION**	**NO LIQUEFACTION**
2400	0.09	0.10	0.07	19.53	**LIQUEFACTION**	**LIQUEFACTION**
2600	0.09	0.11	0.07	29.20	**LIQUEFACTION**	**LIQUEFACTION**
2800	0.10	0.11	0.08	33.15	**LIQUEFACTION**	**LIQUEFACTION**
3000	0.10	0.11	0.08	32.62	**LIQUEFACTION**	**LIQUEFACTION**
3200	0.10	0.12	0.08	32.16	**LIQUEFACTION**	**LIQUEFACTION**
3400	0.10	0.12	0.07	25.64	**LIQUEFACTION**	**LIQUEFACTION**
3600	0.10	0.12	0.06	12.13	**LIQUEFACTION**	**LIQUEFACTION**
3800	0.11	0.12	0.07	8.32	**LIQUEFACTION**	**LIQUEFACTION**
4000	0.11	0.12	0.07	6.90	**LIQUEFACTION**	**LIQUEFACTION**
4200	0.11	0.13	0.07	5.48	**LIQUEFACTION**	**LIQUEFACTION**
4400	0.11	0.13	0.07	5.38	**LIQUEFACTION**	**LIQUEFACTION**
4600	0.11	0.13	0.07	5.51	**LIQUEFACTION**	**LIQUEFACTION**
4800	0.11	0.13	0.07	5.52	**LIQUEFACTION**	**LIQUEFACTION**
5000	0.11	0.13	0.07	4.58	**LIQUEFACTION**	**LIQUEFACTION**
5200	0.12	0.13	0.07	4.72	**LIQUEFACTION**	**LIQUEFACTION**
5400	0.12	0.14	0.07	5.46	**LIQUEFACTION**	**LIQUEFACTION**
5600	0.12	0.14	0.06	16.23	**LIQUEFACTION**	**LIQUEFACTION**
5800	0.12	0.14	0.07	18.73	**LIQUEFACTION**	**LIQUEFACTION**
6000	0.12	0.14	0.07	26.20	**LIQUEFACTION**	**LIQUEFACTION**
6200	0.12	0.14	0.06	10.89	**LIQUEFACTION**	**LIQUEFACTION**
6400	0.12	0.14	0.06	13.92	**LIQUEFACTION**	**LIQUEFACTION**
6600	0.12	0.14	0.07	18.46	**LIQUEFACTION**	**LIQUEFACTION**
6800	0.12	0.14	0.06	14.57	**LIQUEFACTION**	**LIQUEFACTION**
7000	0.12	0.14	0.06	16.29	**LIQUEFACTION**	**LIQUEFACTION**
7200	0.12	0.14	0.08	37.99	**LIQUEFACTION**	**LIQUEFACTION**
7400	0.12	0.14	0.07	19.68	**LIQUEFACTION**	**LIQUEFACTION**
7600	0.12	0.14	0.06	13.91	**LIQUEFACTION**	**LIQUEFACTION**
7800	0.12	0.14	0.06	16.31	**LIQUEFACTION**	**LIQUEFACTION**
8000	0.12	0.14	0.08	6.92	**LIQUEFACTION**	**LIQUEFACTION**
8200	0.12	0.14	0.08	5.78	**LIQUEFACTION**	**LIQUEFACTION**
8400	0.12	0.14	0.07	5.53	**LIQUEFACTION**	**LIQUEFACTION**
8600	0.12	0.14	0.07	19.47	**LIQUEFACTION**	**LIQUEFACTION**
8800	0.12	0.14	0.06	14.25	**LIQUEFACTION**	**LIQUEFACTION**
9000	0.12	0.14	0.07	22.90	**LIQUEFACTION**	**LIQUEFACTION**
9200	0.12	0.14	0.07	18.21	**LIQUEFACTION**	**LIQUEFACTION**
9400	0.12	0.14	0.06	15.74	**LIQUEFACTION**	**LIQUEFACTION**
9600	0.12	0.14	0.06	13.63	**LIQUEFACTION**	**LIQUEFACTION**
9800	0.12	0.14	0.06	14.89	**LIQUEFACTION**	**LIQUEFACTION**
10000	0.12	0.14	0.07	23.39	**LIQUEFACTION**	**LIQUEFACTION**
10200	0.12	0.14	0.06	15.97	**LIQUEFACTION**	**LIQUEFACTION**
10400	0.12	0.14	0.06	15.32	**LIQUEFACTION**	**LIQUEFACTION**
10600	0.12	0.14	0.06	13.47	**LIQUEFACTION**	**LIQUEFACTION**
10800	0.12	0.14	0.06	14.97	**LIQUEFACTION**	**LIQUEFACTION**
11000	0.12	0.14	0.06	17.22	**LIQUEFACTION**	**LIQUEFACTION**
11200	0.12	0.14	0.06	17.06	**LIQUEFACTION**	**LIQUEFACTION**
11400	0.12	0.14	0.06	16.78	**LIQUEFACTION**	**LIQUEFACTION**
11600	0.12	0.14	0.06	13.77	**LIQUEFACTION**	**LIQUEFACTION**
11800	0.12	0.14	0.06	15.08	**LIQUEFACTION**	**LIQUEFACTION**
12000	0.12	0.14	0.06	15.62	**LIQUEFACTION**	**LIQUEFACTION**
12200	0.12	0.14	0.07	18.08	**LIQUEFACTION**	**LIQUEFACTION**
12400	0.12	0.14	0.07	20.17	**LIQUEFACTION**	**LIQUEFACTION**
12600	0.12	0.14	0.07	23.34	**LIQUEFACTION**	**LIQUEFACTION**
12800	0.12	0.14	0.07	25.94	**LIQUEFACTION**	**LIQUEFACTION**
13000	0.12	0.14	0.08	30.82	**LIQUEFACTION**	**LIQUEFACTION**
13200	0.12	0.14	0.07	24.89	**LIQUEFACTION**	**LIQUEFACTION**
13400	0.11	0.14	0.08	37.37	**LIQUEFACTION**	**LIQUEFACTION**
13600	0.11	0.14	0.09	47.57	**LIQUEFACTION**	**LIQUEFACTION**
13800	0.11	0.14	0.07	27.06	**LIQUEFACTION**	**LIQUEFACTION**
14000	0.11	0.14	0.08	38.79	**LIQUEFACTION**	**LIQUEFACTION**

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 6.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)

SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

SHEET : 11 OF 14

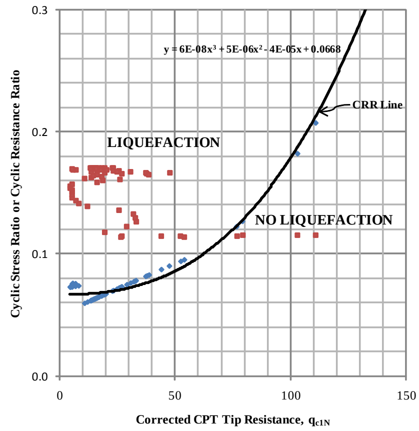
ASSESSMENT RESULTS FOR M=7.0 & 7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

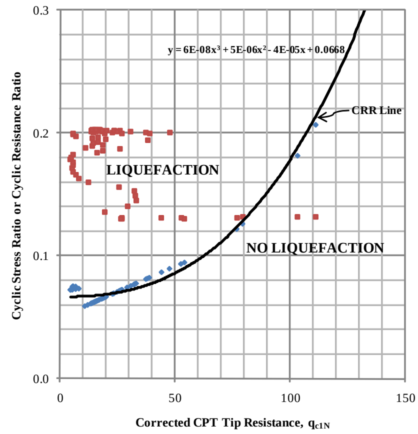
REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=7.0}$**	**$CSR_{M=7.5}$**	**$CRR_{M=7.5}$**	**q_{c1N}**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.5
200	0.12	0.13	0.18	103.02	**NO LIQUEFACTION**	**NO LIQUEFACTION**
400	0.12	0.13	0.21	110.90	**NO LIQUEFACTION**	**NO LIQUEFACTION**
600	0.12	0.13	0.41	152.34	**NO LIQUEFACTION**	**NO LIQUEFACTION**
800	0.12	0.13	0.13	79.19	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1000	0.11	0.13	0.09	44.13	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1200	0.11	0.13	0.07	26.84	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1400	0.11	0.13	0.12	76.67	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1600	0.11	0.13	0.09	52.51	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1800	0.11	0.13	0.09	54.07	**NO LIQUEFACTION**	**NO LIQUEFACTION**
2000	0.11	0.13	0.07	26.72	**NO LIQUEFACTION**	**NO LIQUEFACTION**
2200	0.11	0.13	0.07	26.60	**NO LIQUEFACTION**	**NO LIQUEFACTION**
2400	0.12	0.14	0.07	19.53	**LIQUEFACTION**	**LIQUEFACTION**
2600	0.12	0.14	0.07	29.20	**LIQUEFACTION**	**LIQUEFACTION**
2800	0.13	0.14	0.08	33.15	**LIQUEFACTION**	**LIQUEFACTION**
3000	0.13	0.15	0.08	32.62	**LIQUEFACTION**	**LIQUEFACTION**
3200	0.13	0.15	0.08	32.16	**LIQUEFACTION**	**LIQUEFACTION**
3400	0.14	0.16	0.07	25.64	**LIQUEFACTION**	**LIQUEFACTION**
3600	0.14	0.16	0.06	12.13	**LIQUEFACTION**	**LIQUEFACTION**
3800	0.14	0.16	0.07	8.32	**LIQUEFACTION**	**LIQUEFACTION**
4000	0.14	0.17	0.07	6.90	**LIQUEFACTION**	**LIQUEFACTION**
4200	0.15	0.17	0.07	5.48	**LIQUEFACTION**	**LIQUEFACTION**
4400	0.15	0.17	0.07	5.38	**LIQUEFACTION**	**LIQUEFACTION**
4600	0.15	0.17	0.07	5.51	**LIQUEFACTION**	**LIQUEFACTION**
4800	0.15	0.18	0.07	5.52	**LIQUEFACTION**	**LIQUEFACTION**
5000	0.15	0.18	0.07	4.58	**LIQUEFACTION**	**LIQUEFACTION**
5200	0.16	0.18	0.07	4.72	**LIQUEFACTION**	**LIQUEFACTION**
5400	0.16	0.18	0.07	5.46	**LIQUEFACTION**	**LIQUEFACTION**
5600	0.16	0.18	0.06	16.23	**LIQUEFACTION**	**LIQUEFACTION**
5800	0.16	0.19	0.07	18.73	**LIQUEFACTION**	**LIQUEFACTION**
6000	0.16	0.19	0.07	26.20	**LIQUEFACTION**	**LIQUEFACTION**
6200	0.16	0.19	0.06	10.89	**LIQUEFACTION**	**LIQUEFACTION**
6400	0.16	0.19	0.06	13.92	**LIQUEFACTION**	**LIQUEFACTION**
6600	0.16	0.19	0.07	18.46	**LIQUEFACTION**	**LIQUEFACTION**
6800	0.16	0.19	0.06	14.57	**LIQUEFACTION**	**LIQUEFACTION**
7000	0.16	0.19	0.06	16.29	**LIQUEFACTION**	**LIQUEFACTION**
7200	0.17	0.19	0.08	37.99	**LIQUEFACTION**	**LIQUEFACTION**
7400	0.17	0.19	0.07	19.68	**LIQUEFACTION**	**LIQUEFACTION**
7600	0.17	0.20	0.06	13.91	**LIQUEFACTION**	**LIQUEFACTION**
7800	0.17	0.20	0.06	16.31	**LIQUEFACTION**	**LIQUEFACTION**
8000	0.17	0.20	0.08	6.92	**LIQUEFACTION**	**LIQUEFACTION**
8200	0.17	0.20	0.08	5.78	**LIQUEFACTION**	**LIQUEFACTION**
8400	0.17	0.20	0.07	5.53	**LIQUEFACTION**	**LIQUEFACTION**
8600	0.17	0.20	0.07	19.47	**LIQUEFACTION**	**LIQUEFACTION**
8800	0.17	0.20	0.06	14.25	**LIQUEFACTION**	**LIQUEFACTION**
9000	0.17	0.20	0.07	22.90	**LIQUEFACTION**	**LIQUEFACTION**
9200	0.17	0.20	0.07	18.21	**LIQUEFACTION**	**LIQUEFACTION**
9400	0.17	0.20	0.06	15.74	**LIQUEFACTION**	**LIQUEFACTION**
9600	0.17	0.20	0.06	13.63	**LIQUEFACTION**	**LIQUEFACTION**
9800	0.17	0.20	0.06	14.89	**LIQUEFACTION**	**LIQUEFACTION**
10000	0.17	0.20	0.07	23.39	**LIQUEFACTION**	**LIQUEFACTION**
10200	0.17	0.20	0.06	15.97	**LIQUEFACTION**	**LIQUEFACTION**
10400	0.17	0.20	0.06	15.32	**LIQUEFACTION**	**LIQUEFACTION**
10600	0.17	0.20	0.06	13.47	**LIQUEFACTION**	**LIQUEFACTION**
10800	0.17	0.20	0.06	14.97	**LIQUEFACTION**	**LIQUEFACTION**
11000	0.17	0.20	0.06	17.22	**LIQUEFACTION**	**LIQUEFACTION**
11200	0.17	0.20	0.06	17.06	**LIQUEFACTION**	**LIQUEFACTION**
11400	0.17	0.20	0.06	16.78	**LIQUEFACTION**	**LIQUEFACTION**
11600	0.17	0.20	0.06	13.77	**LIQUEFACTION**	**LIQUEFACTION**
11800	0.17	0.20	0.06	15.08	**LIQUEFACTION**	**LIQUEFACTION**
12000	0.17	0.20	0.06	15.62	**LIQUEFACTION**	**LIQUEFACTION**
12200	0.17	0.20	0.07	18.08	**LIQUEFACTION**	**LIQUEFACTION**
12400	0.17	0.20	0.07	20.17	**LIQUEFACTION**	**LIQUEFACTION**
12600	0.17	0.20	0.07	23.34	**LIQUEFACTION**	**LIQUEFACTION**
12800	0.17	0.20	0.07	25.94	**LIQUEFACTION**	**LIQUEFACTION**
13000	0.17	0.20	0.08	30.82	**LIQUEFACTION**	**LIQUEFACTION**
13200	0.17	0.20	0.07	24.89	**LIQUEFACTION**	**LIQUEFACTION**
13400	0.17	0.20	0.08	37.37	**LIQUEFACTION**	**LIQUEFACTION**
13600	0.17	0.20	0.09	47.57	**LIQUEFACTION**	**LIQUEFACTION**
13800	0.17	0.20	0.07	27.06	**LIQUEFACTION**	**LIQUEFACTION**
14000	0.16	0.20	0.08	38.79	**LIQUEFACTION**	**LIQUEFACTION**

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 7.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

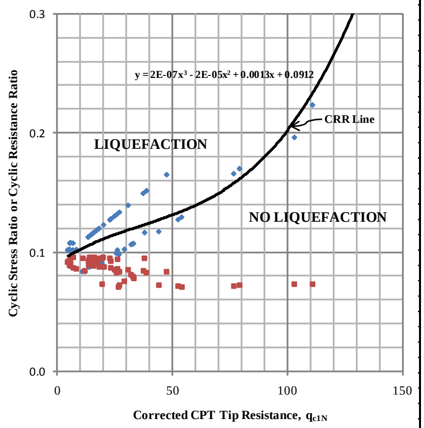
SHEET : 12 OF 14

ASSESSMENT RESULTS INC. AGEING FOR M=5.0 & 5.5

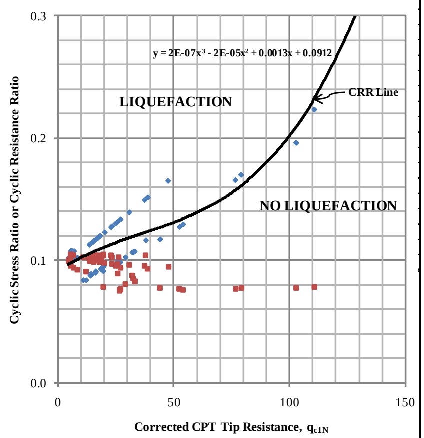
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING			**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA			**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -		**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010				**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**t (years)**	**K_{DR}**	**$CRR_{M=7.5}$**	**$CRR_{M=7.5,DR}$**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.5
200	30	1.08	0.18	0.196	NO LIQUEFACTION	NO LIQUEFACTION
400	30	1.08	0.21	0.224	NO LIQUEFACTION	NO LIQUEFACTION
600	30	1.08	0.41	0.442	NO LIQUEFACTION	NO LIQUEFACTION
800	1120	1.35	0.13	0.170	NO LIQUEFACTION	NO LIQUEFACTION
1000	1187	1.35	0.09	0.117	NO LIQUEFACTION	NO LIQUEFACTION
1200	1254	1.36	0.07	0.098	NO LIQUEFACTION	NO LIQUEFACTION
1400	1321	1.36	0.12	0.166	NO LIQUEFACTION	NO LIQUEFACTION
1600	1388	1.36	0.09	0.128	NO LIQUEFACTION	NO LIQUEFACTION
1800	1455	1.37	0.09	0.130	NO LIQUEFACTION	NO LIQUEFACTION
2000	1522	1.37	0.07	0.099	NO LIQUEFACTION	NO LIQUEFACTION
2200	1589	1.37	0.07	0.099	NO LIQUEFACTION	NO LIQUEFACTION
2400	1656	1.38	0.07	0.091	NO LIQUEFACTION	NO LIQUEFACTION
2600	1723	1.38	0.07	0.103	NO LIQUEFACTION	NO LIQUEFACTION
2800	1790	1.38	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
3000	1857	1.39	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
3200	1924	1.39	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
3400	1991	1.39	0.07	0.099	NO LIQUEFACTION	NO LIQUEFACTION
3600	2058	1.39	0.06	0.084	NO LIQUEFACTION	NO LIQUEFACTION
3800	2125	1.40	0.07	0.102	NO LIQUEFACTION	NO LIQUEFACTION
4000	2192	1.40	0.07	0.102	NO LIQUEFACTION	NO LIQUEFACTION
4200	2259	1.40	0.07	0.102	NO LIQUEFACTION	NO LIQUEFACTION
4400	2326	1.40	0.07	0.102	NO LIQUEFACTION	NO LIQUEFACTION
4600	2393	1.40	0.07	0.102	NO LIQUEFACTION	NO LIQUEFACTION
4800	2460	1.41	0.07	0.102	NO LIQUEFACTION	LIQUEFACTION
5000	2527	1.41	0.07	0.102	NO LIQUEFACTION	LIQUEFACTION
5200	2594	1.41	0.07	0.102	NO LIQUEFACTION	LIQUEFACTION
5400	2661	1.41	0.07	0.103	NO LIQUEFACTION	LIQUEFACTION
5600	2728	1.41	0.06	0.090	NO LIQUEFACTION	NO LIQUEFACTION
5800	2795	1.42	0.07	0.093	NO LIQUEFACTION	NO LIQUEFACTION
6000	2862	1.42	0.07	0.102	NO LIQUEFACTION	NO LIQUEFACTION
6200	2929	1.42	0.06	0.084	NO LIQUEFACTION	NO LIQUEFACTION
6400	2996	1.42	0.06	0.088	NO LIQUEFACTION	NO LIQUEFACTION
6600	3063	1.42	0.07	0.093	NO LIQUEFACTION	NO LIQUEFACTION
6800	3130	1.42	0.06	0.089	NO LIQUEFACTION	NO LIQUEFACTION
7000	3197	1.43	0.06	0.091	NO LIQUEFACTION	NO LIQUEFACTION
7200	3264	1.43	0.08	0.117	NO LIQUEFACTION	NO LIQUEFACTION
7400	3331	1.43	0.07	0.095	NO LIQUEFACTION	NO LIQUEFACTION
7600	3398	1.43	0.06	0.088	NO LIQUEFACTION	NO LIQUEFACTION
7800	3465	1.43	0.06	0.091	NO LIQUEFACTION	NO LIQUEFACTION
8000	3532	1.43	0.08	0.108	NO LIQUEFACTION	LIQUEFACTION
8200	3599	1.43	0.08	0.108	NO LIQUEFACTION	LIQUEFACTION
8400	3666	1.44	0.07	0.108	NO LIQUEFACTION	LIQUEFACTION
8600	3733	1.44	0.07	0.095	NO LIQUEFACTION	NO LIQUEFACTION
8800	3800	1.44	0.06	0.089	NO LIQUEFACTION	NO LIQUEFACTION
9000	900000	1.84	0.07	0.127	NO LIQUEFACTION	NO LIQUEFACTION
9200	900100	1.84	0.07	0.120	NO LIQUEFACTION	NO LIQUEFACTION
9400	900200	1.84	0.06	0.116	NO LIQUEFACTION	NO LIQUEFACTION
9600	900300	1.84	0.06	0.113	NO LIQUEFACTION	NO LIQUEFACTION
9800	900400	1.84	0.06	0.115	NO LIQUEFACTION	NO LIQUEFACTION
10000	900500	1.84	0.07	0.128	NO LIQUEFACTION	NO LIQUEFACTION
10200	900600	1.84	0.06	0.117	NO LIQUEFACTION	NO LIQUEFACTION
10400	900700	1.84	0.06	0.116	NO LIQUEFACTION	NO LIQUEFACTION
10600	900800	1.84	0.06	0.113	NO LIQUEFACTION	NO LIQUEFACTION
10800	900900	1.84	0.06	0.115	NO LIQUEFACTION	NO LIQUEFACTION
11000	901000	1.84	0.06	0.119	NO LIQUEFACTION	NO LIQUEFACTION
11200	901100	1.84	0.06	0.118	NO LIQUEFACTION	NO LIQUEFACTION
11400	901200	1.84	0.06	0.118	NO LIQUEFACTION	NO LIQUEFACTION
11600	901300	1.84	0.06	0.113	NO LIQUEFACTION	NO LIQUEFACTION
11800	901400	1.84	0.06	0.115	NO LIQUEFACTION	NO LIQUEFACTION
12000	901500	1.84	0.06	0.116	NO LIQUEFACTION	NO LIQUEFACTION
12200	901600	1.84	0.07	0.120	NO LIQUEFACTION	NO LIQUEFACTION
12400	901700	1.84	0.07	0.123	NO LIQUEFACTION	NO LIQUEFACTION
12600	901800	1.84	0.07	0.128	NO LIQUEFACTION	NO LIQUEFACTION
12800	901900	1.84	0.07	0.132	NO LIQUEFACTION	NO LIQUEFACTION
13000	902000	1.84	0.08	0.139	NO LIQUEFACTION	NO LIQUEFACTION
13200	902100	1.84	0.07	0.130	NO LIQUEFACTION	NO LIQUEFACTION
13400	902200	1.84	0.08	0.149	NO LIQUEFACTION	NO LIQUEFACTION
13600	902300	1.84	0.09	0.165	NO LIQUEFACTION	NO LIQUEFACTION
13800	902400	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
14000	902500	1.84	0.08	0.152	NO LIQUEFACTION	NO LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 5.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

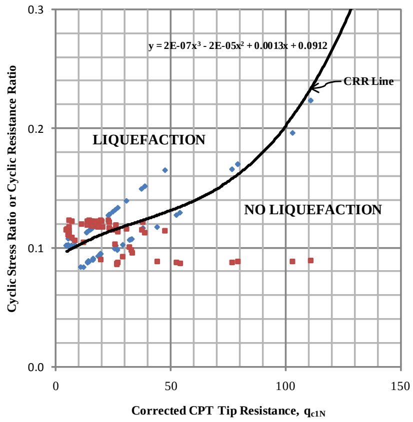
SHEET : 13 OF 14

ASSESSMENT RESULTS INC. AGEING FOR M=6.0 & 6.5

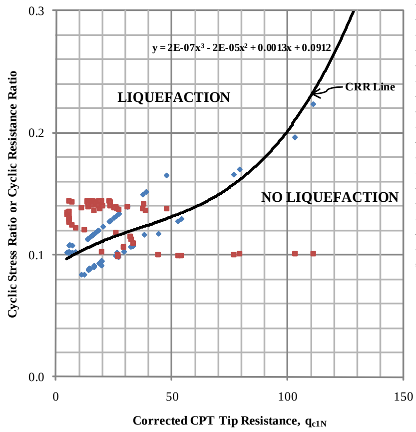
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m	
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan	
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan	
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa	

DEPTH (mm)	t (years)	K_{DR}	$CRR_{M=7.5}$	$CRR_{M=7.5,DR}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.5
200	30	1.08	0.18	0.196	NO LIQUEFACTION	NO LIQUEFACTION
400	30	1.08	0.21	0.224	NO LIQUEFACTION	NO LIQUEFACTION
600	30	1.08	0.41	0.442	NO LIQUEFACTION	NO LIQUEFACTION
800	1120	1.35	0.13	0.170	NO LIQUEFACTION	NO LIQUEFACTION
1000	1187	1.35	0.09	0.117	NO LIQUEFACTION	NO LIQUEFACTION
1200	1254	1.36	0.07	0.098	NO LIQUEFACTION	NO LIQUEFACTION
1400	1321	1.36	0.12	0.166	NO LIQUEFACTION	NO LIQUEFACTION
1600	1388	1.36	0.09	0.128	NO LIQUEFACTION	NO LIQUEFACTION
1800	1455	1.37	0.09	0.130	NO LIQUEFACTION	NO LIQUEFACTION
2000	1522	1.37	0.07	0.099	NO LIQUEFACTION	NO LIQUEFACTION
2200	1589	1.37	0.07	0.099	NO LIQUEFACTION	NO LIQUEFACTION
2400	1656	1.38	0.07	0.091	NO LIQUEFACTION	NO LIQUEFACTION
2600	1723	1.38	0.07	0.103	NO LIQUEFACTION	NO LIQUEFACTION
2800	1790	1.38	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
3000	1857	1.39	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
3200	1924	1.39	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
3400	1991	1.39	0.07	0.099	NO LIQUEFACTION	LIQUEFACTION
3600	2058	1.39	0.06	0.084	LIQUEFACTION	LIQUEFACTION
3800	2125	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4000	2192	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4200	2259	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4400	2326	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4600	2393	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4800	2460	1.41	0.07	0.102	LIQUEFACTION	LIQUEFACTION
5000	2527	1.41	0.07	0.102	LIQUEFACTION	LIQUEFACTION
5200	2594	1.41	0.07	0.102	LIQUEFACTION	LIQUEFACTION
5400	2661	1.41	0.07	0.103	LIQUEFACTION	LIQUEFACTION
5600	2728	1.41	0.06	0.090	LIQUEFACTION	LIQUEFACTION
5800	2795	1.42	0.07	0.093	LIQUEFACTION	LIQUEFACTION
6000	2862	1.42	0.07	0.102	LIQUEFACTION	LIQUEFACTION
6200	2929	1.42	0.06	0.084	LIQUEFACTION	LIQUEFACTION
6400	2996	1.42	0.06	0.088	LIQUEFACTION	LIQUEFACTION
6600	3063	1.42	0.07	0.093	LIQUEFACTION	LIQUEFACTION
6800	3130	1.42	0.06	0.089	LIQUEFACTION	LIQUEFACTION
7000	3197	1.43	0.06	0.091	LIQUEFACTION	LIQUEFACTION
7200	3264	1.43	0.08	0.117	NO LIQUEFACTION	LIQUEFACTION
7400	3331	1.43	0.07	0.095	LIQUEFACTION	LIQUEFACTION
7600	3398	1.43	0.06	0.088	LIQUEFACTION	LIQUEFACTION
7800	3465	1.43	0.06	0.091	LIQUEFACTION	LIQUEFACTION
8000	3532	1.43	0.08	0.108	LIQUEFACTION	LIQUEFACTION
8200	3599	1.43	0.08	0.108	LIQUEFACTION	LIQUEFACTION
8400	3666	1.44	0.07	0.108	LIQUEFACTION	LIQUEFACTION
8600	3733	1.44	0.07	0.095	LIQUEFACTION	LIQUEFACTION
8800	3800	1.44	0.06	0.089	LIQUEFACTION	LIQUEFACTION
9000	900000	1.84	0.07	0.127	LIQUEFACTION	LIQUEFACTION
9200	900100	1.84	0.07	0.120	LIQUEFACTION	LIQUEFACTION
9400	900200	1.84	0.06	0.116	LIQUEFACTION	LIQUEFACTION
9600	900300	1.84	0.06	0.113	LIQUEFACTION	LIQUEFACTION
9800	900400	1.84	0.06	0.115	LIQUEFACTION	LIQUEFACTION
10000	900500	1.84	0.07	0.128	LIQUEFACTION	LIQUEFACTION
10200	900600	1.84	0.06	0.117	LIQUEFACTION	LIQUEFACTION
10400	900700	1.84	0.06	0.116	LIQUEFACTION	LIQUEFACTION
10600	900800	1.84	0.06	0.113	LIQUEFACTION	LIQUEFACTION
10800	900900	1.84	0.06	0.115	LIQUEFACTION	LIQUEFACTION
11000	901000	1.84	0.06	0.119	LIQUEFACTION	LIQUEFACTION
11200	901100	1.84	0.06	0.118	LIQUEFACTION	LIQUEFACTION
11400	901200	1.84	0.06	0.118	LIQUEFACTION	LIQUEFACTION
11600	901300	1.84	0.06	0.113	LIQUEFACTION	LIQUEFACTION
11800	901400	1.84	0.06	0.115	LIQUEFACTION	LIQUEFACTION
12000	901500	1.84	0.06	0.116	LIQUEFACTION	LIQUEFACTION
12200	901600	1.84	0.07	0.120	LIQUEFACTION	LIQUEFACTION
12400	901700	1.84	0.07	0.123	LIQUEFACTION	LIQUEFACTION
12600	901800	1.84	0.07	0.128	LIQUEFACTION	LIQUEFACTION
12800	901900	1.84	0.07	0.132	LIQUEFACTION	LIQUEFACTION
13000	902000	1.84	0.08	0.139	NO LIQUEFACTION	LIQUEFACTION
13200	902100	1.84	0.07	0.130	LIQUEFACTION	LIQUEFACTION
13400	902200	1.84	0.08	0.149	NO LIQUEFACTION	LIQUEFACTION
13600	902300	1.84	0.09	0.165	NO LIQUEFACTION	LIQUEFACTION
13800	902400	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION
14000	902500	1.84	0.08	0.152	NO LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 6.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#1

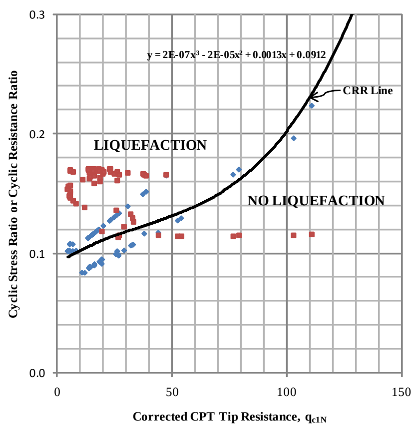
SHEET : 14 OF 14

ASSESSMENT RESULTS INC. AGEING FOR M=7.0 & 7.5

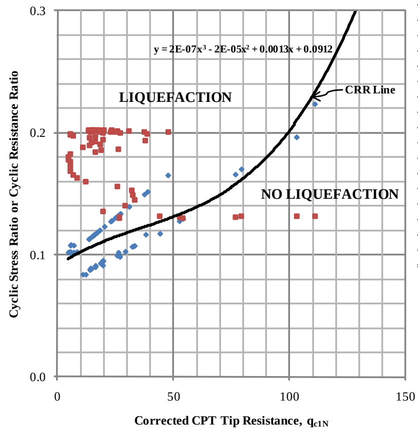
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	t (years)	K_{DR}	$CRR_{M=7.5}$	$CRR_{M=7.5,DR}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.5
200	30	1.08	0.18	0.196	NO LIQUEFACTION	NO LIQUEFACTION
400	30	1.08	0.21	0.224	NO LIQUEFACTION	NO LIQUEFACTION
600	30	1.08	0.41	0.442	NO LIQUEFACTION	NO LIQUEFACTION
800	1120	1.35	0.13	0.170	NO LIQUEFACTION	NO LIQUEFACTION
1000	1187	1.35	0.09	0.117	NO LIQUEFACTION	LIQUEFACTION
1200	1254	1.36	0.07	0.098	NO LIQUEFACTION	LIQUEFACTION
1400	1321	1.36	0.12	0.166	NO LIQUEFACTION	NO LIQUEFACTION
1600	1388	1.36	0.09	0.128	NO LIQUEFACTION	NO LIQUEFACTION
1800	1455	1.37	0.09	0.130	NO LIQUEFACTION	NO LIQUEFACTION
2000	1522	1.37	0.07	0.099	NO LIQUEFACTION	LIQUEFACTION
2200	1589	1.37	0.07	0.099	NO LIQUEFACTION	LIQUEFACTION
2400	1656	1.38	0.07	0.091	LIQUEFACTION	LIQUEFACTION
2600	1723	1.38	0.07	0.103	LIQUEFACTION	LIQUEFACTION
2800	1790	1.38	0.08	0.107	LIQUEFACTION	LIQUEFACTION
3000	1857	1.39	0.08	0.107	LIQUEFACTION	LIQUEFACTION
3200	1924	1.39	0.08	0.107	LIQUEFACTION	LIQUEFACTION
3400	1991	1.39	0.07	0.099	LIQUEFACTION	LIQUEFACTION
3600	2058	1.39	0.06	0.084	LIQUEFACTION	LIQUEFACTION
3800	2125	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4000	2192	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4200	2259	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4400	2326	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4600	2393	1.40	0.07	0.102	LIQUEFACTION	LIQUEFACTION
4800	2460	1.41	0.07	0.102	LIQUEFACTION	LIQUEFACTION
5000	2527	1.41	0.07	0.102	LIQUEFACTION	LIQUEFACTION
5200	2594	1.41	0.07	0.102	LIQUEFACTION	LIQUEFACTION
5400	2661	1.41	0.07	0.103	LIQUEFACTION	LIQUEFACTION
5600	2728	1.41	0.06	0.090	LIQUEFACTION	LIQUEFACTION
5800	2795	1.42	0.07	0.093	LIQUEFACTION	LIQUEFACTION
6000	2862	1.42	0.07	0.102	LIQUEFACTION	LIQUEFACTION
6200	2929	1.42	0.06	0.084	LIQUEFACTION	LIQUEFACTION
6400	2996	1.42	0.06	0.088	LIQUEFACTION	LIQUEFACTION
6600	3063	1.42	0.07	0.093	LIQUEFACTION	LIQUEFACTION
6800	3130	1.42	0.06	0.089	LIQUEFACTION	LIQUEFACTION
7000	3197	1.43	0.06	0.091	LIQUEFACTION	LIQUEFACTION
7200	3264	1.43	0.08	0.117	LIQUEFACTION	LIQUEFACTION
7400	3331	1.43	0.07	0.095	LIQUEFACTION	LIQUEFACTION
7600	3398	1.43	0.06	0.088	LIQUEFACTION	LIQUEFACTION
7800	3465	1.43	0.06	0.091	LIQUEFACTION	LIQUEFACTION
8000	3532	1.43	0.08	0.108	LIQUEFACTION	LIQUEFACTION
8200	3599	1.43	0.08	0.108	LIQUEFACTION	LIQUEFACTION
8400	3666	1.44	0.07	0.108	LIQUEFACTION	LIQUEFACTION
8600	3733	1.44	0.07	0.095	LIQUEFACTION	LIQUEFACTION
8800	3800	1.44	0.06	0.089	LIQUEFACTION	LIQUEFACTION
9000	900000	1.84	0.07	0.127	LIQUEFACTION	LIQUEFACTION
9200	900100	1.84	0.07	0.120	LIQUEFACTION	LIQUEFACTION
9400	900200	1.84	0.06	0.116	LIQUEFACTION	LIQUEFACTION
9600	900300	1.84	0.06	0.113	LIQUEFACTION	LIQUEFACTION
9800	900400	1.84	0.06	0.115	LIQUEFACTION	LIQUEFACTION
10000	900500	1.84	0.07	0.128	LIQUEFACTION	LIQUEFACTION
10200	900600	1.84	0.06	0.117	LIQUEFACTION	LIQUEFACTION
10400	900700	1.84	0.06	0.116	LIQUEFACTION	LIQUEFACTION
10600	900800	1.84	0.06	0.113	LIQUEFACTION	LIQUEFACTION
10800	900900	1.84	0.06	0.115	LIQUEFACTION	LIQUEFACTION
11000	901000	1.84	0.06	0.119	LIQUEFACTION	LIQUEFACTION
11200	901100	1.84	0.06	0.118	LIQUEFACTION	LIQUEFACTION
11400	901200	1.84	0.06	0.118	LIQUEFACTION	LIQUEFACTION
11600	901300	1.84	0.06	0.113	LIQUEFACTION	LIQUEFACTION
11800	901400	1.84	0.06	0.115	LIQUEFACTION	LIQUEFACTION
12000	901500	1.84	0.06	0.116	LIQUEFACTION	LIQUEFACTION
12200	901600	1.84	0.07	0.120	LIQUEFACTION	LIQUEFACTION
12400	901700	1.84	0.07	0.123	LIQUEFACTION	LIQUEFACTION
12600	901800	1.84	0.07	0.128	LIQUEFACTION	LIQUEFACTION
12800	901900	1.84	0.07	0.132	LIQUEFACTION	LIQUEFACTION
13000	902000	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
13200	902100	1.84	0.07	0.130	LIQUEFACTION	LIQUEFACTION
13400	902200	1.84	0.08	0.149	LIQUEFACTION	LIQUEFACTION
13600	902300	1.84	0.09	0.165	LIQUEFACTION	LIQUEFACTION
13800	902400	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
14000	902500	1.84	0.08	0.152	LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 7.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

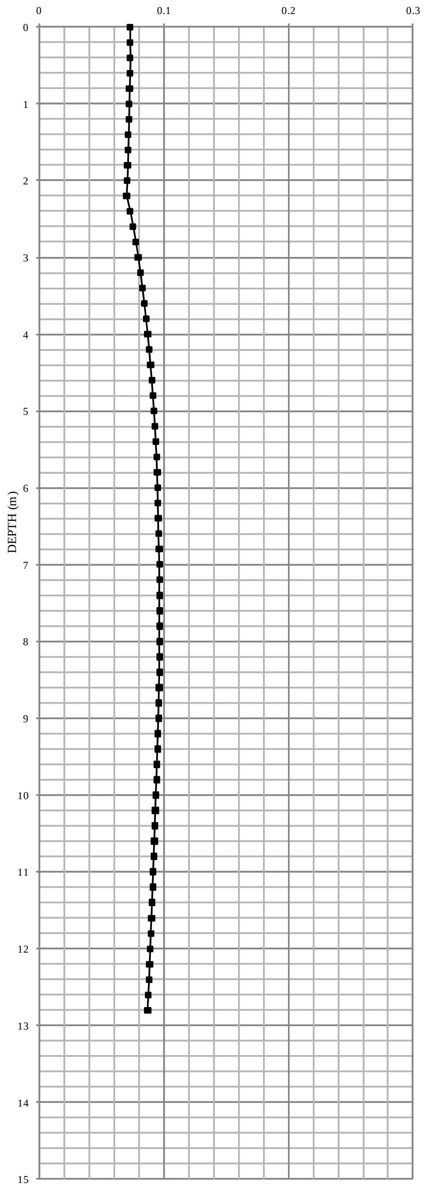
SHEET : 1 OF 14

CYCLIC STRESS RATIO FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.18	20.18	4.04	4.04	1.00	0.202	1.80	**0.073**
400	21.71	21.71	8.38	8.38	1.00	0.202	1.80	**0.073**
600	21.35	21.35	12.65	12.65	1.00	0.202	1.80	**0.073**
800	21.21	21.21	16.89	16.89	0.99	0.202	1.80	**0.073**
1000	20.97	20.97	21.08	21.08	0.99	0.202	1.80	**0.072**
1200	20.05	20.05	25.10	25.10	0.99	0.202	1.80	**0.072**
1400	20.29	20.29	29.15	29.15	0.98	0.202	1.80	**0.072**
1600	20.42	20.42	33.24	33.24	0.98	0.202	1.80	**0.071**
1800	19.33	19.33	37.10	37.10	0.97	0.202	1.80	**0.071**
2000	19.55	19.55	41.01	41.01	0.97	0.202	1.80	**0.071**
2200	18.47	18.47	44.71	44.71	0.96	0.202	1.80	**0.070**
2400	18.03	8.22	48.31	46.35	0.96	0.202	1.80	**0.073**
2600	17.65	7.85	51.84	47.92	0.95	0.202	1.80	**0.075**
2800	17.74	7.93	55.39	49.51	0.95	0.202	1.80	**0.078**
3000	17.94	8.13	58.98	51.13	0.94	0.202	1.80	**0.079**
3200	18.12	8.31	62.60	52.80	0.94	0.202	1.80	**0.081**
3400	17.98	8.17	66.20	54.43	0.93	0.202	1.80	**0.083**
3600	17.24	7.43	69.65	55.92	0.93	0.202	1.80	**0.084**
3800	16.93	7.13	73.03	57.34	0.92	0.202	1.80	**0.086**
4000	16.76	6.95	76.38	58.73	0.92	0.202	1.80	**0.087**
4200	16.35	6.55	79.66	60.04	0.91	0.202	1.80	**0.088**
4400	16.40	6.59	82.94	61.36	0.91	0.202	1.80	**0.090**
4600	16.54	6.73	86.24	62.71	0.90	0.202	1.80	**0.091**
4800	16.57	6.76	89.56	64.06	0.90	0.202	1.80	**0.091**
5000	16.48	6.67	92.85	65.39	0.89	0.202	1.80	**0.092**
5200	16.18	6.37	96.09	66.67	0.89	0.202	1.80	**0.093**
5400	16.33	6.52	99.35	67.97	0.88	0.202	1.80	**0.094**
5600	16.61	6.80	102.68	69.33	0.87	0.202	1.80	**0.094**
5800	17.02	7.22	106.08	70.78	0.87	0.202	1.80	**0.095**
6000	18.39	8.58	109.76	72.49	0.86	0.202	1.80	**0.095**
6200	18.76	8.95	113.51	74.28	0.86	0.202	1.80	**0.095**
6400	17.33	7.52	116.98	75.79	0.85	0.202	1.80	**0.096**
6600	17.31	7.50	120.44	77.29	0.84	0.202	1.80	**0.096**
6800	13.92	4.12	123.22	78.11	0.84	0.202	1.80	**0.096**
7000	16.12	6.32	126.45	79.37	0.83	0.202	1.80	**0.097**
7200	18.13	8.32	130.07	81.04	0.83	0.202	1.80	**0.097**
7400	17.77	7.97	133.63	82.63	0.82	0.202	1.80	**0.097**
7600	18.46	8.65	137.32	84.36	0.81	0.202	1.80	**0.097**
7800	16.88	7.07	140.69	85.77	0.81	0.202	1.80	**0.097**
8000	16.15	6.34	143.92	87.04	0.80	0.202	1.80	**0.097**
8200	16.04	6.23	147.13	88.29	0.80	0.202	1.80	**0.097**
8400	16.00	6.19	150.33	89.53	0.79	0.202	1.80	**0.097**
8600	18.44	8.64	154.02	91.25	0.78	0.202	1.80	**0.096**
8800	18.34	8.53	157.69	92.96	0.78	0.202	1.80	**0.096**
9000	18.60	8.79	161.41	94.72	0.77	0.202	1.80	**0.096**
9200	18.72	8.91	165.15	96.50	0.77	0.202	1.80	**0.095**
9400	19.09	9.29	168.97	98.36	0.76	0.202	1.80	**0.095**
9600	18.21	8.40	172.61	100.04	0.75	0.202	1.80	**0.095**
9800	18.31	8.50	176.27	101.74	0.75	0.202	1.80	**0.094**
10000	19.88	10.07	180.25	103.75	0.74	0.202	1.80	**0.094**
10200	18.08	8.27	183.86	105.41	0.73	0.202	1.80	**0.093**
10400	18.20	8.39	187.50	107.09	0.73	0.202	1.80	**0.093**
10600	17.79	7.99	191.06	108.68	0.72	0.202	1.80	**0.093**
10800	18.36	8.56	194.74	110.40	0.72	0.202	1.80	**0.092**
11000	18.43	8.62	198.42	112.12	0.71	0.202	1.80	**0.092**
11200	18.28	8.47	202.08	113.81	0.70	0.202	1.80	**0.091**
11400	18.05	8.25	205.69	115.46	0.70	0.202	1.80	**0.091**
11600	17.93	8.12	209.27	117.09	0.69	0.202	1.80	**0.090**
11800	18.15	8.35	212.90	118.76	0.69	0.202	1.80	**0.090**
12000	17.50	7.69	216.40	120.30	0.68	0.202	1.80	**0.089**
12200	17.12	7.32	219.83	121.76	0.67	0.202	1.80	**0.089**
12400	18.26	8.45	223.48	123.45	0.67	0.202	1.80	**0.088**
12600	19.30	9.50	227.34	125.35	0.66	0.202	1.80	**0.088**
12800	19.61	9.81	231.26	127.31	0.66	0.202	1.80	**0.087**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

SHEET : 2 OF 14

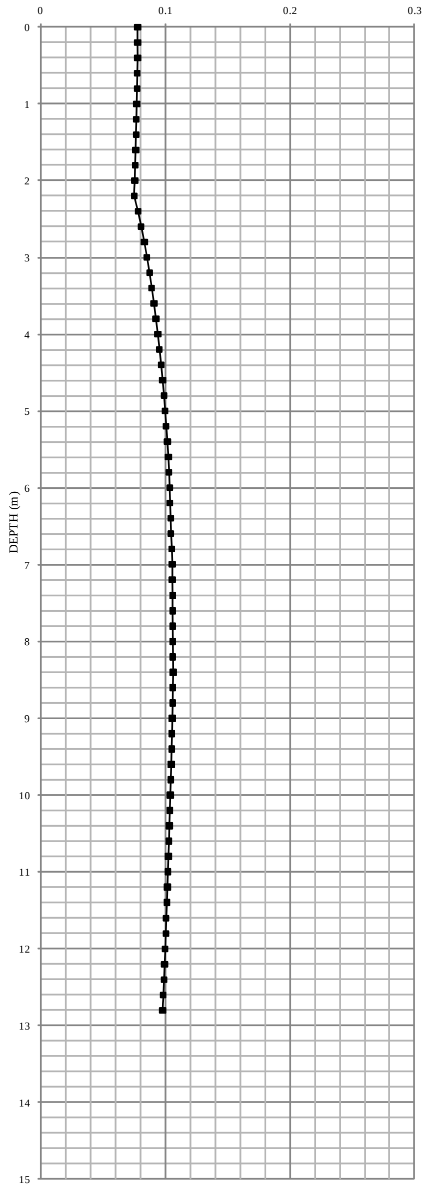
CYCLIC STRESS RATIO FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.18	20.18	4.04	4.04	1.00	0.202	1.69	**0.078**
400	21.71	21.71	8.38	8.38	1.00	0.202	1.69	**0.078**
600	21.35	21.35	12.65	12.65	1.00	0.202	1.69	**0.078**
800	21.21	21.21	16.89	16.89	1.00	0.202	1.69	**0.078**
1000	20.97	20.97	21.08	21.08	0.99	0.202	1.69	**0.077**
1200	20.05	20.05	25.10	25.10	0.99	0.202	1.69	**0.077**
1400	20.29	20.29	29.15	29.15	0.98	0.202	1.69	**0.077**
1600	20.42	20.42	33.24	33.24	0.98	0.202	1.69	**0.076**
1800	19.33	19.33	37.10	37.10	0.98	0.202	1.69	**0.076**
2000	19.55	19.55	41.01	41.01	0.97	0.202	1.69	**0.076**
2200	18.47	18.47	44.71	44.71	0.97	0.202	1.69	**0.075**
2400	18.03	8.22	48.31	46.35	0.96	0.202	1.69	**0.078**
2600	17.65	7.85	51.84	47.92	0.96	0.202	1.69	**0.081**
2800	17.74	7.93	55.39	49.51	0.96	0.202	1.69	**0.083**
3000	17.94	8.13	58.98	51.13	0.95	0.202	1.69	**0.085**
3200	18.12	8.31	62.60	52.80	0.95	0.202	1.69	**0.087**
3400	17.98	8.17	66.20	54.43	0.94	0.202	1.69	**0.089**
3600	17.24	7.43	69.65	55.92	0.94	0.202	1.69	**0.091**
3800	16.93	7.13	73.03	57.34	0.93	0.202	1.69	**0.093**
4000	16.76	6.95	76.38	58.73	0.93	0.202	1.69	**0.094**
4200	16.35	6.55	79.66	60.04	0.92	0.202	1.69	**0.095**
4400	16.40	6.59	82.94	61.36	0.92	0.202	1.69	**0.097**
4600	16.54	6.73	86.24	62.71	0.91	0.202	1.69	**0.098**
4800	16.57	6.76	89.56	64.06	0.91	0.202	1.69	**0.099**
5000	16.48	6.67	92.85	65.39	0.90	0.202	1.69	**0.100**
5200	16.18	6.37	96.09	66.67	0.90	0.202	1.69	**0.101**
5400	16.33	6.52	99.35	67.97	0.89	0.202	1.69	**0.102**
5600	16.61	6.80	102.68	69.33	0.89	0.202	1.69	**0.103**
5800	17.02	7.22	106.08	70.78	0.88	0.202	1.69	**0.103**
6000	18.39	8.58	109.76	72.49	0.88	0.202	1.69	**0.104**
6200	18.76	8.95	113.51	74.28	0.87	0.202	1.69	**0.104**
6400	17.33	7.52	116.98	75.79	0.87	0.202	1.69	**0.104**
6600	17.31	7.50	120.44	77.29	0.86	0.202	1.69	**0.105**
6800	13.92	4.12	123.22	78.11	0.86	0.202	1.69	**0.105**
7000	16.12	6.32	126.45	79.37	0.85	0.202	1.69	**0.106**
7200	18.13	8.32	130.07	81.04	0.85	0.202	1.69	**0.106**
7400	17.77	7.97	133.63	82.63	0.84	0.202	1.69	**0.106**
7600	18.46	8.65	137.32	84.36	0.84	0.202	1.69	**0.106**
7800	16.88	7.07	140.69	85.77	0.83	0.202	1.69	**0.106**
8000	16.15	6.34	143.92	87.04	0.82	0.202	1.69	**0.106**
8200	16.04	6.23	147.13	88.29	0.82	0.202	1.69	**0.106**
8400	16.00	6.19	150.33	89.53	0.81	0.202	1.69	**0.106**
8600	18.44	8.64	154.02	91.25	0.81	0.202	1.69	**0.106**
8800	18.34	8.53	157.69	92.96	0.80	0.202	1.69	**0.106**
9000	18.60	8.79	161.41	94.72	0.80	0.202	1.69	**0.106**
9200	18.72	8.91	165.15	96.50	0.79	0.202	1.69	**0.105**
9400	19.09	9.29	168.97	98.36	0.79	0.202	1.69	**0.105**
9600	18.21	8.40	172.61	100.04	0.78	0.202	1.69	**0.105**
9800	18.31	8.50	176.27	101.74	0.77	0.202	1.69	**0.105**
10000	19.88	10.07	180.25	103.75	0.77	0.202	1.69	**0.104**
10200	18.08	8.27	183.86	105.41	0.76	0.202	1.69	**0.104**
10400	18.20	8.39	187.50	107.09	0.76	0.202	1.69	**0.103**
10600	17.79	7.99	191.06	108.68	0.75	0.202	1.69	**0.103**
10800	18.36	8.56	194.74	110.40	0.75	0.202	1.69	**0.103**
11000	18.43	8.62	198.42	112.12	0.74	0.202	1.69	**0.102**
11200	18.28	8.47	202.08	113.81	0.74	0.202	1.69	**0.102**
11400	18.05	8.25	205.69	115.46	0.73	0.202	1.69	**0.101**
11600	17.93	8.12	209.27	117.09	0.73	0.202	1.69	**0.101**
11800	18.15	8.35	212.90	118.76	0.72	0.202	1.69	**0.100**
12000	17.50	7.69	216.40	120.30	0.71	0.202	1.69	**0.100**
12200	17.12	7.32	219.83	121.76	0.71	0.202	1.69	**0.100**
12400	18.26	8.45	223.48	123.45	0.70	0.202	1.69	**0.099**
12600	19.30	9.50	227.34	125.35	0.70	0.202	1.69	**0.099**
12800	19.61	9.81	231.26	127.31	0.69	0.202	1.69	**0.098**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

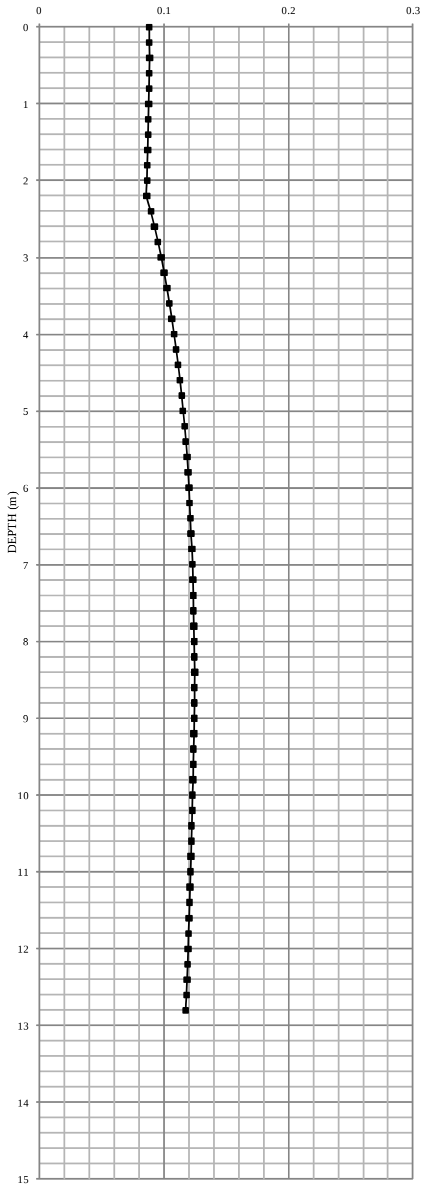
SHEET : 3 OF 14

CYCLIC STRESS RATIO FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m
		REDUCE LEVEL	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
		OPERATOR	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
		SUPERVISED BY	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010	**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m³)	γ' (kN/m³)	σ_v (kN/m²)	σ'_v (kN/m²)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.18	20.18	4.04	4.04	1.00	0.202	1.48	**0.089**
400	21.71	21.71	8.38	8.38	1.00	0.202	1.48	**0.089**
600	21.35	21.35	12.65	12.65	1.00	0.202	1.48	**0.089**
800	21.21	21.21	16.89	16.89	1.00	0.202	1.48	**0.088**
1000	20.97	20.97	21.08	21.08	0.99	0.202	1.48	**0.088**
1200	20.05	20.05	25.10	25.10	0.99	0.202	1.48	**0.088**
1400	20.29	20.29	29.15	29.15	0.99	0.202	1.48	**0.088**
1600	20.42	20.42	33.24	33.24	0.98	0.202	1.48	**0.087**
1800	19.33	19.33	37.10	37.10	0.98	0.202	1.48	**0.087**
2000	19.55	19.55	41.01	41.01	0.98	0.202	1.48	**0.087**
2200	18.47	18.47	44.71	44.71	0.97	0.202	1.48	**0.086**
2400	18.03	8.22	48.31	46.35	0.97	0.202	1.48	**0.090**
2600	17.65	7.85	51.84	47.92	0.97	0.202	1.48	**0.093**
2800	17.74	7.93	55.39	49.51	0.96	0.202	1.48	**0.096**
3000	17.94	8.13	58.98	51.13	0.96	0.202	1.48	**0.098**
3200	18.12	8.31	62.60	52.80	0.96	0.202	1.48	**0.100**
3400	17.98	8.17	66.20	54.43	0.95	0.202	1.48	**0.103**
3600	17.24	7.43	69.65	55.92	0.95	0.202	1.48	**0.105**
3800	16.93	7.13	73.03	57.34	0.94	0.202	1.48	**0.107**
4000	16.76	6.95	76.38	58.73	0.94	0.202	1.48	**0.108**
4200	16.35	6.55	79.66	60.04	0.94	0.202	1.48	**0.110**
4400	16.40	6.59	82.94	61.36	0.93	0.202	1.48	**0.112**
4600	16.54	6.73	86.24	62.71	0.93	0.202	1.48	**0.113**
4800	16.57	6.76	89.56	64.06	0.92	0.202	1.48	**0.114**
5000	16.48	6.67	92.85	65.39	0.92	0.202	1.48	**0.116**
5200	16.18	6.37	96.09	66.67	0.91	0.202	1.48	**0.117**
5400	16.33	6.52	99.35	67.97	0.91	0.202	1.48	**0.118**
5600	16.61	6.80	102.68	69.33	0.91	0.202	1.48	**0.119**
5800	17.02	7.22	106.08	70.78	0.90	0.202	1.48	**0.120**
6000	18.39	8.58	109.76	72.49	0.90	0.202	1.48	**0.120**
6200	18.76	8.95	113.51	74.28	0.89	0.202	1.48	**0.121**
6400	17.33	7.52	116.98	75.79	0.89	0.202	1.48	**0.121**
6600	17.31	7.50	120.44	77.29	0.88	0.202	1.48	**0.122**
6800	13.92	4.12	123.22	78.11	0.88	0.202	1.48	**0.123**
7000	16.12	6.32	126.45	79.37	0.87	0.202	1.48	**0.123**
7200	18.13	8.32	130.07	81.04	0.87	0.202	1.48	**0.123**
7400	17.77	7.97	133.63	82.63	0.86	0.202	1.48	**0.124**
7600	18.46	8.65	137.32	84.36	0.86	0.202	1.48	**0.124**
7800	16.88	7.07	140.69	85.77	0.85	0.202	1.48	**0.124**
8000	16.15	6.34	143.92	87.04	0.85	0.202	1.48	**0.124**
8200	16.04	6.23	147.13	88.29	0.84	0.202	1.48	**0.125**
8400	16.00	6.19	150.33	89.53	0.84	0.202	1.48	**0.125**
8600	18.44	8.64	154.02	91.25	0.83	0.202	1.48	**0.125**
8800	18.34	8.53	157.69	92.96	0.83	0.202	1.48	**0.125**
9000	18.60	8.79	161.41	94.72	0.82	0.202	1.48	**0.124**
9200	18.72	8.91	165.15	96.50	0.82	0.202	1.48	**0.124**
9400	19.09	9.29	168.97	98.36	0.81	0.202	1.48	**0.124**
9600	18.21	8.40	172.61	100.04	0.81	0.202	1.48	**0.124**
9800	18.31	8.50	176.27	101.74	0.80	0.202	1.48	**0.123**
10000	19.88	10.07	180.25	103.75	0.80	0.202	1.48	**0.123**
10200	18.08	8.27	183.86	105.41	0.79	0.202	1.48	**0.123**
10400	18.20	8.39	187.50	107.09	0.79	0.202	1.48	**0.122**
10600	17.79	7.99	191.06	108.68	0.78	0.202	1.48	**0.122**
10800	18.36	8.56	194.74	110.40	0.78	0.202	1.48	**0.122**
11000	18.43	8.62	198.42	112.12	0.77	0.202	1.48	**0.121**
11200	18.28	8.47	202.08	113.81	0.77	0.202	1.48	**0.121**
11400	18.05	8.25	205.69	115.46	0.76	0.202	1.48	**0.121**
11600	17.93	8.12	209.27	117.09	0.76	0.202	1.48	**0.120**
11800	18.15	8.35	212.90	118.76	0.75	0.202	1.48	**0.120**
12000	17.50	7.69	216.40	120.30	0.75	0.202	1.48	**0.120**
12200	17.12	7.32	219.83	121.76	0.74	0.202	1.48	**0.119**
12400	18.26	8.45	223.48	123.45	0.74	0.202	1.48	**0.119**
12600	19.30	9.50	227.34	125.35	0.74	0.202	1.48	**0.118**
12800	19.61	9.81	231.26	127.31	0.73	0.202	1.48	**0.118**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

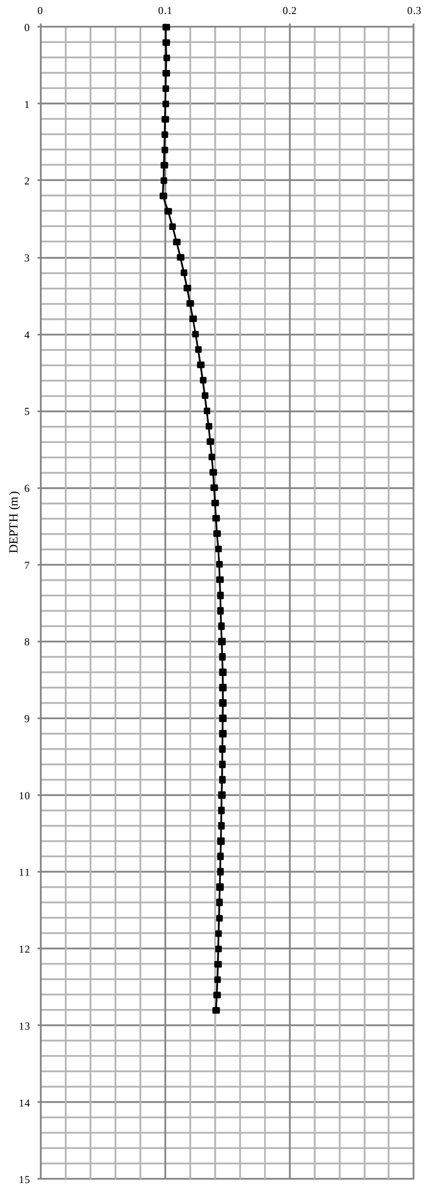
SHEET : 4 OF 14

CYCLIC STRESS RATIO FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.18	20.18	4.04	4.04	1.00	0.202	1.30	**0.101**
400	21.71	21.71	8.38	8.38	1.00	0.202	1.30	**0.101**
600	21.35	21.35	12.65	12.65	1.00	0.202	1.30	**0.101**
800	21.21	21.21	16.89	16.89	1.00	0.202	1.30	**0.101**
1000	20.97	20.97	21.08	21.08	1.00	0.202	1.30	**0.101**
1200	20.05	20.05	25.10	25.10	0.99	0.202	1.30	**0.100**
1400	20.29	20.29	29.15	29.15	0.99	0.202	1.30	**0.100**
1600	20.42	20.42	33.24	33.24	0.99	0.202	1.30	**0.100**
1800	19.33	19.33	37.10	37.10	0.98	0.202	1.30	**0.099**
2000	19.55	19.55	41.01	41.01	0.98	0.202	1.30	**0.099**
2200	18.47	18.47	44.71	44.71	0.98	0.202	1.30	**0.099**
2400	18.03	8.22	48.31	46.35	0.98	0.202	1.30	**0.103**
2600	17.65	7.85	51.84	47.92	0.97	0.202	1.30	**0.106**
2800	17.74	7.93	55.39	49.51	0.97	0.202	1.30	**0.110**
3000	17.94	8.13	58.98	51.13	0.97	0.202	1.30	**0.113**
3200	18.12	8.31	62.60	52.80	0.96	0.202	1.30	**0.115**
3400	17.98	8.17	66.20	54.43	0.96	0.202	1.30	**0.118**
3600	17.24	7.43	69.65	55.92	0.96	0.202	1.30	**0.120**
3800	16.93	7.13	73.03	57.34	0.95	0.202	1.30	**0.123**
4000	16.76	6.95	76.38	58.73	0.95	0.202	1.30	**0.125**
4200	16.35	6.55	79.66	60.04	0.95	0.202	1.30	**0.127**
4400	16.40	6.59	82.94	61.36	0.94	0.202	1.30	**0.129**
4600	16.54	6.73	86.24	62.71	0.94	0.202	1.30	**0.130**
4800	16.57	6.76	89.56	64.06	0.94	0.202	1.30	**0.132**
5000	16.48	6.67	92.85	65.39	0.93	0.202	1.30	**0.134**
5200	16.18	6.37	96.09	66.67	0.93	0.202	1.30	**0.135**
5400	16.33	6.52	99.35	67.97	0.92	0.202	1.30	**0.136**
5600	16.61	6.80	102.68	69.33	0.92	0.202	1.30	**0.138**
5800	17.02	7.22	106.08	70.78	0.92	0.202	1.30	**0.139**
6000	18.39	8.58	109.76	72.49	0.91	0.202	1.30	**0.140**
6200	18.76	8.95	113.51	74.28	0.91	0.202	1.30	**0.140**
6400	17.33	7.52	116.98	75.79	0.91	0.202	1.30	**0.141**
6600	17.31	7.50	120.44	77.29	0.90	0.202	1.30	**0.142**
6800	13.92	4.12	123.22	78.11	0.90	0.202	1.30	**0.143**
7000	16.12	6.32	126.45	79.37	0.89	0.202	1.30	**0.144**
7200	18.13	8.32	130.07	81.04	0.89	0.202	1.30	**0.144**
7400	17.77	7.97	133.63	82.63	0.89	0.202	1.30	**0.145**
7600	18.46	8.65	137.32	84.36	0.88	0.202	1.30	**0.145**
7800	16.88	7.07	140.69	85.77	0.88	0.202	1.30	**0.145**
8000	16.15	6.34	143.92	87.04	0.87	0.202	1.30	**0.146**
8200	16.04	6.23	147.13	88.29	0.87	0.202	1.30	**0.146**
8400	16.00	6.19	150.33	89.53	0.86	0.202	1.30	**0.147**
8600	18.44	8.64	154.02	91.25	0.86	0.202	1.30	**0.147**
8800	18.34	8.53	157.69	92.96	0.86	0.202	1.30	**0.147**
9000	18.60	8.79	161.41	94.72	0.85	0.202	1.30	**0.147**
9200	18.72	8.91	165.15	96.50	0.85	0.202	1.30	**0.146**
9400	19.09	9.29	168.97	98.36	0.84	0.202	1.30	**0.146**
9600	18.21	8.40	172.61	100.04	0.84	0.202	1.30	**0.146**
9800	18.31	8.50	176.27	101.74	0.83	0.202	1.30	**0.146**
10000	19.88	10.07	180.25	103.75	0.83	0.202	1.30	**0.146**
10200	18.08	8.27	183.86	105.41	0.83	0.202	1.30	**0.145**
10400	18.20	8.39	187.50	107.09	0.82	0.202	1.30	**0.145**
10600	17.79	7.99	191.06	108.68	0.82	0.202	1.30	**0.145**
10800	18.36	8.56	194.74	110.40	0.81	0.202	1.30	**0.145**
11000	18.43	8.62	198.42	112.12	0.81	0.202	1.30	**0.144**
11200	18.28	8.47	202.08	113.81	0.80	0.202	1.30	**0.144**
11400	18.05	8.25	205.69	115.46	0.80	0.202	1.30	**0.144**
11600	17.93	8.12	209.27	117.09	0.80	0.202	1.30	**0.144**
11800	18.15	8.35	212.90	118.76	0.79	0.202	1.30	**0.143**
12000	17.50	7.69	216.40	120.30	0.79	0.202	1.30	**0.143**
12200	17.12	7.32	219.83	121.76	0.78	0.202	1.30	**0.143**
12400	18.26	8.45	223.48	123.45	0.78	0.202	1.30	**0.142**
12600	19.30	9.50	227.34	125.35	0.77	0.202	1.30	**0.142**
12800	19.61	9.81	231.26	127.31	0.77	0.202	1.30	**0.141**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

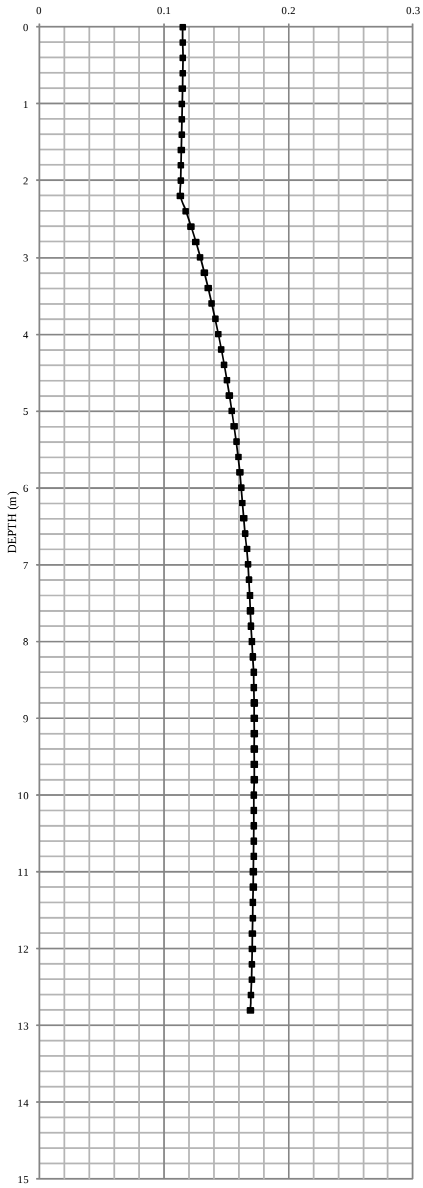
SHEET : 5 OF 14

CYCLIC STRESS RATIO FOR M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.18	20.18	4.04	4.04	1.00	0.202	1.14	**0.115**
400	21.71	21.71	8.38	8.38	1.00	0.202	1.14	**0.115**
600	21.35	21.35	12.65	12.65	1.00	0.202	1.14	**0.115**
800	21.21	21.21	16.89	16.89	1.00	0.202	1.14	**0.115**
1000	20.97	20.97	21.08	21.08	1.00	0.202	1.14	**0.115**
1200	20.05	20.05	25.10	25.10	1.00	0.202	1.14	**0.115**
1400	20.29	20.29	29.15	29.15	0.99	0.202	1.14	**0.114**
1600	20.42	20.42	33.24	33.24	0.99	0.202	1.14	**0.114**
1800	19.33	19.33	37.10	37.10	0.99	0.202	1.14	**0.114**
2000	19.55	19.55	41.01	41.01	0.99	0.202	1.14	**0.114**
2200	18.47	18.47	44.71	44.71	0.98	0.202	1.14	**0.113**
2400	18.03	8.22	48.31	46.35	0.98	0.202	1.14	**0.118**
2600	17.65	7.85	51.84	47.92	0.98	0.202	1.14	**0.122**
2800	17.74	7.93	55.39	49.51	0.98	0.202	1.14	**0.126**
3000	17.94	8.13	58.98	51.13	0.97	0.202	1.14	**0.129**
3200	18.12	8.31	62.60	52.80	0.97	0.202	1.14	**0.133**
3400	17.98	8.17	66.20	54.43	0.97	0.202	1.14	**0.136**
3600	17.24	7.43	69.65	55.92	0.97	0.202	1.14	**0.139**
3800	16.93	7.13	73.03	57.34	0.96	0.202	1.14	**0.141**
4000	16.76	6.95	76.38	58.73	0.96	0.202	1.14	**0.144**
4200	16.35	6.55	79.66	60.04	0.96	0.202	1.14	**0.146**
4400	16.40	6.59	82.94	61.36	0.96	0.202	1.14	**0.149**
4600	16.54	6.73	86.24	62.71	0.95	0.202	1.14	**0.151**
4800	16.57	6.76	89.56	64.06	0.95	0.202	1.14	**0.153**
5000	16.48	6.67	92.85	65.39	0.95	0.202	1.14	**0.155**
5200	16.18	6.37	96.09	66.67	0.94	0.202	1.14	**0.156**
5400	16.33	6.52	99.35	67.97	0.94	0.202	1.14	**0.158**
5600	16.61	6.80	102.68	69.33	0.94	0.202	1.14	**0.160**
5800	17.02	7.22	106.08	70.78	0.93	0.202	1.14	**0.161**
6000	18.39	8.58	109.76	72.49	0.93	0.202	1.14	**0.162**
6200	18.76	8.95	113.51	74.28	0.93	0.202	1.14	**0.163**
6400	17.33	7.52	116.98	75.79	0.92	0.202	1.14	**0.164**
6600	17.31	7.50	120.44	77.29	0.92	0.202	1.14	**0.165**
6800	13.92	4.12	123.22	78.11	0.92	0.202	1.14	**0.167**
7000	16.12	6.32	126.45	79.37	0.91	0.202	1.14	**0.168**
7200	18.13	8.32	130.07	81.04	0.91	0.202	1.14	**0.168**
7400	17.77	7.97	133.63	82.63	0.91	0.202	1.14	**0.169**
7600	18.46	8.65	137.32	84.36	0.90	0.202	1.14	**0.169**
7800	16.88	7.07	140.69	85.77	0.90	0.202	1.14	**0.170**
8000	16.15	6.34	143.92	87.04	0.90	0.202	1.14	**0.171**
8200	16.04	6.23	147.13	88.29	0.89	0.202	1.14	**0.172**
8400	16.00	6.19	150.33	89.53	0.89	0.202	1.14	**0.172**
8600	18.44	8.64	154.02	91.25	0.89	0.202	1.14	**0.172**
8800	18.34	8.53	157.69	92.96	0.88	0.202	1.14	**0.173**
9000	18.60	8.79	161.41	94.72	0.88	0.202	1.14	**0.173**
9200	18.72	8.91	165.15	96.50	0.88	0.202	1.14	**0.173**
9400	19.09	9.29	168.97	98.36	0.87	0.202	1.14	**0.173**
9600	18.21	8.40	172.61	100.04	0.87	0.202	1.14	**0.173**
9800	18.31	8.50	176.27	101.74	0.87	0.202	1.14	**0.173**
10000	19.88	10.07	180.25	103.75	0.86	0.202	1.14	**0.172**
10200	18.08	8.27	183.86	105.41	0.86	0.202	1.14	**0.172**
10400	18.20	8.39	187.50	107.09	0.86	0.202	1.14	**0.172**
10600	17.79	7.99	191.06	108.68	0.85	0.202	1.14	**0.172**
10800	18.36	8.56	194.74	110.40	0.85	0.202	1.14	**0.172**
11000	18.43	8.62	198.42	112.12	0.84	0.202	1.14	**0.172**
11200	18.28	8.47	202.08	113.81	0.84	0.202	1.14	**0.172**
11400	18.05	8.25	205.69	115.46	0.84	0.202	1.14	**0.172**
11600	17.93	8.12	209.27	117.09	0.83	0.202	1.14	**0.171**
11800	18.15	8.35	212.90	118.76	0.83	0.202	1.14	**0.171**
12000	17.50	7.69	216.40	120.30	0.83	0.202	1.14	**0.171**
12200	17.12	7.32	219.83	121.76	0.82	0.202	1.14	**0.171**
12400	18.26	8.45	223.48	123.45	0.82	0.202	1.14	**0.171**
12600	19.30	9.50	227.34	125.35	0.82	0.202	1.14	**0.170**
12800	19.61	9.81	231.26	127.31	0.81	0.202	1.14	**0.170**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

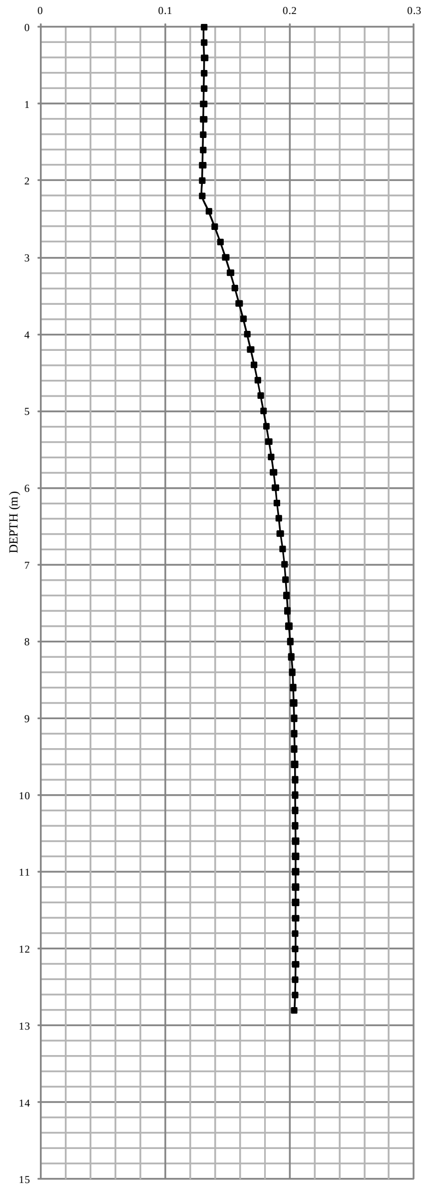
SHEET : 6 OF 14

CYCLIC STRESS RATIO FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING			**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA			**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -		**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010				**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m³)	γ' (kN/m³)	σ_v (kN/m²)	σ'_v (kN/m²)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	20.18	20.18	4.04	4.04	1.00	0.202	1	**0.131**
400	21.71	21.71	8.38	8.38	1.00	0.202	1	**0.132**
600	21.35	21.35	12.65	12.65	1.00	0.202	1	**0.132**
800	21.21	21.21	16.89	16.89	1.00	0.202	1	**0.131**
1000	20.97	20.97	21.08	21.08	1.00	0.202	1	**0.131**
1200	20.05	20.05	25.10	25.10	1.00	0.202	1	**0.131**
1400	20.29	20.29	29.15	29.15	1.00	0.202	1	**0.131**
1600	20.42	20.42	33.24	33.24	0.99	0.202	1	**0.131**
1800	19.33	19.33	37.10	37.10	0.99	0.202	1	**0.130**
2000	19.55	19.55	41.01	41.01	0.99	0.202	1	**0.130**
2200	18.47	18.47	44.71	44.71	0.99	0.202	1	**0.130**
2400	18.03	8.22	48.31	46.35	0.99	0.202	1	**0.135**
2600	17.65	7.85	51.84	47.92	0.99	0.202	1	**0.140**
2800	17.74	7.93	55.39	49.51	0.98	0.202	1	**0.145**
3000	17.94	8.13	58.98	51.13	0.98	0.202	1	**0.149**
3200	18.12	8.31	62.60	52.80	0.98	0.202	1	**0.153**
3400	17.98	8.17	66.20	54.43	0.98	0.202	1	**0.156**
3600	17.24	7.43	69.65	55.92	0.98	0.202	1	**0.160**
3800	16.93	7.13	73.03	57.34	0.97	0.202	1	**0.163**
4000	16.76	6.95	76.38	58.73	0.97	0.202	1	**0.166**
4200	16.35	6.55	79.66	60.04	0.97	0.202	1	**0.169**
4400	16.40	6.59	82.94	61.36	0.97	0.202	1	**0.172**
4600	16.54	6.73	86.24	62.71	0.97	0.202	1	**0.174**
4800	16.57	6.76	89.56	64.06	0.96	0.202	1	**0.177**
5000	16.48	6.67	92.85	65.39	0.96	0.202	1	**0.179**
5200	16.18	6.37	96.09	66.67	0.96	0.202	1	**0.181**
5400	16.33	6.52	99.35	67.97	0.96	0.202	1	**0.184**
5600	16.61	6.80	102.68	69.33	0.95	0.202	1	**0.185**
5800	17.02	7.22	106.08	70.78	0.95	0.202	1	**0.187**
6000	18.39	8.58	109.76	72.49	0.95	0.202	1	**0.189**
6200	18.76	8.95	113.51	74.28	0.95	0.202	1	**0.190**
6400	17.33	7.52	116.98	75.79	0.94	0.202	1	**0.191**
6600	17.31	7.50	120.44	77.29	0.94	0.202	1	**0.193**
6800	13.92	4.12	123.22	78.11	0.94	0.202	1	**0.195**
7000	16.12	6.32	126.45	79.37	0.94	0.202	1	**0.196**
7200	18.13	8.32	130.07	81.04	0.93	0.202	1	**0.197**
7400	17.77	7.97	133.63	82.63	0.93	0.202	1	**0.198**
7600	18.46	8.65	137.32	84.36	0.93	0.202	1	**0.199**
7800	16.88	7.07	140.69	85.77	0.93	0.202	1	**0.200**
8000	16.15	6.34	143.92	87.04	0.92	0.202	1	**0.201**
8200	16.04	6.23	147.13	88.29	0.92	0.202	1	**0.202**
8400	16.00	6.19	150.33	89.53	0.92	0.202	1	**0.202**
8600	18.44	8.64	154.02	91.25	0.92	0.202	1	**0.203**
8800	18.34	8.53	157.69	92.96	0.91	0.202	1	**0.203**
9000	18.60	8.79	161.41	94.72	0.91	0.202	1	**0.204**
9200	18.72	8.91	165.15	96.50	0.91	0.202	1	**0.204**
9400	19.09	9.29	168.97	98.36	0.90	0.202	1	**0.204**
9600	18.21	8.40	172.61	100.04	0.90	0.202	1	**0.204**
9800	18.31	8.50	176.27	101.74	0.90	0.202	1	**0.204**
10000	19.88	10.07	180.25	103.75	0.90	0.202	1	**0.204**
10200	18.08	8.27	183.86	105.41	0.89	0.202	1	**0.205**
10400	18.20	8.39	187.50	107.09	0.89	0.202	1	**0.205**
10600	17.79	7.99	191.06	108.68	0.89	0.202	1	**0.205**
10800	18.36	8.56	194.74	110.40	0.88	0.202	1	**0.205**
11000	18.43	8.62	198.42	112.12	0.88	0.202	1	**0.205**
11200	18.28	8.47	202.08	113.81	0.88	0.202	1	**0.205**
11400	18.05	8.25	205.69	115.46	0.88	0.202	1	**0.205**
11600	17.93	8.12	209.27	117.09	0.87	0.202	1	**0.205**
11800	18.15	8.35	212.90	118.76	0.87	0.202	1	**0.205**
12000	17.50	7.69	216.40	120.30	0.87	0.202	1	**0.205**
12200	17.12	7.32	219.83	121.76	0.86	0.202	1	**0.205**
12400	18.26	8.45	223.48	123.45	0.86	0.202	1	**0.205**
12600	19.30	9.50	227.34	125.35	0.86	0.202	1	**0.204**
12800	19.61	9.81	231.26	127.31	0.86	0.202	1	**0.204**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

SHEET : 7 OF 14

SOIL BEHAVIOUR TYPE INDEX CORRECTION

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	γ (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	F	$Q_{(1)}$	$I_{c(1)}$	1st Screening	$Q_{(0.5)}$	$C_{Q(0.5)}$	$I_{c(2)}$	2nd Screening	$I_{c(3)}$	q_{c1N}
200	5640	29.20	20.18	4.04	4.04	0.01	1396.14	1.11	to the next step	278.7	1.7	1.5	<-------------Use the Ic(2)	------------	94.6
400	7750	191.90	21.71	8.38	8.38	0.02	924.05	0.63	to the next step	265.7	1.7	1.1	<-------------Use the Ic(2)	------------	130.0
600	9740	184.95	21.35	12.65	12.65	0.02	769.12	0.77	to the next step	271.7	1.7	1.2	<-------------Use the Ic(2)	------------	163.4
800	6280	185.90	21.21	16.89	16.89	0.03	370.83	0.95	to the next step	151.4	1.7	1.3	<-------------Use the Ic(2)	------------	105.4
1000	8590	179.00	20.97	21.08	21.08	0.02	406.41	0.98	to the next step	185.4	1.7	1.3	<-------------Use the Ic(2)	------------	142.3
1200	5500	82.00	20.05	25.10	25.10	0.01	218.17	1.28	to the next step	108.6	1.7	1.6	<-------------Use the Ic(2)	------------	92.3
1400	7900	117.33	20.29	29.15	29.15	0.01	269.98	1.20	to the next step	144.8	1.7	1.4	<-------------Use the Ic(2)	------------	132.5
1600	5320	138.40	20.42	33.24	33.24	0.03	159.06	1.32	to the next step	91.1	1.7	1.6	<-------------Use the Ic(2)	------------	91.7
1800	2670	54.05	19.33	37.10	37.10	0.02	70.96	1.69	to the next step	42.9	1.7	1.9	<-------------Use the Ic(2)	------------	43.5
2000	3130	70.32	19.55	41.01	41.01	0.02	75.32	1.65	to the next step	47.9	1.6	1.8	<-------------Use the Ic(2)	------------	48.6
2200	660	37.95	18.47	44.71	44.71	0.06	13.76	2.33	to the next step	9.1	1.5	2.5	<-------------Use the Ic(2)	------------	9.8
2400	1050	22.80	18.03	48.31	48.31	0.02	20.73	2.19	to the next step	14.3	1.4	2.4	<-------------Use the Ic(2)	------------	15.0
2600	1470	15.65	17.65	51.84	51.84	0.01	27.35	2.16	to the next step	19.6	1.4	2.3	<-------------Use the Ic(2)	------------	20.3
2800	2080	16.89	17.74	55.39	55.39	0.01	36.55	2.09	to the next step	27.0	1.4	2.2	<-------------Use the Ic(2)	------------	27.8
3000	3000	20.80	17.94	58.98	58.98	0.01	49.87	2.00	to the next step	38.0	1.3	2.1	<-------------Use the Ic(2)	------------	38.8
3200	3030	25.60	18.12	62.60	62.60	0.01	47.40	1.98	to the next step	37.3	1.3	2.1	<-------------Use the Ic(2)	------------	38.0
3400	2360	23.65	17.98	66.20	66.20	0.01	34.65	2.08	to the next step	28.0	1.2	2.2	<-------------Use the Ic(2)	------------	28.8
3600	1110	14.05	17.24	69.65	69.65	0.01	14.94	2.39	to the next step	12.4	1.2	2.5	<-------------Use the Ic(2)	------------	13.2
3800	780	12.25	16.93	73.03	73.03	0.02	9.68	2.54	to the next step	8.9	1.2	------------	Use the Ic(3)------------->	2.6	9.1
4000	800	10.65	16.76	76.38	76.38	0.01	9.47	2.57	to the next step	8.8	1.2	------------	Use the Ic(3)------------->	2.6	9.1
4200	570	8.75	16.35	79.66	79.66	0.02	6.16	2.73	Lab check		1.3				7.2
4400	580	9.32	16.40	82.94	82.94	0.02	5.99	2.74	Lab check		1.2				7.0
4600	620	10.60	16.54	86.24	86.24	0.02	6.19	2.72	Lab check		1.2				7.2
4800	630	11.10	16.57	89.56	89.56	0.02	6.03	2.73	Lab check		1.1				7.0
5000	630	10.50	16.48	92.85	92.85	0.02	5.78	2.75	Lab check		1.1				6.8
5200	640	8.10	16.18	96.09	96.09	0.01	5.66	2.78	Lab check		1.1				6.7
5400	620	9.68	16.33	99.35	99.35	0.02	5.24	2.80	Lab check		1.0				6.2
5600	910	11.05	16.61	102.68	102.68	0.01	7.86	2.65	Lab check		1.0				8.9
5800	1220	15.30	17.02	106.08	106.08	0.01	10.50	2.53	to the next step	10.7	1.0	2.5	<-------------Use the Ic(2)	------------	11.8
6000	1760	51.37	18.39	109.76	109.76	0.03	15.04	2.31	to the next step	15.6	1.0	2.3	<-------------Use the Ic(2)	------------	16.7
6200	890	86.30	18.76	113.51	113.51	0.11	6.84	2.65	Lab check		0.9				7.8
6400	8040	20.33	17.33	116.98	116.98	0.00	67.73	2.14	to the next step	72.8	0.9	2.1	<-------------Use the Ic(2)	------------	73.8
6600	8040	20.30	17.31	120.44	120.44	0.00	65.76	2.15	to the next step	71.7	0.9	2.1	<-------------Use the Ic(2)	------------	72.8
6800	1080	1.00	13.92	123.22	123.22	0.00	7.76	3.12	Lab check		0.8				8.8
7000	3250	6.70	16.12	126.45	126.45	0.00	24.70	2.53	to the next step	27.6	0.9	2.5	<-------------Use the Ic(2)	------------	28.7
7200	2970	43.45	18.13	130.07	130.07	0.02	21.83	2.21	to the next step	24.7	0.9	2.2	<-------------Use the Ic(2)	------------	25.9
7400	1520	34.20	17.77	133.63	133.63	0.02	10.38	2.48	to the next step	11.9	0.9	2.4	<-------------Use the Ic(2)	------------	13.1
7600	1420	66.00	18.46	137.32	137.32	0.05	9.34	2.50	to the next step	10.9	0.9	2.4	<-------------Use the Ic(2)	------------	12.0
7800	910	17.55	16.88	140.69	140.69	0.02	5.47	2.76	Lab check		0.7				6.5
8000	1410	8.15	16.15	143.92	143.92	0.01	8.80	2.71	Lab check		0.7				9.8
8200	920	8.32	16.04	147.13	147.13	0.01	5.25	2.85	Lab check		0.7				6.3
8400	780	8.65	16.00	150.33	150.33	0.01	4.19	2.92	Lab check		0.7				5.2
8600	2960	65.30	18.44	154.02	154.02	0.02	18.22	2.25	to the next step	22.5	0.8	2.2	<-------------Use the Ic(2)	------------	23.7
8800	1900	62.32	18.34	157.69	157.69	0.04	11.05	2.44	to the next step	13.8	0.8	2.3	<-------------Use the Ic(2)	------------	15.0
9000	3030	77.70	18.60	161.41	161.41	0.03	17.77	2.25	to the next step	22.4	0.8	2.1	<-------------Use the Ic(2)	------------	23.7
9200	2910	88.11	18.72	165.15	165.15	0.03	16.62	2.27	to the next step	21.2	0.8	2.2	<-------------Use the Ic(2)	------------	22.5
9400	1700	132.40	19.09	168.97	168.97	0.09	9.06	2.52	to the next step	11.7	0.8	2.4	<-------------Use the Ic(2)	------------	13.0
9600	1320	61.90	18.21	172.61	172.61	0.05	6.65	2.65	Lab check		0.6				7.6
9800	3230	62.37	18.31	176.27	176.27	0.02	17.32	2.28	to the next step	22.8	0.8	2.2	<-------------Use the Ic(2)	------------	24.2
10000	2070	276.84	19.88	180.25	180.25	0.15	10.48	2.48	to the next step	14.0	0.7	2.4	<-------------Use the Ic(2)	------------	15.3
10200	1340	57.00	18.08	183.86	183.86	0.05	6.29	2.67	Lab check		0.6				7.3
10400	1550	62.75	18.20	187.50	187.50	0.05	7.27	2.61	Lab check		0.5				8.3
10600	1510	43.90	17.79	191.06	191.06	0.03	6.90	2.64	Lab check		0.5				7.9
10800	2040	72.11	18.36	194.74	194.74	0.04	9.48	2.50	to the next step	13.1	0.7	2.4	<-------------Use the Ic(2)	------------	14.5
11000	2110	76.90	18.43	198.42	198.42	0.04	9.63	2.49	to the next step	13.5	0.7	2.3	<-------------Use the Ic(2)	------------	14.9
11200	2230	67.65	18.28	202.08	202.08	0.03	10.04	2.48	to the next step	14.2	0.7	2.3	<-------------Use the Ic(2)	------------	15.6
11400	1880	56.65	18.05	205.69	205.69	0.03	8.14	2.57	to the next step	11.6	0.7	2.4	<-------------Use the Ic(2)	------------	13.0
11600	1570	52.30	17.93	209.27	209.27	0.04	6.50	2.66	No Liquefaction	9.3	0.7	2.5	<-------------Use the Ic(2)	------------	10.8
11800	2420	61.95	18.15	212.90	212.90	0.03	10.37	2.48	to the next step	15.0	0.7	2.3	<-------------Use the Ic(2)	------------	16.5
12000	1970	34.85	17.50	216.40	216.40	0.02	8.10	2.61	Lab check		0.5				9.1
12200	2130	24.75	17.12	219.83	219.83	0.01	8.69	2.62	Lab check		0.5				9.7
12400	2890	69.55	18.26	223.48	223.48	0.03	11.93	2.42	to the next step	17.7	0.7	2.3	<-------------Use the Ic(2)	------------	19.2
12600	4580	185.35	19.30	227.34	227.34	0.04	19.15	2.19	to the next step	28.7	0.7	2.0	<-------------Use the Ic(2)	------------	30.2
12800	4190	247.94	19.61	231.26	231.26	0.06	17.12	2.24	to the next step	25.9	0.7	2.1	<-------------Use the Ic(2)	------------	27.4

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

SHEET : 8 OF 14

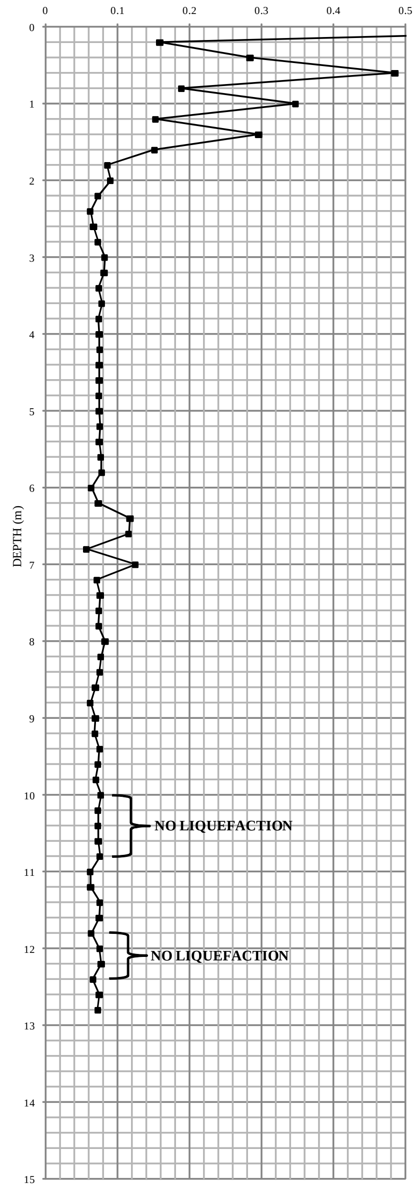
CYCLIC RESISTANCE RATIO

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (MPa)	σ'_v (kN/m^2)	P_a (kN/m^2)	q_{c1N}	I_c	K_c	q_{c1Ncs}	$CRR_{M=7.5}$
200	5.64	4.04	101.325	94.63	1.48	1.00	**94.63**	**0.16**
400	7.75	8.38	101.325	130.03	1.11	1.00	**130.03**	**0.28**
600	9.74	12.65	101.325	163.41	1.15	1.00	**163.41**	**0.49**
800	6.28	16.89	101.325	105.36	1.33	1.00	**105.36**	**0.19**
1000	8.59	21.08	101.325	142.27	1.29	1.00	**142.27**	**0.35**
1200	5.5	25.10	101.325	92.28	1.56	1.00	**92.28**	**0.15**
1400	7.9	29.15	101.325	132.54	1.44	1.00	**132.54**	**0.30**
1600	5.32	33.24	101.325	91.67	1.55	1.00	**91.67**	**0.15**
1800	2.67	37.10	101.325	43.55	1.90	1.00	**43.55**	**0.09**
2000	3.13	41.01	101.325	48.55	1.84	1.00	**48.55**	**0.09**
2200	0.66	44.71	101.325	9.81	2.51	2.81	**27.60**	**0.07**
2400	1.05	46.35	101.325	15.01	2.35	1.00	**15.01**	**0.06**
2600	1.47	47.92	101.325	20.28	2.30	1.00	**20.28**	**0.07**
2800	2.08	49.51	101.325	27.76	2.21	1.00	**27.76**	**0.07**
3000	3	51.13	101.325	38.81	2.11	1.00	**38.81**	**0.08**
3200	3.03	52.80	101.325	38.04	2.08	1.00	**38.04**	**0.08**
3400	2.36	54.43	101.325	28.82	2.16	1.00	**28.82**	**0.07**
3600	1.11	55.92	101.325	13.21	2.46	2.59	**34.28**	**0.08**
3800	0.78	57.34	101.325	9.07	2.58	3.19	**28.92**	**0.07**
4000	0.8	58.73	101.325	9.09	2.60	3.31	**30.10**	**0.08**
4200	0.57	60.04	101.325	7.16	2.73	4.24	**30.32**	**0.08**
4400	0.58	61.36	101.325	6.99	2.74	4.29	**30.03**	**0.08**
4600	0.62	62.71	101.325	7.19	2.72	4.15	**29.87**	**0.07**
4800	0.63	64.06	101.325	7.03	2.73	4.22	**29.67**	**0.07**
5000	0.63	65.39	101.325	6.78	2.75	4.39	**29.76**	**0.07**
5200	0.64	66.67	101.325	6.66	2.78	4.65	**30.98**	**0.08**
5400	0.62	67.97	101.325	6.24	2.80	4.76	**29.73**	**0.07**
5600	0.91	69.33	101.325	8.86	2.65	3.67	**32.54**	**0.08**
5800	1.22	70.78	101.325	11.77	2.52	2.88	**33.91**	**0.08**
6000	1.76	72.49	101.325	16.69	2.29	1.00	**16.69**	**0.06**
6200	0.89	74.28	101.325	7.84	2.65	3.64	**28.50**	**0.07**
6400	8.04	75.79	101.325	73.85	2.11	1.00	**73.85**	**0.12**
6600	8.04	77.29	101.325	72.78	2.12	1.00	**72.78**	**0.12**
6800	1.08	78.11	101.325	8.76	3.12	1.00	**8.76**	**0.06**
7000	3.25	79.37	101.325	28.71	2.49	2.73	**78.50**	**0.12**
7200	2.97	81.04	101.325	25.87	2.16	1.00	**25.87**	**0.07**
7400	1.52	82.63	101.325	13.06	2.43	2.42	**31.59**	**0.08**
7600	1.42	84.36	101.325	12.04	2.43	2.46	**29.60**	**0.07**
7800	0.91	85.77	101.325	6.47	2.76	4.49	**29.05**	**0.07**
8000	1.41	87.04	101.325	9.80	2.71	4.04	**39.58**	**0.08**
8200	0.92	88.29	101.325	6.25	2.85	5.22	**32.65**	**0.08**
8400	0.78	89.53	101.325	5.19	2.92	5.89	**30.57**	**0.08**
8600	2.96	91.25	101.325	23.69	2.16	1.00	**23.69**	**0.07**
8800	1.9	92.96	101.325	15.03	2.34	1.00	**15.03**	**0.06**
9000	3.03	94.72	101.325	23.69	2.15	1.00	**23.69**	**0.07**
9200	2.91	96.50	101.325	22.50	2.16	1.00	**22.50**	**0.07**
9400	1.7	98.36	101.325	12.99	2.41	2.34	**30.41**	**0.08**
9600	1.32	100.04	101.325	7.65	2.65	3.63	**27.78**	**0.07**
9800	3.23	101.74	101.325	24.17	2.16	1.00	**24.17**	**0.07**
10000	2.07	103.75	101.325	15.32	2.36	2.14	**32.81**	**0.08**
10200	1.34	105.41	101.325	7.29	2.67	3.80	**27.72**	**0.07**
10400	1.55	107.09	101.325	8.27	2.61	3.40	**28.08**	**0.07**
10600	1.51	108.68	101.325	7.90	2.64	3.60	**28.48**	**0.07**
10800	2.04	110.40	101.325	14.52	2.36	2.15	**31.26**	**0.08**
11000	2.11	112.12	101.325	14.88	2.35	1.00	**14.88**	**0.06**
11200	2.23	113.81	101.325	15.58	2.33	1.00	**15.58**	**0.06**
11400	1.88	115.46	101.325	13.02	2.42	2.39	**31.13**	**0.08**
11600	1.57	117.09	101.325	10.78	2.51	2.80	**30.24**	**0.08**
11800	2.42	118.76	101.325	16.48	2.32	1.00	**16.48**	**0.06**
12000	1.97	120.30	101.325	9.10	2.61	3.37	**30.63**	**0.08**
12200	2.13	121.76	101.325	9.69	2.62	3.44	**33.29**	**0.08**
12400	2.89	123.45	101.325	19.21	2.25	1.00	**19.21**	**0.07**
12600	4.58	125.35	101.325	30.18	2.02	1.00	**30.18**	**0.08**
12800	4.19	127.31	101.325	27.37	2.06	1.00	**27.37**	**0.07**

CPT PROFILE FOR CYCLIC RESISTANCE



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

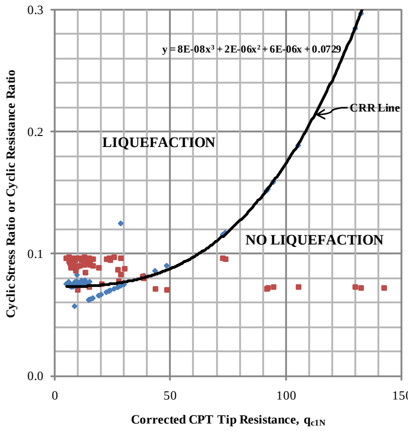
Date : 20 August 2011

CONE PENETRATION TEST (CPT) ***SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT***	**CPT#2**	**SHEET : 9 OF 14** ASSESSMENT RESULTS FOR M=5.0 & 5.5

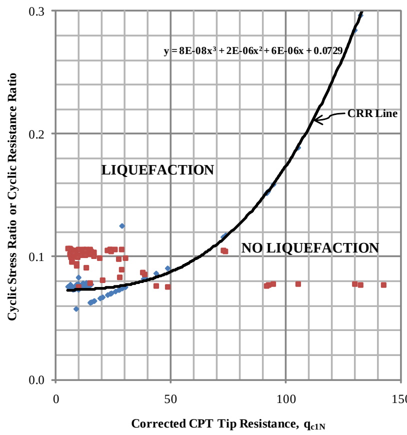
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m	
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan	
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan	
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa	

DEPTH (mm)	**$CSR_{M=5.0}$**	**$CSR_{M=5.5}$**	**$CRR_{M=7.5}$**	**q_{c1N}**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.5
200	0.07	0.08	0.16	94.63	**NO LIQUEFACTION**	**NO LIQUEFACTION**
400	0.07	0.08	0.28	130.03	**NO LIQUEFACTION**	**NO LIQUEFACTION**
600	0.07	0.08	0.49	163.41	**NO LIQUEFACTION**	**NO LIQUEFACTION**
800	0.07	0.08	0.19	105.36	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1000	0.07	0.08	0.35	142.27	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1200	0.07	0.08	0.15	92.28	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1400	0.07	0.08	0.30	132.54	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1600	0.07	0.08	0.15	91.67	**NO LIQUEFACTION**	**NO LIQUEFACTION**
1800	0.07	0.08	0.09	43.55	**NO LIQUEFACTION**	**NO LIQUEFACTION**
2000	0.07	0.08	0.09	48.55	**NO LIQUEFACTION**	**NO LIQUEFACTION**
2200	0.07	0.08	0.07	9.81	**NO LIQUEFACTION**	**LIQUEFACTION**
2400	0.07	0.08	0.06	15.01	**NO LIQUEFACTION**	**LIQUEFACTION**
2600	0.08	0.08	0.07	20.28	**LIQUEFACTION**	**LIQUEFACTION**
2800	0.08	0.08	0.07	27.76	**LIQUEFACTION**	**LIQUEFACTION**
3000	0.08	0.09	0.08	38.81	**NO LIQUEFACTION**	**LIQUEFACTION**
3200	0.08	0.09	0.08	38.04	**LIQUEFACTION**	**LIQUEFACTION**
3400	0.08	0.09	0.07	28.82	**LIQUEFACTION**	**LIQUEFACTION**
3600	0.08	0.09	0.08	13.21	**LIQUEFACTION**	**LIQUEFACTION**
3800	0.09	0.09	0.07	9.07	**LIQUEFACTION**	**LIQUEFACTION**
4000	0.09	0.09	0.08	9.09	**LIQUEFACTION**	**LIQUEFACTION**
4200	0.09	0.10	0.08	7.16	**LIQUEFACTION**	**LIQUEFACTION**
4400	0.09	0.10	0.08	6.99	**LIQUEFACTION**	**LIQUEFACTION**
4600	0.09	0.10	0.07	7.19	**LIQUEFACTION**	**LIQUEFACTION**
4800	0.09	0.10	0.07	7.03	**LIQUEFACTION**	**LIQUEFACTION**
5000	0.09	0.10	0.07	6.78	**LIQUEFACTION**	**LIQUEFACTION**
5200	0.09	0.10	0.08	6.66	**LIQUEFACTION**	**LIQUEFACTION**
5400	0.09	0.10	0.07	6.24	**LIQUEFACTION**	**LIQUEFACTION**
5600	0.09	0.10	0.08	8.86	**LIQUEFACTION**	**LIQUEFACTION**
5800	0.09	0.10	0.08	11.77	**LIQUEFACTION**	**LIQUEFACTION**
6000	0.10	0.10	0.06	16.69	**LIQUEFACTION**	**LIQUEFACTION**
6200	0.10	0.10	0.07	7.84	**LIQUEFACTION**	**LIQUEFACTION**
6400	0.10	0.10	0.12	73.85	**NO LIQUEFACTION**	**NO LIQUEFACTION**
6600	0.10	0.10	0.12	72.78	**NO LIQUEFACTION**	**NO LIQUEFACTION**
6800	0.10	0.11	0.06	8.76	**LIQUEFACTION**	**LIQUEFACTION**
7000	0.10	0.11	0.12	28.71	**LIQUEFACTION**	**LIQUEFACTION**
7200	0.10	0.11	0.07	25.87	**LIQUEFACTION**	**LIQUEFACTION**
7400	0.10	0.11	0.08	13.06	**LIQUEFACTION**	**LIQUEFACTION**
7600	0.10	0.11	0.07	12.04	**LIQUEFACTION**	**LIQUEFACTION**
7800	0.10	0.11	0.07	6.47	**LIQUEFACTION**	**LIQUEFACTION**
8000	0.10	0.11	0.08	9.80	**LIQUEFACTION**	**LIQUEFACTION**
8200	0.10	0.11	0.08	6.25	**LIQUEFACTION**	**LIQUEFACTION**
8400	0.10	0.11	0.08	5.19	**LIQUEFACTION**	**LIQUEFACTION**
8600	0.10	0.11	0.07	23.69	**LIQUEFACTION**	**LIQUEFACTION**
8800	0.10	0.11	0.06	15.03	**LIQUEFACTION**	**LIQUEFACTION**
9000	0.10	0.11	0.07	23.69	**LIQUEFACTION**	**LIQUEFACTION**
9200	0.10	0.11	0.07	22.50	**LIQUEFACTION**	**LIQUEFACTION**
9400	0.10	0.11	0.08	12.99	**LIQUEFACTION**	**LIQUEFACTION**
9600	0.09	0.10	0.07	7.65	**LIQUEFACTION**	**LIQUEFACTION**
9800	0.09	0.10	0.07	24.17	**LIQUEFACTION**	**LIQUEFACTION**
10000	0.09	0.10	0.08	15.32	**LIQUEFACTION**	**LIQUEFACTION**
10200	0.09	0.10	0.07	7.29	**LIQUEFACTION**	**LIQUEFACTION**
10400	0.09	0.10	0.07	8.27	**LIQUEFACTION**	**LIQUEFACTION**
10600	0.09	0.10	0.07	7.90	**LIQUEFACTION**	**LIQUEFACTION**
10800	0.09	0.10	0.08	14.52	**LIQUEFACTION**	**LIQUEFACTION**
11000	0.09	0.10	0.06	14.88	**LIQUEFACTION**	**LIQUEFACTION**
11200	0.09	0.10	0.06	15.58	**LIQUEFACTION**	**LIQUEFACTION**
11400	0.09	0.10	0.08	13.02	**LIQUEFACTION**	**LIQUEFACTION**
11600	0.09	0.10	0.08	10.78	**LIQUEFACTION**	**LIQUEFACTION**
11800	0.09	0.10	0.06	16.48	**LIQUEFACTION**	**LIQUEFACTION**
12000	0.09	0.10	0.08	9.10	**LIQUEFACTION**	**LIQUEFACTION**
12200	0.09	0.10	0.08	9.69	**LIQUEFACTION**	**LIQUEFACTION**
12400	0.09	0.10	0.07	19.21	**LIQUEFACTION**	**LIQUEFACTION**
12600	0.09	0.10	0.08	30.18	**LIQUEFACTION**	**LIQUEFACTION**
12800	0.09	0.10	0.07	27.37	**LIQUEFACTION**	**LIQUEFACTION**

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 5.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

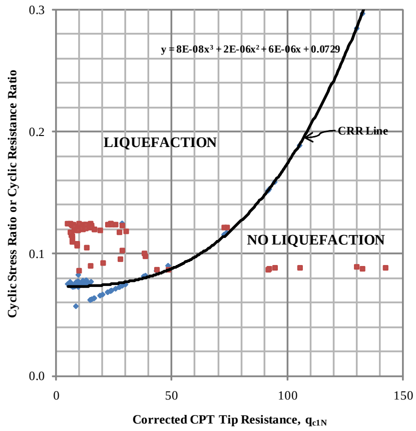
SHEET : 10 OF 14

ASSESSMENT RESULTS FOR M=6.0 & 6.5

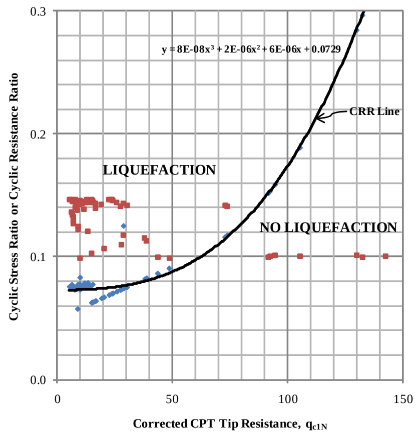
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=6.0}$	$CSR_{M=6.5}$	$CRR_{M=7.5}$	q_{c1N}	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.5
200	0.09	0.10	0.16	94.63	NO LIQUEFACTION	NO LIQUEFACTION
400	0.09	0.10	0.28	130.03	NO LIQUEFACTION	NO LIQUEFACTION
600	0.09	0.10	0.49	163.41	NO LIQUEFACTION	NO LIQUEFACTION
800	0.09	0.10	0.19	105.36	NO LIQUEFACTION	NO LIQUEFACTION
1000	0.09	0.10	0.35	142.27	NO LIQUEFACTION	NO LIQUEFACTION
1200	0.09	0.10	0.15	92.28	NO LIQUEFACTION	NO LIQUEFACTION
1400	0.09	0.10	0.30	132.54	NO LIQUEFACTION	NO LIQUEFACTION
1600	0.09	0.10	0.15	91.67	NO LIQUEFACTION	NO LIQUEFACTION
1800	0.09	0.10	0.09	43.55	LIQUEFACTION	LIQUEFACTION
2000	0.09	0.10	0.09	48.55	NO LIQUEFACTION	LIQUEFACTION
2200	0.09	0.10	0.07	9.81	LIQUEFACTION	LIQUEFACTION
2400	0.09	0.10	0.06	15.01	LIQUEFACTION	LIQUEFACTION
2600	0.09	0.11	0.07	20.28	LIQUEFACTION	LIQUEFACTION
2800	0.10	0.11	0.07	27.76	LIQUEFACTION	LIQUEFACTION
3000	0.10	0.11	0.08	38.81	LIQUEFACTION	LIQUEFACTION
3200	0.10	0.12	0.08	38.04	LIQUEFACTION	LIQUEFACTION
3400	0.10	0.12	0.07	28.82	LIQUEFACTION	LIQUEFACTION
3600	0.10	0.12	0.08	13.21	LIQUEFACTION	LIQUEFACTION
3800	0.11	0.12	0.07	9.07	LIQUEFACTION	LIQUEFACTION
4000	0.11	0.12	0.08	9.09	LIQUEFACTION	LIQUEFACTION
4200	0.11	0.13	0.08	7.16	LIQUEFACTION	LIQUEFACTION
4400	0.11	0.13	0.08	6.99	LIQUEFACTION	LIQUEFACTION
4600	0.11	0.13	0.07	7.19	LIQUEFACTION	LIQUEFACTION
4800	0.11	0.13	0.07	7.03	LIQUEFACTION	LIQUEFACTION
5000	0.12	0.13	0.07	6.78	LIQUEFACTION	LIQUEFACTION
5200	0.12	0.14	0.08	6.66	LIQUEFACTION	LIQUEFACTION
5400	0.12	0.14	0.07	6.24	LIQUEFACTION	LIQUEFACTION
5600	0.12	0.14	0.08	8.86	LIQUEFACTION	LIQUEFACTION
5800	0.12	0.14	0.08	11.77	LIQUEFACTION	LIQUEFACTION
6000	0.12	0.14	0.06	16.69	LIQUEFACTION	LIQUEFACTION
6200	0.12	0.14	0.07	7.84	LIQUEFACTION	LIQUEFACTION
6400	0.12	0.14	0.12	73.85	LIQUEFACTION	LIQUEFACTION
6600	0.12	0.14	0.12	72.78	LIQUEFACTION	LIQUEFACTION
6800	0.12	0.14	0.06	8.76	LIQUEFACTION	LIQUEFACTION
7000	0.12	0.14	0.12	28.71	LIQUEFACTION	LIQUEFACTION
7200	0.12	0.14	0.07	25.87	LIQUEFACTION	LIQUEFACTION
7400	0.12	0.14	0.08	13.06	LIQUEFACTION	LIQUEFACTION
7600	0.12	0.14	0.07	12.04	LIQUEFACTION	LIQUEFACTION
7800	0.12	0.15	0.07	6.47	LIQUEFACTION	LIQUEFACTION
8000	0.12	0.15	0.08	9.80	LIQUEFACTION	LIQUEFACTION
8200	0.12	0.15	0.08	6.25	LIQUEFACTION	LIQUEFACTION
8400	0.12	0.15	0.08	5.19	LIQUEFACTION	LIQUEFACTION
8600	0.12	0.15	0.07	23.69	LIQUEFACTION	LIQUEFACTION
8800	0.12	0.15	0.06	15.03	LIQUEFACTION	LIQUEFACTION
9000	0.12	0.15	0.07	23.69	LIQUEFACTION	LIQUEFACTION
9200	0.12	0.15	0.07	22.50	LIQUEFACTION	LIQUEFACTION
9400	0.12	0.15	0.08	12.99	LIQUEFACTION	LIQUEFACTION
9600	0.12	0.15	0.07	7.65	LIQUEFACTION	LIQUEFACTION
9800	0.12	0.15	0.07	24.17	LIQUEFACTION	LIQUEFACTION
10000	0.12	0.15	0.08	15.32	LIQUEFACTION	LIQUEFACTION
10200	0.12	0.15	0.07	7.29	LIQUEFACTION	LIQUEFACTION
10400	0.12	0.15	0.07	8.27	LIQUEFACTION	LIQUEFACTION
10600	0.12	0.15	0.07	7.90	LIQUEFACTION	LIQUEFACTION
10800	0.12	0.14	0.08	14.52	LIQUEFACTION	LIQUEFACTION
11000	0.12	0.14	0.06	14.88	LIQUEFACTION	LIQUEFACTION
11200	0.12	0.14	0.06	15.58	LIQUEFACTION	LIQUEFACTION
11400	0.12	0.14	0.08	13.02	LIQUEFACTION	LIQUEFACTION
11600	0.12	0.14	0.08	10.78	LIQUEFACTION	LIQUEFACTION
11800	0.12	0.14	0.06	16.48	LIQUEFACTION	LIQUEFACTION
12000	0.12	0.14	0.08	9.10	LIQUEFACTION	LIQUEFACTION
12200	0.12	0.14	0.08	9.69	LIQUEFACTION	LIQUEFACTION
12400	0.12	0.14	0.07	19.21	LIQUEFACTION	LIQUEFACTION
12600	0.12	0.14	0.08	30.18	LIQUEFACTION	LIQUEFACTION
12800	0.12	0.14	0.07	27.37	LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 6.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

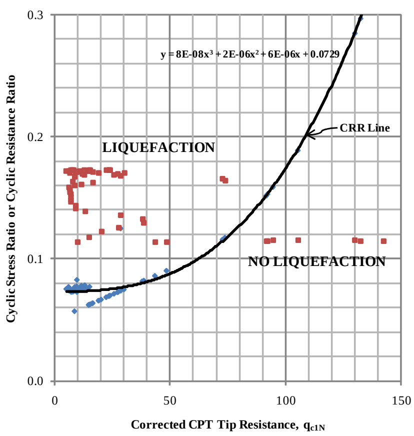
SHEET : 11 OF 14

ASSESSMENT RESULTS FOR M=7.0 & 7.5

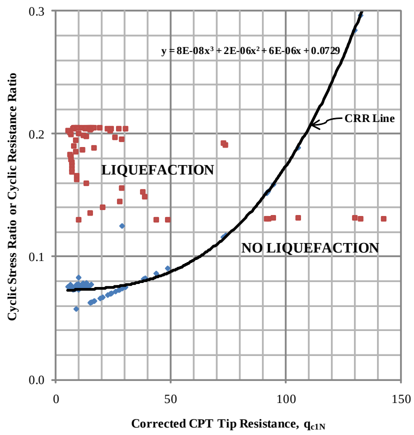
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CSR_{M=7.0}$	$CSR_{M=7.5}$	$CRR_{M=7.5}$	q_{c1N}	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.5
200	0.12	0.13	0.16	94.63	NO LIQUEFACTION	NO LIQUEFACTION
400	0.12	0.13	0.28	130.03	NO LIQUEFACTION	NO LIQUEFACTION
600	0.12	0.13	0.49	163.41	NO LIQUEFACTION	NO LIQUEFACTION
800	0.12	0.13	0.19	105.36	NO LIQUEFACTION	NO LIQUEFACTION
1000	0.11	0.13	0.35	142.27	NO LIQUEFACTION	NO LIQUEFACTION
1200	0.11	0.13	0.15	92.28	NO LIQUEFACTION	NO LIQUEFACTION
1400	0.11	0.13	0.30	132.54	NO LIQUEFACTION	NO LIQUEFACTION
1600	0.11	0.13	0.15	91.67	NO LIQUEFACTION	NO LIQUEFACTION
1800	0.11	0.13	0.09	43.55	LIQUEFACTION	LIQUEFACTION
2000	0.11	0.13	0.09	48.55	LIQUEFACTION	LIQUEFACTION
2200	0.11	0.13	0.07	9.81	LIQUEFACTION	LIQUEFACTION
2400	0.12	0.14	0.06	15.01	LIQUEFACTION	LIQUEFACTION
2600	0.12	0.14	0.07	20.28	LIQUEFACTION	LIQUEFACTION
2800	0.13	0.14	0.07	27.76	LIQUEFACTION	LIQUEFACTION
3000	0.13	0.15	0.08	38.81	LIQUEFACTION	LIQUEFACTION
3200	0.13	0.15	0.08	38.04	LIQUEFACTION	LIQUEFACTION
3400	0.14	0.16	0.07	28.82	LIQUEFACTION	LIQUEFACTION
3600	0.14	0.16	0.08	13.21	LIQUEFACTION	LIQUEFACTION
3800	0.14	0.16	0.07	9.07	LIQUEFACTION	LIQUEFACTION
4000	0.14	0.17	0.08	9.09	LIQUEFACTION	LIQUEFACTION
4200	0.15	0.17	0.08	7.16	LIQUEFACTION	LIQUEFACTION
4400	0.15	0.17	0.08	6.99	LIQUEFACTION	LIQUEFACTION
4600	0.15	0.17	0.07	7.19	LIQUEFACTION	LIQUEFACTION
4800	0.15	0.18	0.07	7.03	LIQUEFACTION	LIQUEFACTION
5000	0.15	0.18	0.07	6.78	LIQUEFACTION	LIQUEFACTION
5200	0.16	0.18	0.08	6.66	LIQUEFACTION	LIQUEFACTION
5400	0.16	0.18	0.07	6.24	LIQUEFACTION	LIQUEFACTION
5600	0.16	0.19	0.08	8.86	LIQUEFACTION	LIQUEFACTION
5800	0.16	0.19	0.08	11.77	LIQUEFACTION	LIQUEFACTION
6000	0.16	0.19	0.06	16.69	LIQUEFACTION	LIQUEFACTION
6200	0.16	0.19	0.07	7.84	LIQUEFACTION	LIQUEFACTION
6400	0.16	0.19	0.12	73.85	LIQUEFACTION	LIQUEFACTION
6600	0.17	0.19	0.12	72.78	LIQUEFACTION	LIQUEFACTION
6800	0.17	0.19	0.06	8.76	LIQUEFACTION	LIQUEFACTION
7000	0.17	0.20	0.12	28.71	LIQUEFACTION	LIQUEFACTION
7200	0.17	0.20	0.07	25.87	LIQUEFACTION	LIQUEFACTION
7400	0.17	0.20	0.08	13.06	LIQUEFACTION	LIQUEFACTION
7600	0.17	0.20	0.07	12.04	LIQUEFACTION	LIQUEFACTION
7800	0.17	0.20	0.07	6.47	LIQUEFACTION	LIQUEFACTION
8000	0.17	0.20	0.08	9.80	LIQUEFACTION	LIQUEFACTION
8200	0.17	0.20	0.08	6.25	LIQUEFACTION	LIQUEFACTION
8400	0.17	0.20	0.08	5.19	LIQUEFACTION	LIQUEFACTION
8600	0.17	0.20	0.07	23.69	LIQUEFACTION	LIQUEFACTION
8800	0.17	0.20	0.06	15.03	LIQUEFACTION	LIQUEFACTION
9000	0.17	0.20	0.07	23.69	LIQUEFACTION	LIQUEFACTION
9200	0.17	0.20	0.07	22.50	LIQUEFACTION	LIQUEFACTION
9400	0.17	0.20	0.08	12.99	LIQUEFACTION	LIQUEFACTION
9600	0.17	0.20	0.07	7.65	LIQUEFACTION	LIQUEFACTION
9800	0.17	0.20	0.07	24.17	LIQUEFACTION	LIQUEFACTION
10000	0.17	0.20	0.08	15.32	LIQUEFACTION	LIQUEFACTION
10200	0.17	0.20	0.07	7.29	LIQUEFACTION	LIQUEFACTION
10400	0.17	0.20	0.07	8.27	LIQUEFACTION	LIQUEFACTION
10600	0.17	0.20	0.07	7.90	LIQUEFACTION	LIQUEFACTION
10800	0.17	0.20	0.08	14.52	LIQUEFACTION	LIQUEFACTION
11000	0.17	0.20	0.06	14.88	LIQUEFACTION	LIQUEFACTION
11200	0.17	0.20	0.06	15.58	LIQUEFACTION	LIQUEFACTION
11400	0.17	0.20	0.08	13.02	LIQUEFACTION	LIQUEFACTION
11600	0.17	0.20	0.08	10.78	LIQUEFACTION	LIQUEFACTION
11800	0.17	0.20	0.06	16.48	LIQUEFACTION	LIQUEFACTION
12000	0.17	0.20	0.08	9.10	LIQUEFACTION	LIQUEFACTION
12200	0.17	0.20	0.08	9.69	LIQUEFACTION	LIQUEFACTION
12400	0.17	0.20	0.07	19.21	LIQUEFACTION	LIQUEFACTION
12600	0.17	0.20	0.08	30.18	LIQUEFACTION	LIQUEFACTION
12800	0.17	0.20	0.07	27.37	LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 7.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

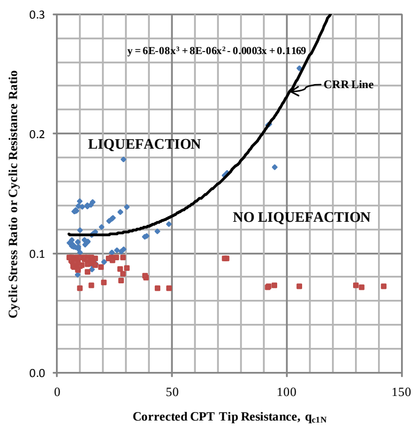
SHEET : 12 OF 14

ASSESSMENT RESULTS INC. AGEING FOR M=5.0 & 5.5

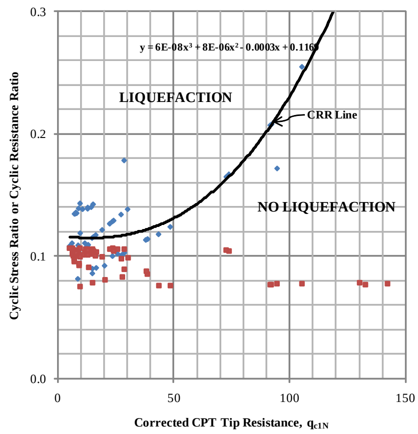
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**t (years)**	K_{DR}	$CRR_{M=7.5}$	$CRR_{M=7.5,DR}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.5
200	30	1.08	0.16	0.172	NO LIQUEFACTION	NO LIQUEFACTION
400	30	1.08	0.28	0.308	NO LIQUEFACTION	NO LIQUEFACTION
600	30	1.08	0.49	0.525	NO LIQUEFACTION	NO LIQUEFACTION
800	1120	1.35	0.19	0.255	NO LIQUEFACTION	NO LIQUEFACTION
1000	1187	1.35	0.35	0.470	NO LIQUEFACTION	NO LIQUEFACTION
1200	1254	1.36	0.15	0.208	NO LIQUEFACTION	NO LIQUEFACTION
1400	1321	1.36	0.30	0.403	NO LIQUEFACTION	NO LIQUEFACTION
1600	1388	1.36	0.15	0.207	NO LIQUEFACTION	NO LIQUEFACTION
1800	1455	1.37	0.09	0.118	NO LIQUEFACTION	NO LIQUEFACTION
2000	1522	1.37	0.09	0.124	NO LIQUEFACTION	NO LIQUEFACTION
2200	1589	1.37	0.07	0.100	NO LIQUEFACTION	NO LIQUEFACTION
2400	1656	1.38	0.06	0.086	NO LIQUEFACTION	NO LIQUEFACTION
2600	1723	1.38	0.07	0.092	NO LIQUEFACTION	NO LIQUEFACTION
2800	1790	1.38	0.07	0.101	NO LIQUEFACTION	NO LIQUEFACTION
3000	1857	1.39	0.08	0.114	NO LIQUEFACTION	NO LIQUEFACTION
3200	1924	1.39	0.08	0.113	NO LIQUEFACTION	NO LIQUEFACTION
3400	1991	1.39	0.07	0.103	NO LIQUEFACTION	NO LIQUEFACTION
3600	2058	1.39	0.08	0.109	NO LIQUEFACTION	NO LIQUEFACTION
3800	2125	1.40	0.07	0.103	NO LIQUEFACTION	NO LIQUEFACTION
4000	2192	1.40	0.08	0.105	NO LIQUEFACTION	NO LIQUEFACTION
4200	2259	1.40	0.08	0.105	NO LIQUEFACTION	NO LIQUEFACTION
4400	2326	1.40	0.08	0.105	NO LIQUEFACTION	NO LIQUEFACTION
4600	2393	1.40	0.07	0.105	NO LIQUEFACTION	NO LIQUEFACTION
4800	2460	1.41	0.07	0.105	NO LIQUEFACTION	NO LIQUEFACTION
5000	2527	1.41	0.07	0.105	NO LIQUEFACTION	NO LIQUEFACTION
5200	2594	1.41	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
5400	2661	1.41	0.07	0.106	NO LIQUEFACTION	NO LIQUEFACTION
5600	2728	1.41	0.08	0.109	NO LIQUEFACTION	NO LIQUEFACTION
5800	2795	1.42	0.08	0.111	NO LIQUEFACTION	NO LIQUEFACTION
6000	2862	1.42	0.06	0.091	NO LIQUEFACTION	NO LIQUEFACTION
6200	2929	1.42	0.07	0.105	NO LIQUEFACTION	NO LIQUEFACTION
6400	2996	1.42	0.12	0.167	NO LIQUEFACTION	NO LIQUEFACTION
6600	3063	1.42	0.12	0.165	NO LIQUEFACTION	NO LIQUEFACTION
6800	3130	1.42	0.06	0.082	NO LIQUEFACTION	NO LIQUEFACTION
7000	3197	1.43	0.12	0.178	NO LIQUEFACTION	NO LIQUEFACTION
7200	3264	1.43	0.07	0.102	NO LIQUEFACTION	NO LIQUEFACTION
7400	3331	1.43	0.08	0.109	NO LIQUEFACTION	NO LIQUEFACTION
7600	3398	1.43	0.07	0.107	NO LIQUEFACTION	NO LIQUEFACTION
7800	3465	1.43	0.07	0.106	NO LIQUEFACTION	NO LIQUEFACTION
8000	3532	1.43	0.08	0.119	NO LIQUEFACTION	NO LIQUEFACTION
8200	3599	1.43	0.08	0.111	NO LIQUEFACTION	NO LIQUEFACTION
8400	3666	1.44	0.08	0.108	NO LIQUEFACTION	NO LIQUEFACTION
8600	3733	1.44	0.07	0.100	NO LIQUEFACTION	NO LIQUEFACTION
8800	3800	1.44	0.06	0.090	NO LIQUEFACTION	NO LIQUEFACTION
9000	900000	1.84	0.07	0.128	NO LIQUEFACTION	NO LIQUEFACTION
9200	900100	1.84	0.07	0.127	NO LIQUEFACTION	NO LIQUEFACTION
9400	900200	1.84	0.08	0.139	NO LIQUEFACTION	NO LIQUEFACTION
9600	900300	1.84	0.07	0.135	NO LIQUEFACTION	NO LIQUEFACTION
9800	900400	1.84	0.07	0.129	NO LIQUEFACTION	NO LIQUEFACTION
10000	900500	1.84	0.08	0.142	NO LIQUEFACTION	NO LIQUEFACTION
10200	900600	1.84	0.07	0.135	NO LIQUEFACTION	NO LIQUEFACTION
10400	900700	1.84	0.07	0.135	NO LIQUEFACTION	NO LIQUEFACTION
10600	900800	1.84	0.07	0.136	NO LIQUEFACTION	NO LIQUEFACTION
10800	900900	1.84	0.08	0.140	NO LIQUEFACTION	NO LIQUEFACTION
11000	901000	1.84	0.06	0.115	NO LIQUEFACTION	NO LIQUEFACTION
11200	901100	1.84	0.06	0.116	NO LIQUEFACTION	NO LIQUEFACTION
11400	901200	1.84	0.08	0.140	NO LIQUEFACTION	NO LIQUEFACTION
11600	901300	1.84	0.08	0.139	NO LIQUEFACTION	NO LIQUEFACTION
11800	901400	1.84	0.06	0.117	NO LIQUEFACTION	NO LIQUEFACTION
12000	901500	1.84	0.08	0.139	NO LIQUEFACTION	NO LIQUEFACTION
12200	901600	1.84	0.08	0.143	NO LIQUEFACTION	NO LIQUEFACTION
12400	901700	1.84	0.07	0.122	NO LIQUEFACTION	NO LIQUEFACTION
12600	901800	1.84	0.08	0.138	NO LIQUEFACTION	NO LIQUEFACTION
12800	901900	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 5.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

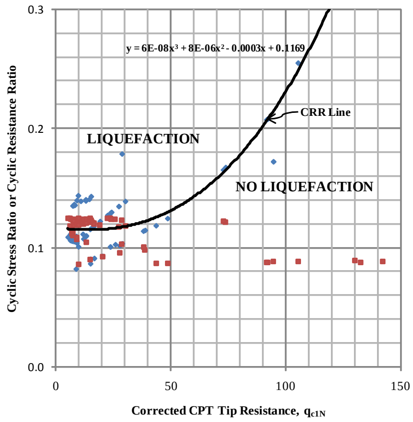
SHEET : 13 OF 14

ASSESSMENT RESULTS INC. AGEING FOR M=6.0 & 6.5

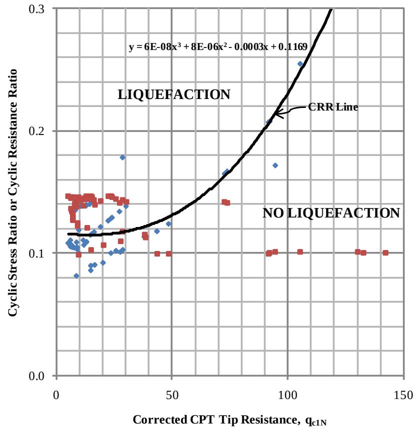
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**t (years)**	K_{DR}	$CRR_{M=7.5}$	$CRR_{M=7.5,DR}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.5
200	30	1.08	0.16	0.172	NO LIQUEFACTION	NO LIQUEFACTION
400	30	1.08	0.28	0.308	NO LIQUEFACTION	NO LIQUEFACTION
600	30	1.08	0.49	0.525	NO LIQUEFACTION	NO LIQUEFACTION
800	1120	1.35	0.19	0.255	NO LIQUEFACTION	NO LIQUEFACTION
1000	1187	1.35	0.35	0.470	NO LIQUEFACTION	NO LIQUEFACTION
1200	1254	1.36	0.15	0.208	NO LIQUEFACTION	NO LIQUEFACTION
1400	1321	1.36	0.30	0.403	NO LIQUEFACTION	NO LIQUEFACTION
1600	1388	1.36	0.15	0.207	NO LIQUEFACTION	NO LIQUEFACTION
1800	1455	1.37	0.09	0.118	NO LIQUEFACTION	NO LIQUEFACTION
2000	1522	1.37	0.09	0.124	NO LIQUEFACTION	NO LIQUEFACTION
2200	1589	1.37	0.07	0.100	NO LIQUEFACTION	NO LIQUEFACTION
2400	1656	1.38	0.06	0.086	NO LIQUEFACTION	NO LIQUEFACTION
2600	1723	1.38	0.07	0.092	NO LIQUEFACTION	NO LIQUEFACTION
2800	1790	1.38	0.07	0.101	NO LIQUEFACTION	NO LIQUEFACTION
3000	1857	1.39	0.08	0.114	NO LIQUEFACTION	NO LIQUEFACTION
3200	1924	1.39	0.08	0.113	NO LIQUEFACTION	NO LIQUEFACTION
3400	1991	1.39	0.07	0.103	NO LIQUEFACTION	NO LIQUEFACTION
3600	2058	1.39	0.08	0.109	NO LIQUEFACTION	NO LIQUEFACTION
3800	2125	1.40	0.07	0.103	NO LIQUEFACTION	LIQUEFACTION
4000	2192	1.40	0.08	0.105	NO LIQUEFACTION	LIQUEFACTION
4200	2259	1.40	0.08	0.105	NO LIQUEFACTION	LIQUEFACTION
4400	2326	1.40	0.08	0.105	NO LIQUEFACTION	LIQUEFACTION
4600	2393	1.40	0.07	0.105	NO LIQUEFACTION	LIQUEFACTION
4800	2460	1.41	0.07	0.105	NO LIQUEFACTION	LIQUEFACTION
5000	2527	1.41	0.07	0.105	NO LIQUEFACTION	LIQUEFACTION
5200	2594	1.41	0.08	0.107	NO LIQUEFACTION	LIQUEFACTION
5400	2661	1.41	0.07	0.106	NO LIQUEFACTION	LIQUEFACTION
5600	2728	1.41	0.08	0.109	NO LIQUEFACTION	LIQUEFACTION
5800	2795	1.42	0.08	0.111	NO LIQUEFACTION	LIQUEFACTION
6000	2862	1.42	0.06	0.091	NO LIQUEFACTION	LIQUEFACTION
6200	2929	1.42	0.07	0.105	LIQUEFACTION	LIQUEFACTION
6400	2996	1.42	0.12	0.167	NO LIQUEFACTION	NO LIQUEFACTION
6600	3063	1.42	0.12	0.165	NO LIQUEFACTION	NO LIQUEFACTION
6800	3130	1.42	0.06	0.082	LIQUEFACTION	LIQUEFACTION
7000	3197	1.43	0.12	0.178	NO LIQUEFACTION	LIQUEFACTION
7200	3264	1.43	0.07	0.102	NO LIQUEFACTION	LIQUEFACTION
7400	3331	1.43	0.08	0.109	LIQUEFACTION	LIQUEFACTION
7600	3398	1.43	0.07	0.107	LIQUEFACTION	LIQUEFACTION
7800	3465	1.43	0.07	0.106	LIQUEFACTION	LIQUEFACTION
8000	3532	1.43	0.08	0.119	LIQUEFACTION	LIQUEFACTION
8200	3599	1.43	0.08	0.111	LIQUEFACTION	LIQUEFACTION
8400	3666	1.44	0.08	0.108	LIQUEFACTION	LIQUEFACTION
8600	3733	1.44	0.07	0.100	NO LIQUEFACTION	LIQUEFACTION
8800	3800	1.44	0.06	0.090	LIQUEFACTION	LIQUEFACTION
9000	900000	1.84	0.07	0.128	NO LIQUEFACTION	LIQUEFACTION
9200	900100	1.84	0.07	0.127	NO LIQUEFACTION	LIQUEFACTION
9400	900200	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
9600	900300	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
9800	900400	1.84	0.07	0.129	NO LIQUEFACTION	LIQUEFACTION
10000	900500	1.84	0.08	0.142	NO LIQUEFACTION	LIQUEFACTION
10200	900600	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
10400	900700	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
10600	900800	1.84	0.07	0.136	LIQUEFACTION	LIQUEFACTION
10800	900900	1.84	0.08	0.140	NO LIQUEFACTION	LIQUEFACTION
11000	901000	1.84	0.06	0.115	NO LIQUEFACTION	LIQUEFACTION
11200	901100	1.84	0.06	0.116	NO LIQUEFACTION	LIQUEFACTION
11400	901200	1.84	0.08	0.140	NO LIQUEFACTION	LIQUEFACTION
11600	901300	1.84	0.08	0.139	NO LIQUEFACTION	LIQUEFACTION
11800	901400	1.84	0.06	0.117	NO LIQUEFACTION	LIQUEFACTION
12000	901500	1.84	0.08	0.139	NO LIQUEFACTION	LIQUEFACTION
12200	901600	1.84	0.08	0.143	NO LIQUEFACTION	LIQUEFACTION
12400	901700	1.84	0.07	0.122	NO LIQUEFACTION	LIQUEFACTION
12600	901800	1.84	0.08	0.138	NO LIQUEFACTION	LIQUEFACTION
12800	901900	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 6.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#2

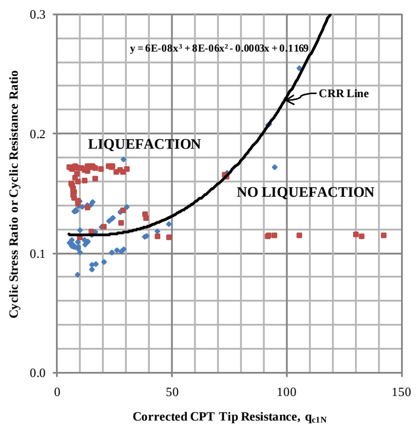
SHEET : 14 OF 14

ASSESSMENT RESULTS INC. AGEING FOR M=7.0 & 7.5

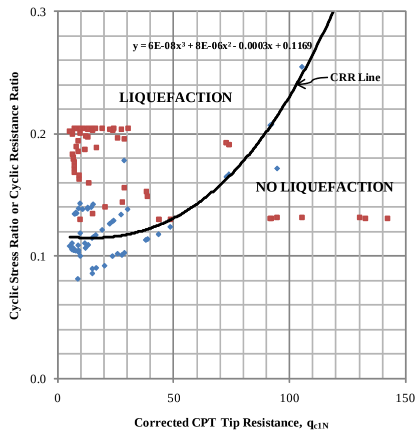
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	t (years)	K_{DR}	$CRR_{M=7.5}$	$CRR_{M=7.5,DR}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.5
200	30	1.08	0.16	0.172	NO LIQUEFACTION	NO LIQUEFACTION
400	30	1.08	0.28	0.308	NO LIQUEFACTION	NO LIQUEFACTION
600	30	1.08	0.49	0.525	NO LIQUEFACTION	NO LIQUEFACTION
800	1120	1.35	0.19	0.255	NO LIQUEFACTION	NO LIQUEFACTION
1000	1187	1.35	0.35	0.470	NO LIQUEFACTION	NO LIQUEFACTION
1200	1254	1.36	0.15	0.208	NO LIQUEFACTION	NO LIQUEFACTION
1400	1321	1.36	0.30	0.403	NO LIQUEFACTION	NO LIQUEFACTION
1600	1388	1.36	0.15	0.207	NO LIQUEFACTION	NO LIQUEFACTION
1800	1455	1.37	0.09	0.118	NO LIQUEFACTION	NO LIQUEFACTION
2000	1522	1.37	0.09	0.124	NO LIQUEFACTION	NO LIQUEFACTION
2200	1589	1.37	0.07	0.100	NO LIQUEFACTION	LIQUEFACTION
2400	1656	1.38	0.06	0.086	NO LIQUEFACTION	LIQUEFACTION
2600	1723	1.38	0.07	0.092	NO LIQUEFACTION	LIQUEFACTION
2800	1790	1.38	0.07	0.101	NO LIQUEFACTION	LIQUEFACTION
3000	1857	1.39	0.08	0.114	NO LIQUEFACTION	LIQUEFACTION
3200	1924	1.39	0.08	0.113	NO LIQUEFACTION	LIQUEFACTION
3400	1991	1.39	0.07	0.103	LIQUEFACTION	LIQUEFACTION
3600	2058	1.39	0.08	0.109	LIQUEFACTION	LIQUEFACTION
3800	2125	1.40	0.07	0.103	LIQUEFACTION	LIQUEFACTION
4000	2192	1.40	0.08	0.105	LIQUEFACTION	LIQUEFACTION
4200	2259	1.40	0.08	0.105	LIQUEFACTION	LIQUEFACTION
4400	2326	1.40	0.08	0.105	LIQUEFACTION	LIQUEFACTION
4600	2393	1.40	0.07	0.105	LIQUEFACTION	LIQUEFACTION
4800	2460	1.41	0.07	0.105	LIQUEFACTION	LIQUEFACTION
5000	2527	1.41	0.07	0.105	LIQUEFACTION	LIQUEFACTION
5200	2594	1.41	0.08	0.107	LIQUEFACTION	LIQUEFACTION
5400	2661	1.41	0.07	0.106	LIQUEFACTION	LIQUEFACTION
5600	2728	1.41	0.08	0.109	LIQUEFACTION	LIQUEFACTION
5800	2795	1.42	0.08	0.111	LIQUEFACTION	LIQUEFACTION
6000	2862	1.42	0.06	0.091	LIQUEFACTION	LIQUEFACTION
6200	2929	1.42	0.07	0.105	LIQUEFACTION	LIQUEFACTION
6400	2996	1.42	0.12	0.167	NO LIQUEFACTION	NO LIQUEFACTION
6600	3063	1.42	0.12	0.165	NO LIQUEFACTION	NO LIQUEFACTION
6800	3130	1.42	0.06	0.082	LIQUEFACTION	LIQUEFACTION
7000	3197	1.43	0.12	0.178	LIQUEFACTION	LIQUEFACTION
7200	3264	1.43	0.07	0.102	LIQUEFACTION	LIQUEFACTION
7400	3331	1.43	0.08	0.109	LIQUEFACTION	LIQUEFACTION
7600	3398	1.43	0.07	0.107	LIQUEFACTION	LIQUEFACTION
7800	3465	1.43	0.07	0.106	LIQUEFACTION	LIQUEFACTION
8000	3532	1.43	0.08	0.119	LIQUEFACTION	LIQUEFACTION
8200	3599	1.43	0.08	0.111	LIQUEFACTION	LIQUEFACTION
8400	3666	1.44	0.08	0.108	LIQUEFACTION	LIQUEFACTION
8600	3733	1.44	0.07	0.100	LIQUEFACTION	LIQUEFACTION
8800	3800	1.44	0.06	0.090	LIQUEFACTION	LIQUEFACTION
9000	900000	1.84	0.07	0.128	LIQUEFACTION	LIQUEFACTION
9200	900100	1.84	0.07	0.127	LIQUEFACTION	LIQUEFACTION
9400	900200	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
9600	900300	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
9800	900400	1.84	0.07	0.129	LIQUEFACTION	LIQUEFACTION
10000	900500	1.84	0.08	0.142	LIQUEFACTION	LIQUEFACTION
10200	900600	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
10400	900700	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
10600	900800	1.84	0.07	0.136	LIQUEFACTION	LIQUEFACTION
10800	900900	1.84	0.08	0.140	LIQUEFACTION	LIQUEFACTION
11000	901000	1.84	0.06	0.115	LIQUEFACTION	LIQUEFACTION
11200	901100	1.84	0.06	0.116	LIQUEFACTION	LIQUEFACTION
11400	901200	1.84	0.08	0.140	LIQUEFACTION	LIQUEFACTION
11600	901300	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
11800	901400	1.84	0.06	0.117	LIQUEFACTION	LIQUEFACTION
12000	901500	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
12200	901600	1.84	0.08	0.143	LIQUEFACTION	LIQUEFACTION
12400	901700	1.84	0.07	0.122	LIQUEFACTION	LIQUEFACTION
12600	901800	1.84	0.08	0.138	LIQUEFACTION	LIQUEFACTION
12800	901900	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 7.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

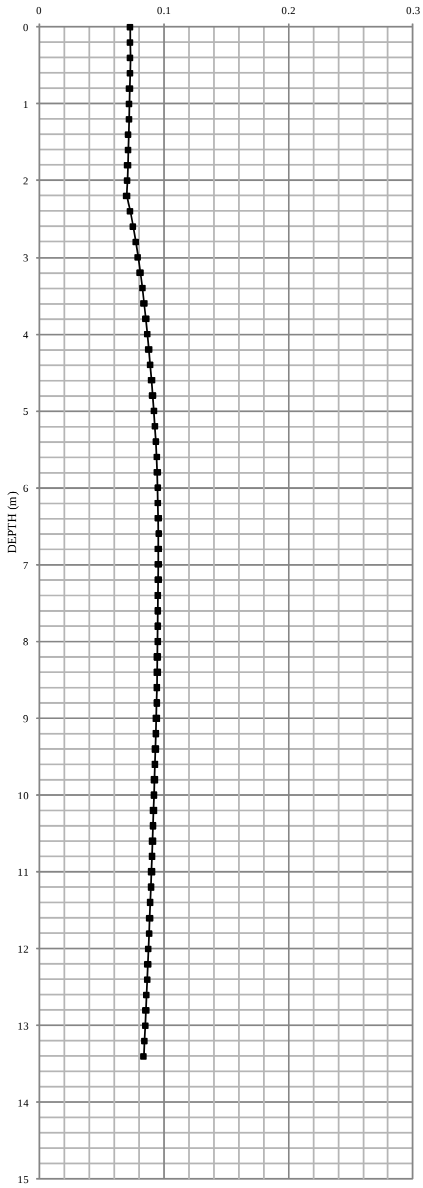
SHEET : 1 OF 14

CYCLIC STRESS RATIO FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	21.09	21.09	4.22	4.22	1.00	0.202	1.80	**0.073**
400	21.92	21.92	8.60	8.60	1.00	0.202	1.80	**0.073**
600	21.50	21.50	12.90	12.90	1.00	0.202	1.80	**0.073**
800	20.93	20.93	17.09	17.09	0.99	0.202	1.80	**0.073**
1000	20.69	20.69	21.23	21.23	0.99	0.202	1.80	**0.072**
1200	20.59	20.59	25.35	25.35	0.99	0.202	1.80	**0.072**
1400	21.01	21.01	29.55	29.55	0.98	0.202	1.80	**0.072**
1600	20.64	20.64	33.68	33.68	0.98	0.202	1.80	**0.071**
1800	19.73	19.73	37.62	37.62	0.97	0.202	1.80	**0.071**
2000	19.38	19.38	41.50	41.50	0.97	0.202	1.80	**0.071**
2200	18.25	18.25	45.15	45.15	0.96	0.202	1.80	**0.070**
2400	17.82	8.01	48.71	46.75	0.96	0.202	1.80	**0.073**
2600	17.79	7.98	52.27	48.34	0.95	0.202	1.80	**0.075**
2800	18.09	8.29	55.89	50.00	0.95	0.202	1.80	**0.077**
3000	18.05	8.24	59.50	51.65	0.94	0.202	1.80	**0.079**
3200	18.28	8.47	63.15	53.34	0.94	0.202	1.80	**0.081**
3400	18.26	8.45	66.80	55.04	0.93	0.202	1.80	**0.083**
3600	18.24	8.43	70.45	56.72	0.93	0.202	1.80	**0.084**
3800	17.41	7.61	73.93	58.24	0.92	0.202	1.80	**0.086**
4000	16.68	6.87	77.27	59.62	0.92	0.202	1.80	**0.087**
4200	16.68	6.87	80.60	60.99	0.91	0.202	1.80	**0.088**
4400	16.49	6.68	83.90	62.33	0.91	0.202	1.80	**0.089**
4600	15.65	5.84	87.03	63.50	0.90	0.202	1.80	**0.090**
4800	16.10	6.29	90.25	64.75	0.90	0.202	1.80	**0.091**
5000	15.27	5.46	93.31	65.85	0.89	0.202	1.80	**0.092**
5200	15.62	5.81	96.43	67.01	0.89	0.202	1.80	**0.093**
5400	14.82	5.01	99.39	68.01	0.88	0.202	1.80	**0.094**
5600	16.34	6.53	102.66	69.32	0.87	0.202	1.80	**0.094**
5800	17.64	7.84	106.19	70.88	0.87	0.202	1.80	**0.095**
6000	18.75	8.94	109.94	72.67	0.86	0.202	1.80	**0.095**
6200	18.03	8.22	113.54	74.32	0.86	0.202	1.80	**0.095**
6400	18.00	8.20	117.15	75.96	0.85	0.202	1.80	**0.096**
6600	18.28	8.48	120.80	77.65	0.84	0.202	1.80	**0.096**
6800	19.64	9.83	124.73	79.62	0.84	0.202	1.80	**0.096**
7000	19.76	9.96	128.68	81.61	0.83	0.202	1.80	**0.096**
7200	19.46	9.66	132.58	83.54	0.83	0.202	1.80	**0.096**
7400	19.30	9.49	136.44	85.44	0.82	0.202	1.80	**0.096**
7600	18.81	9.01	140.20	87.24	0.81	0.202	1.80	**0.095**
7800	19.17	9.36	144.03	89.11	0.81	0.202	1.80	**0.095**
8000	18.86	9.05	147.80	90.92	0.80	0.202	1.80	**0.095**
8200	17.60	7.79	151.32	92.48	0.80	0.202	1.80	**0.095**
8400	17.73	7.93	154.87	94.07	0.79	0.202	1.80	**0.095**
8600	17.50	7.69	158.37	95.61	0.78	0.202	1.80	**0.095**
8800	18.96	9.15	162.16	97.44	0.78	0.202	1.80	**0.094**
9000	18.50	8.69	165.86	99.17	0.77	0.202	1.80	**0.094**
9200	18.52	8.71	169.57	100.92	0.77	0.202	1.80	**0.094**
9400	19.03	9.23	173.37	102.76	0.76	0.202	1.80	**0.093**
9600	18.37	8.57	177.05	104.48	0.75	0.202	1.80	**0.093**
9800	18.42	8.61	180.73	106.20	0.75	0.202	1.80	**0.093**
10000	17.85	8.04	184.30	107.81	0.74	0.202	1.80	**0.092**
10200	19.52	9.71	188.20	109.75	0.73	0.202	1.80	**0.092**
10400	18.98	9.17	192.00	111.58	0.73	0.202	1.80	**0.091**
10600	18.23	8.42	195.65	113.27	0.72	0.202	1.80	**0.091**
10800	18.04	8.24	199.26	114.92	0.72	0.202	1.80	**0.091**
11000	18.01	8.20	202.86	116.56	0.71	0.202	1.80	**0.090**
11200	18.15	8.34	206.49	118.22	0.70	0.202	1.80	**0.090**
11400	18.19	8.39	210.13	119.90	0.70	0.202	1.80	**0.089**
11600	18.85	9.05	213.90	121.71	0.69	0.202	1.80	**0.089**
11800	18.42	8.61	217.58	123.43	0.69	0.202	1.80	**0.088**
12000	18.23	8.43	221.23	125.12	0.68	0.202	1.80	**0.088**
12200	18.62	8.82	224.95	126.88	0.67	0.202	1.80	**0.087**
12400	18.30	8.49	228.61	128.58	0.67	0.202	1.80	**0.087**
12600	18.46	8.65	232.30	130.31	0.66	0.202	1.80	**0.086**
12800	18.56	8.75	236.01	132.06	0.66	0.202	1.80	**0.086**
13000	18.45	8.64	239.70	133.79	0.65	0.202	1.80	**0.085**
13200	19.25	9.44	243.55	135.68	0.65	0.202	1.80	**0.085**
13400	19.68	9.87	247.49	137.65	0.64	0.202	1.80	**0.084**

CPT PROFILE FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

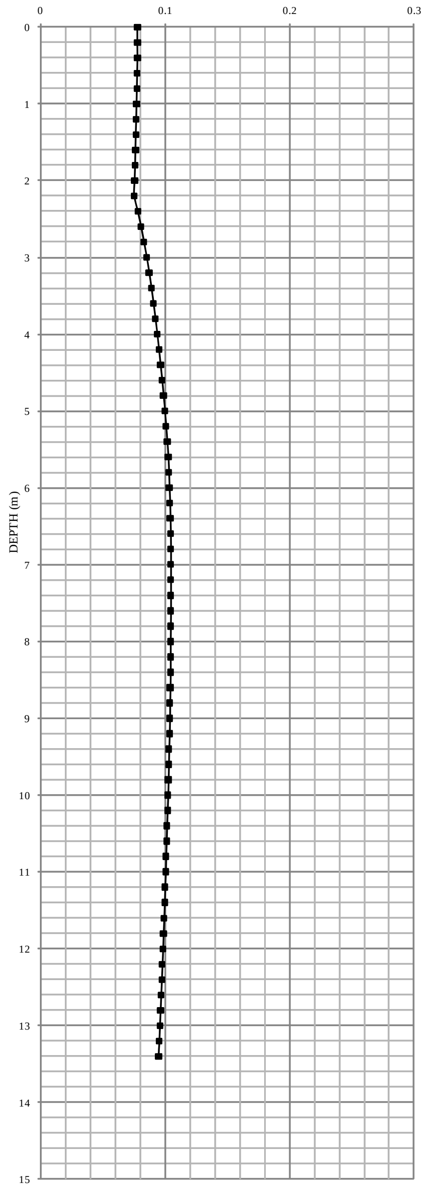
SHEET : 2 OF 14

CYCLIC STRESS RATIO FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m³)	γ' (kN/m³)	σ_v (kN/m²)	σ'_v (kN/m²)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	21.09	21.09	4.22	4.22	1.00	0.202	1.69	**0.078**
400	21.92	21.92	8.60	8.60	1.00	0.202	1.69	**0.078**
600	21.50	21.50	12.90	12.90	1.00	0.202	1.69	**0.078**
800	20.93	20.93	17.09	17.09	1.00	0.202	1.69	**0.078**
1000	20.69	20.69	21.23	21.23	0.99	0.202	1.69	**0.077**
1200	20.59	20.59	25.35	25.35	0.99	0.202	1.69	**0.077**
1400	21.01	21.01	29.55	29.55	0.98	0.202	1.69	**0.077**
1600	20.64	20.64	33.68	33.68	0.98	0.202	1.69	**0.076**
1800	19.73	19.73	37.62	37.62	0.98	0.202	1.69	**0.076**
2000	19.38	19.38	41.50	41.50	0.97	0.202	1.69	**0.076**
2200	18.25	18.25	45.15	45.15	0.97	0.202	1.69	**0.075**
2400	17.82	8.01	48.71	46.75	0.96	0.202	1.69	**0.078**
2600	17.79	7.98	52.27	48.34	0.96	0.202	1.69	**0.081**
2800	18.09	8.29	55.89	50.00	0.96	0.202	1.69	**0.083**
3000	18.05	8.24	59.50	51.65	0.95	0.202	1.69	**0.085**
3200	18.28	8.47	63.15	53.34	0.95	0.202	1.69	**0.087**
3400	18.26	8.45	66.80	55.04	0.94	0.202	1.69	**0.089**
3600	18.24	8.43	70.45	56.72	0.94	0.202	1.69	**0.091**
3800	17.41	7.61	73.93	58.24	0.93	0.202	1.69	**0.092**
4000	16.68	6.87	77.27	59.62	0.93	0.202	1.69	**0.094**
4200	16.68	6.87	80.60	60.99	0.92	0.202	1.69	**0.095**
4400	16.49	6.68	83.90	62.33	0.92	0.202	1.69	**0.096**
4600	15.65	5.84	87.03	63.50	0.91	0.202	1.69	**0.098**
4800	16.10	6.29	90.25	64.75	0.91	0.202	1.69	**0.099**
5000	15.27	5.46	93.31	65.85	0.90	0.202	1.69	**0.100**
5200	15.62	5.81	96.43	67.01	0.90	0.202	1.69	**0.101**
5400	14.82	5.01	99.39	68.01	0.89	0.202	1.69	**0.102**
5600	16.34	6.53	102.66	69.32	0.89	0.202	1.69	**0.103**
5800	17.64	7.84	106.19	70.88	0.88	0.202	1.69	**0.103**
6000	18.75	8.94	109.94	72.67	0.88	0.202	1.69	**0.104**
6200	18.03	8.22	113.54	74.32	0.87	0.202	1.69	**0.104**
6400	18.00	8.20	117.15	75.96	0.87	0.202	1.69	**0.104**
6600	18.28	8.48	120.80	77.65	0.86	0.202	1.69	**0.105**
6800	19.64	9.83	124.73	79.62	0.86	0.202	1.69	**0.105**
7000	19.76	9.96	128.68	81.61	0.85	0.202	1.69	**0.105**
7200	19.46	9.66	132.58	83.54	0.85	0.202	1.69	**0.105**
7400	19.30	9.49	136.44	85.44	0.84	0.202	1.69	**0.105**
7600	18.81	9.01	140.20	87.24	0.84	0.202	1.69	**0.105**
7800	19.17	9.36	144.03	89.11	0.83	0.202	1.69	**0.104**
8000	18.86	9.05	147.80	90.92	0.82	0.202	1.69	**0.104**
8200	17.60	7.79	151.32	92.48	0.82	0.202	1.69	**0.104**
8400	17.73	7.93	154.87	94.07	0.81	0.202	1.69	**0.104**
8600	17.50	7.69	158.37	95.61	0.81	0.202	1.69	**0.104**
8800	18.96	9.15	162.16	97.44	0.80	0.202	1.69	**0.104**
9000	18.50	8.69	165.86	99.17	0.80	0.202	1.69	**0.104**
9200	18.52	8.71	169.57	100.92	0.79	0.202	1.69	**0.104**
9400	19.03	9.23	173.37	102.76	0.79	0.202	1.69	**0.103**
9600	18.37	8.57	177.05	104.48	0.78	0.202	1.69	**0.103**
9800	18.42	8.61	180.73	106.20	0.77	0.202	1.69	**0.103**
10000	17.85	8.04	184.30	107.81	0.77	0.202	1.69	**0.102**
10200	19.52	9.71	188.20	109.75	0.76	0.202	1.69	**0.102**
10400	18.98	9.17	192.00	111.58	0.76	0.202	1.69	**0.102**
10600	18.23	8.42	195.65	113.27	0.75	0.202	1.69	**0.101**
10800	18.04	8.24	199.26	114.92	0.75	0.202	1.69	**0.101**
11000	18.01	8.20	202.86	116.56	0.74	0.202	1.69	**0.100**
11200	18.15	8.34	206.49	118.22	0.74	0.202	1.69	**0.100**
11400	18.19	8.39	210.13	119.90	0.73	0.202	1.69	**0.100**
11600	18.85	9.05	213.90	121.71	0.73	0.202	1.69	**0.099**
11800	18.42	8.61	217.58	123.43	0.72	0.202	1.69	**0.099**
12000	18.23	8.43	221.23	125.12	0.71	0.202	1.69	**0.098**
12200	18.62	8.82	224.95	126.88	0.71	0.202	1.69	**0.098**
12400	18.30	8.49	228.61	128.58	0.70	0.202	1.69	**0.097**
12600	18.46	8.65	232.30	130.31	0.70	0.202	1.69	**0.097**
12800	18.56	8.75	236.01	132.06	0.69	0.202	1.69	**0.096**
13000	18.45	8.64	239.70	133.79	0.69	0.202	1.69	**0.096**
13200	19.25	9.44	243.55	135.68	0.68	0.202	1.69	**0.095**
13400	19.68	9.87	247.49	137.65	0.68	0.202	1.69	**0.095**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

SHEET : 3 OF 14

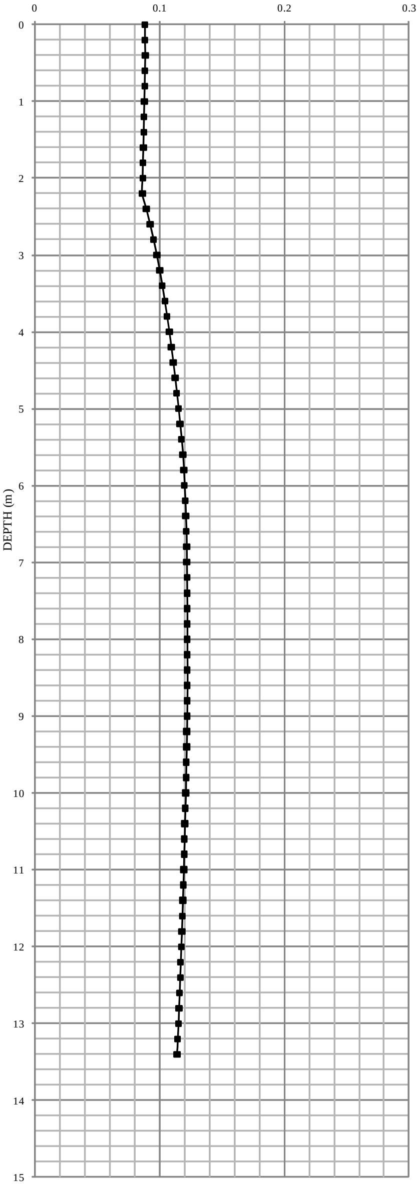
CYCLIC STRESS RATIO FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	21.09	21.09	4.22	4.22	1.00	0.202	1.48	**0.089**
400	21.92	21.92	8.60	8.60	1.00	0.202	1.48	**0.089**
600	21.50	21.50	12.90	12.90	1.00	0.202	1.48	**0.089**
800	20.93	20.93	17.09	17.09	1.00	0.202	1.48	**0.088**
1000	20.69	20.69	21.23	21.23	0.99	0.202	1.48	**0.088**
1200	20.59	20.59	25.35	25.35	0.99	0.202	1.48	**0.088**
1400	21.01	21.01	29.55	29.55	0.99	0.202	1.48	**0.088**
1600	20.64	20.64	33.68	33.68	0.98	0.202	1.48	**0.087**
1800	19.73	19.73	37.62	37.62	0.98	0.202	1.48	**0.087**
2000	19.38	19.38	41.50	41.50	0.98	0.202	1.48	**0.087**
2200	18.25	18.25	45.15	45.15	0.97	0.202	1.48	**0.086**
2400	17.82	8.01	48.71	46.75	0.97	0.202	1.48	**0.090**
2600	17.79	7.98	52.27	48.34	0.97	0.202	1.48	**0.093**
2800	18.09	8.29	55.89	50.00	0.96	0.202	1.48	**0.095**
3000	18.05	8.24	59.50	51.65	0.96	0.202	1.48	**0.098**
3200	18.28	8.47	63.15	53.34	0.96	0.202	1.48	**0.100**
3400	18.26	8.45	66.80	55.04	0.95	0.202	1.48	**0.102**
3600	18.24	8.43	70.45	56.72	0.95	0.202	1.48	**0.104**
3800	17.41	7.61	73.93	58.24	0.94	0.202	1.48	**0.106**
4000	16.68	6.87	77.27	59.62	0.94	0.202	1.48	**0.108**
4200	16.68	6.87	80.60	60.99	0.94	0.202	1.48	**0.110**
4400	16.49	6.68	83.90	62.33	0.93	0.202	1.48	**0.111**
4600	15.65	5.84	87.03	63.50	0.93	0.202	1.48	**0.113**
4800	16.10	6.29	90.25	64.75	0.92	0.202	1.48	**0.114**
5000	15.27	5.46	93.31	65.85	0.92	0.202	1.48	**0.115**
5200	15.62	5.81	96.43	67.01	0.91	0.202	1.48	**0.117**
5400	14.82	5.01	99.39	68.01	0.91	0.202	1.48	**0.118**
5600	16.34	6.53	102.66	69.32	0.91	0.202	1.48	**0.119**
5800	17.64	7.84	106.19	70.88	0.90	0.202	1.48	**0.120**
6000	18.75	8.94	109.94	72.67	0.90	0.202	1.48	**0.120**
6200	18.03	8.22	113.54	74.32	0.89	0.202	1.48	**0.121**
6400	18.00	8.20	117.15	75.96	0.89	0.202	1.48	**0.121**
6600	18.28	8.48	120.80	77.65	0.88	0.202	1.48	**0.122**
6800	19.64	9.83	124.73	79.62	0.88	0.202	1.48	**0.122**
7000	19.76	9.96	128.68	81.61	0.87	0.202	1.48	**0.122**
7200	19.46	9.66	132.58	83.54	0.87	0.202	1.48	**0.122**
7400	19.30	9.49	136.44	85.44	0.86	0.202	1.48	**0.122**
7600	18.81	9.01	140.20	87.24	0.86	0.202	1.48	**0.122**
7800	19.17	9.36	144.03	89.11	0.85	0.202	1.48	**0.122**
8000	18.86	9.05	147.80	90.92	0.85	0.202	1.48	**0.122**
8200	17.60	7.79	151.32	92.48	0.84	0.202	1.48	**0.122**
8400	17.73	7.93	154.87	94.07	0.84	0.202	1.48	**0.122**
8600	17.50	7.69	158.37	95.61	0.83	0.202	1.48	**0.122**
8800	18.96	9.15	162.16	97.44	0.83	0.202	1.48	**0.122**
9000	18.50	8.69	165.86	99.17	0.82	0.202	1.48	**0.122**
9200	18.52	8.71	169.57	100.92	0.82	0.202	1.48	**0.122**
9400	19.03	9.23	173.37	102.76	0.81	0.202	1.48	**0.122**
9600	18.37	8.57	177.05	104.48	0.81	0.202	1.48	**0.122**
9800	18.42	8.61	180.73	106.20	0.80	0.202	1.48	**0.121**
10000	17.85	8.04	184.30	107.81	0.80	0.202	1.48	**0.121**
10200	19.52	9.71	188.20	109.75	0.79	0.202	1.48	**0.121**
10400	18.98	9.17	192.00	111.58	0.79	0.202	1.48	**0.120**
10600	18.23	8.42	195.65	113.27	0.78	0.202	1.48	**0.120**
10800	18.04	8.24	199.26	114.92	0.78	0.202	1.48	**0.120**
11000	18.01	8.20	202.86	116.56	0.77	0.202	1.48	**0.119**
11200	18.15	8.34	206.49	118.22	0.77	0.202	1.48	**0.119**
11400	18.19	8.39	210.13	119.90	0.76	0.202	1.48	**0.119**
11600	18.85	9.05	213.90	121.71	0.76	0.202	1.48	**0.118**
11800	18.42	8.61	217.58	123.43	0.75	0.202	1.48	**0.118**
12000	18.23	8.43	221.23	125.12	0.75	0.202	1.48	**0.117**
12200	18.62	8.82	224.95	126.88	0.74	0.202	1.48	**0.117**
12400	18.30	8.49	228.61	128.58	0.74	0.202	1.48	**0.117**
12600	18.46	8.65	232.30	130.31	0.74	0.202	1.48	**0.116**
12800	18.56	8.75	236.01	132.06	0.73	0.202	1.48	**0.116**
13000	18.45	8.64	239.70	133.79	0.73	0.202	1.48	**0.115**
13200	19.25	9.44	243.55	135.68	0.72	0.202	1.48	**0.115**
13400	19.68	9.87	247.49	137.65	0.72	0.202	1.48	**0.114**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :
Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

SHEET : 4 OF 14

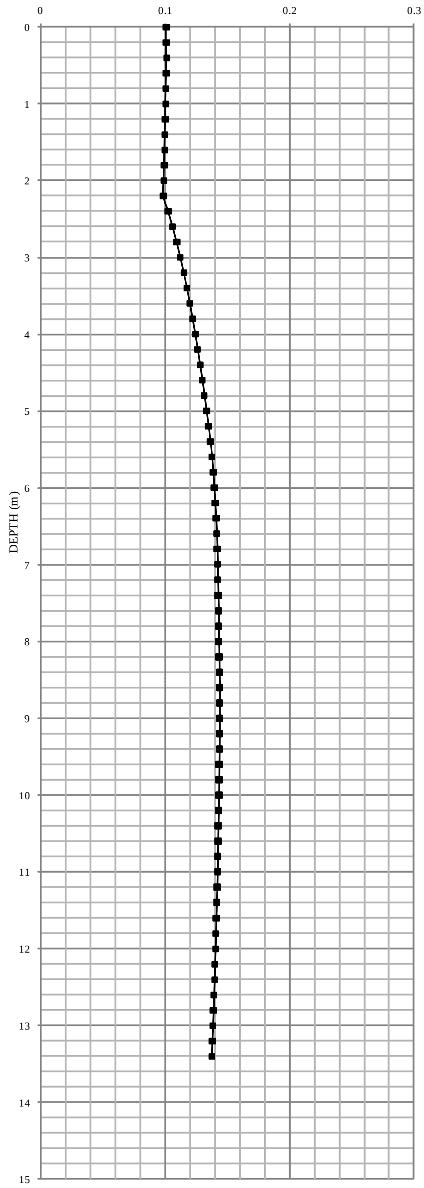
CYCLIC STRESS RATIO FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	21.09	21.09	4.22	4.22	1.00	0.202	1.30	**0.101**
400	21.92	21.92	8.60	8.60	1.00	0.202	1.30	**0.101**
600	21.50	21.50	12.90	12.90	1.00	0.202	1.30	**0.101**
800	20.93	20.93	17.09	17.09	1.00	0.202	1.30	**0.101**
1000	20.69	20.69	21.23	21.23	1.00	0.202	1.30	**0.101**
1200	20.59	20.59	25.35	25.35	0.99	0.202	1.30	**0.100**
1400	21.01	21.01	29.55	29.55	0.99	0.202	1.30	**0.100**
1600	20.64	20.64	33.68	33.68	0.99	0.202	1.30	**0.100**
1800	19.73	19.73	37.62	37.62	0.98	0.202	1.30	**0.099**
2000	19.38	19.38	41.50	41.50	0.98	0.202	1.30	**0.099**
2200	18.25	18.25	45.15	45.15	0.98	0.202	1.30	**0.099**
2400	17.82	8.01	48.71	46.75	0.98	0.202	1.30	**0.103**
2600	17.79	7.98	52.27	48.34	0.97	0.202	1.30	**0.106**
2800	18.09	8.29	55.89	50.00	0.97	0.202	1.30	**0.109**
3000	18.05	8.24	59.50	51.65	0.97	0.202	1.30	**0.112**
3200	18.28	8.47	63.15	53.34	0.96	0.202	1.30	**0.115**
3400	18.26	8.45	66.80	55.04	0.96	0.202	1.30	**0.118**
3600	18.24	8.43	70.45	56.72	0.96	0.202	1.30	**0.120**
3800	17.41	7.61	73.93	58.24	0.95	0.202	1.30	**0.122**
4000	16.68	6.87	77.27	59.62	0.95	0.202	1.30	**0.124**
4200	16.68	6.87	80.60	60.99	0.95	0.202	1.30	**0.126**
4400	16.49	6.68	83.90	62.33	0.94	0.202	1.30	**0.128**
4600	15.65	5.84	87.03	63.50	0.94	0.202	1.30	**0.130**
4800	16.10	6.29	90.25	64.75	0.94	0.202	1.30	**0.132**
5000	15.27	5.46	93.31	65.85	0.93	0.202	1.30	**0.133**
5200	15.62	5.81	96.43	67.01	0.93	0.202	1.30	**0.135**
5400	14.82	5.01	99.39	68.01	0.92	0.202	1.30	**0.136**
5600	16.34	6.53	102.66	69.32	0.92	0.202	1.30	**0.138**
5800	17.64	7.84	106.19	70.88	0.92	0.202	1.30	**0.139**
6000	18.75	8.94	109.94	72.67	0.91	0.202	1.30	**0.139**
6200	18.03	8.22	113.54	74.32	0.91	0.202	1.30	**0.140**
6400	18.00	8.20	117.15	75.96	0.91	0.202	1.30	**0.141**
6600	18.28	8.48	120.80	77.65	0.90	0.202	1.30	**0.142**
6800	19.64	9.83	124.73	79.62	0.90	0.202	1.30	**0.142**
7000	19.76	9.96	128.68	81.61	0.89	0.202	1.30	**0.142**
7200	19.46	9.66	132.58	83.54	0.89	0.202	1.30	**0.142**
7400	19.30	9.49	136.44	85.44	0.89	0.202	1.30	**0.143**
7600	18.81	9.01	140.20	87.24	0.88	0.202	1.30	**0.143**
7800	19.17	9.36	144.03	89.11	0.88	0.202	1.30	**0.143**
8000	18.86	9.05	147.80	90.92	0.87	0.202	1.30	**0.143**
8200	17.60	7.79	151.32	92.48	0.87	0.202	1.30	**0.143**
8400	17.73	7.93	154.87	94.07	0.86	0.202	1.30	**0.144**
8600	17.50	7.69	158.37	95.61	0.86	0.202	1.30	**0.144**
8800	18.96	9.15	162.16	97.44	0.86	0.202	1.30	**0.144**
9000	18.50	8.69	165.86	99.17	0.85	0.202	1.30	**0.144**
9200	18.52	8.71	169.57	100.92	0.85	0.202	1.30	**0.144**
9400	19.03	9.23	173.37	102.76	0.84	0.202	1.30	**0.144**
9600	18.37	8.57	177.05	104.48	0.84	0.202	1.30	**0.144**
9800	18.42	8.61	180.73	106.20	0.83	0.202	1.30	**0.143**
10000	17.85	8.04	184.30	107.81	0.83	0.202	1.30	**0.143**
10200	19.52	9.71	188.20	109.75	0.83	0.202	1.30	**0.143**
10400	18.98	9.17	192.00	111.58	0.82	0.202	1.30	**0.143**
10600	18.23	8.42	195.65	113.27	0.82	0.202	1.30	**0.143**
10800	18.04	8.24	199.26	114.92	0.81	0.202	1.30	**0.142**
11000	18.01	8.20	202.86	116.56	0.81	0.202	1.30	**0.142**
11200	18.15	8.34	206.49	118.22	0.80	0.202	1.30	**0.142**
11400	18.19	8.39	210.13	119.90	0.80	0.202	1.30	**0.142**
11600	18.85	9.05	213.90	121.71	0.80	0.202	1.30	**0.141**
11800	18.42	8.61	217.58	123.43	0.79	0.202	1.30	**0.141**
12000	18.23	8.43	221.23	125.12	0.79	0.202	1.30	**0.140**
12200	18.62	8.82	224.95	126.88	0.78	0.202	1.30	**0.140**
12400	18.30	8.49	228.61	128.58	0.78	0.202	1.30	**0.140**
12600	18.46	8.65	232.30	130.31	0.77	0.202	1.30	**0.139**
12800	18.56	8.75	236.01	132.06	0.77	0.202	1.30	**0.139**
13000	18.45	8.64	239.70	133.79	0.77	0.202	1.30	**0.138**
13200	19.25	9.44	243.55	135.68	0.76	0.202	1.30	**0.138**
13400	19.68	9.87	247.49	137.65	0.76	0.202	1.30	**0.137**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

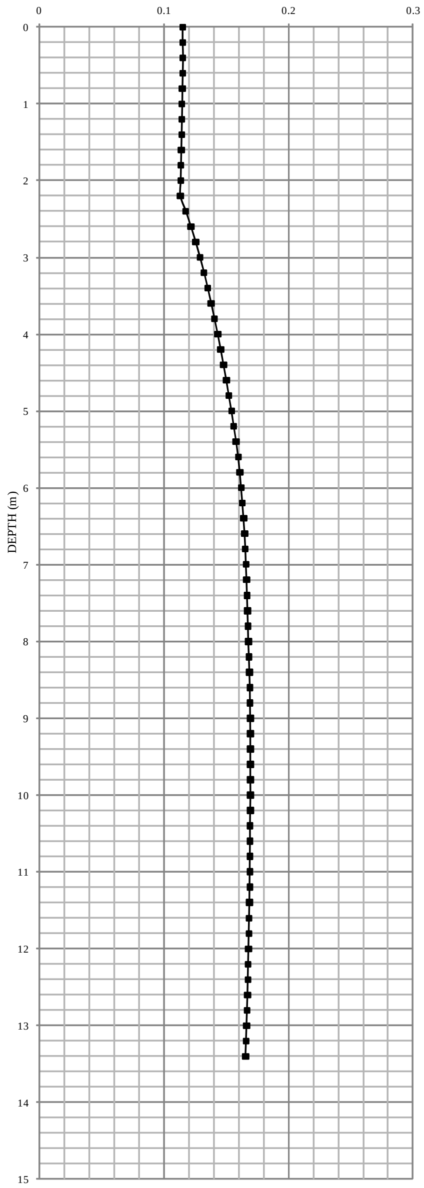
SHEET : 5 OF 14

CYCLIC STRESS RATIO FOR M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	CSR$_{M=7.5}$
200	21.09	21.09	4.22	4.22	1.00	0.202	1.14	**0.115**
400	21.92	21.92	8.60	8.60	1.00	0.202	1.14	**0.115**
600	21.50	21.50	12.90	12.90	1.00	0.202	1.14	**0.115**
800	20.93	20.93	17.09	17.09	1.00	0.202	1.14	**0.115**
1000	20.69	20.69	21.23	21.23	1.00	0.202	1.14	**0.115**
1200	20.59	20.59	25.35	25.35	1.00	0.202	1.14	**0.115**
1400	21.01	21.01	29.55	29.55	0.99	0.202	1.14	**0.114**
1600	20.64	20.64	33.68	33.68	0.99	0.202	1.14	**0.114**
1800	19.73	19.73	37.62	37.62	0.99	0.202	1.14	**0.114**
2000	19.38	19.38	41.50	41.50	0.99	0.202	1.14	**0.114**
2200	18.25	18.25	45.15	45.15	0.98	0.202	1.14	**0.113**
2400	17.82	8.01	48.71	46.75	0.98	0.202	1.14	**0.118**
2600	17.79	7.98	52.27	48.34	0.98	0.202	1.14	**0.122**
2800	18.09	8.29	55.89	50.00	0.98	0.202	1.14	**0.126**
3000	18.05	8.24	59.50	51.65	0.97	0.202	1.14	**0.129**
3200	18.28	8.47	63.15	53.34	0.97	0.202	1.14	**0.132**
3400	18.26	8.45	66.80	55.04	0.97	0.202	1.14	**0.135**
3600	18.24	8.43	70.45	56.72	0.97	0.202	1.14	**0.138**
3800	17.41	7.61	73.93	58.24	0.96	0.202	1.14	**0.141**
4000	16.68	6.87	77.27	59.62	0.96	0.202	1.14	**0.143**
4200	16.68	6.87	80.60	60.99	0.96	0.202	1.14	**0.146**
4400	16.49	6.68	83.90	62.33	0.96	0.202	1.14	**0.148**
4600	15.65	5.84	87.03	63.50	0.95	0.202	1.14	**0.150**
4800	16.10	6.29	90.25	64.75	0.95	0.202	1.14	**0.152**
5000	15.27	5.46	93.31	65.85	0.95	0.202	1.14	**0.154**
5200	15.62	5.81	96.43	67.01	0.94	0.202	1.14	**0.156**
5400	14.82	5.01	99.39	68.01	0.94	0.202	1.14	**0.158**
5600	16.34	6.53	102.66	69.32	0.94	0.202	1.14	**0.160**
5800	17.64	7.84	106.19	70.88	0.93	0.202	1.14	**0.161**
6000	18.75	8.94	109.94	72.67	0.93	0.202	1.14	**0.162**
6200	18.03	8.22	113.54	74.32	0.93	0.202	1.14	**0.163**
6400	18.00	8.20	117.15	75.96	0.92	0.202	1.14	**0.164**
6600	18.28	8.48	120.80	77.65	0.92	0.202	1.14	**0.165**
6800	19.64	9.83	124.73	79.62	0.92	0.202	1.14	**0.166**
7000	19.76	9.96	128.68	81.61	0.91	0.202	1.14	**0.166**
7200	19.46	9.66	132.58	83.54	0.91	0.202	1.14	**0.166**
7400	19.30	9.49	136.44	85.44	0.91	0.202	1.14	**0.167**
7600	18.81	9.01	140.20	87.24	0.90	0.202	1.14	**0.167**
7800	19.17	9.36	144.03	89.11	0.90	0.202	1.14	**0.168**
8000	18.86	9.05	147.80	90.92	0.90	0.202	1.14	**0.168**
8200	17.60	7.79	151.32	92.48	0.89	0.202	1.14	**0.168**
8400	17.73	7.93	154.87	94.07	0.89	0.202	1.14	**0.169**
8600	17.50	7.69	158.37	95.61	0.89	0.202	1.14	**0.169**
8800	18.96	9.15	162.16	97.44	0.88	0.202	1.14	**0.169**
9000	18.50	8.69	165.86	99.17	0.88	0.202	1.14	**0.169**
9200	18.52	8.71	169.57	100.92	0.88	0.202	1.14	**0.170**
9400	19.03	9.23	173.37	102.76	0.87	0.202	1.14	**0.170**
9600	18.37	8.57	177.05	104.48	0.87	0.202	1.14	**0.170**
9800	18.42	8.61	180.73	106.20	0.87	0.202	1.14	**0.170**
10000	17.85	8.04	184.30	107.81	0.86	0.202	1.14	**0.170**
10200	19.52	9.71	188.20	109.75	0.86	0.202	1.14	**0.169**
10400	18.98	9.17	192.00	111.58	0.86	0.202	1.14	**0.169**
10600	18.23	8.42	195.65	113.27	0.85	0.202	1.14	**0.169**
10800	18.04	8.24	199.26	114.92	0.85	0.202	1.14	**0.169**
11000	18.01	8.20	202.86	116.56	0.84	0.202	1.14	**0.169**
11200	18.15	8.34	206.49	118.22	0.84	0.202	1.14	**0.169**
11400	18.19	8.39	210.13	119.90	0.84	0.202	1.14	**0.169**
11600	18.85	9.05	213.90	121.71	0.83	0.202	1.14	**0.169**
11800	18.42	8.61	217.58	123.43	0.83	0.202	1.14	**0.168**
12000	18.23	8.43	221.23	125.12	0.83	0.202	1.14	**0.168**
12200	18.62	8.82	224.95	126.88	0.82	0.202	1.14	**0.168**
12400	18.30	8.49	228.61	128.58	0.82	0.202	1.14	**0.168**
12600	18.46	8.65	232.30	130.31	0.82	0.202	1.14	**0.167**
12800	18.56	8.75	236.01	132.06	0.81	0.202	1.14	**0.167**
13000	18.45	8.64	239.70	133.79	0.81	0.202	1.14	**0.167**
13200	19.25	9.44	243.55	135.68	0.80	0.202	1.14	**0.166**
13400	19.68	9.87	247.49	137.65	0.80	0.202	1.14	**0.166**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

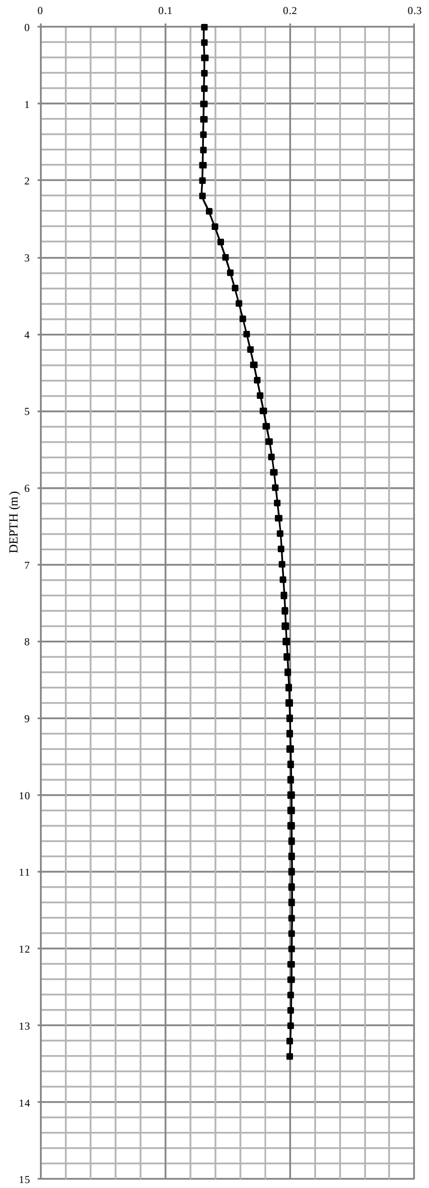
SHEET : 6 OF 14

CYCLIC STRESS RATIO FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	21.09	21.09	4.22	4.22	1.00	0.202	1	**0.131**
400	21.92	21.92	8.60	8.60	1.00	0.202	1	**0.132**
600	21.50	21.50	12.90	12.90	1.00	0.202	1	**0.132**
800	20.93	20.93	17.09	17.09	1.00	0.202	1	**0.131**
1000	20.69	20.69	21.23	21.23	1.00	0.202	1	**0.131**
1200	20.59	20.59	25.35	25.35	1.00	0.202	1	**0.131**
1400	21.01	21.01	29.55	29.55	1.00	0.202	1	**0.131**
1600	20.64	20.64	33.68	33.68	0.99	0.202	1	**0.131**
1800	19.73	19.73	37.62	37.62	0.99	0.202	1	**0.130**
2000	19.38	19.38	41.50	41.50	0.99	0.202	1	**0.130**
2200	18.25	18.25	45.15	45.15	0.99	0.202	1	**0.130**
2400	17.82	8.01	48.71	46.75	0.99	0.202	1	**0.135**
2600	17.79	7.98	52.27	48.34	0.99	0.202	1	**0.140**
2800	18.09	8.29	55.89	50.00	0.98	0.202	1	**0.144**
3000	18.05	8.24	59.50	51.65	0.98	0.202	1	**0.149**
3200	18.28	8.47	63.15	53.34	0.98	0.202	1	**0.152**
3400	18.26	8.45	66.80	55.04	0.98	0.202	1	**0.156**
3600	18.24	8.43	70.45	56.72	0.98	0.202	1	**0.159**
3800	17.41	7.61	73.93	58.24	0.97	0.202	1	**0.162**
4000	16.68	6.87	77.27	59.62	0.97	0.202	1	**0.165**
4200	16.68	6.87	80.60	60.99	0.97	0.202	1	**0.168**
4400	16.49	6.68	83.90	62.33	0.97	0.202	1	**0.171**
4600	15.65	5.84	87.03	63.50	0.97	0.202	1	**0.174**
4800	16.10	6.29	90.25	64.75	0.96	0.202	1	**0.176**
5000	15.27	5.46	93.31	65.85	0.96	0.202	1	**0.179**
5200	15.62	5.81	96.43	67.01	0.96	0.202	1	**0.181**
5400	14.82	5.01	99.39	68.01	0.96	0.202	1	**0.183**
5600	16.34	6.53	102.66	69.32	0.95	0.202	1	**0.185**
5800	17.64	7.84	106.19	70.88	0.95	0.202	1	**0.187**
6000	18.75	8.94	109.94	72.67	0.95	0.202	1	**0.189**
6200	18.03	8.22	113.54	74.32	0.95	0.202	1	**0.190**
6400	18.00	8.20	117.15	75.96	0.94	0.202	1	**0.191**
6600	18.28	8.48	120.80	77.65	0.94	0.202	1	**0.192**
6800	19.64	9.83	124.73	79.62	0.94	0.202	1	**0.193**
7000	19.76	9.96	128.68	81.61	0.94	0.202	1	**0.194**
7200	19.46	9.66	132.58	83.54	0.93	0.202	1	**0.195**
7400	19.30	9.49	136.44	85.44	0.93	0.202	1	**0.195**
7600	18.81	9.01	140.20	87.24	0.93	0.202	1	**0.196**
7800	19.17	9.36	144.03	89.11	0.93	0.202	1	**0.197**
8000	18.86	9.05	147.80	90.92	0.92	0.202	1	**0.197**
8200	17.60	7.79	151.32	92.48	0.92	0.202	1	**0.198**
8400	17.73	7.93	154.87	94.07	0.92	0.202	1	**0.199**
8600	17.50	7.69	158.37	95.61	0.92	0.202	1	**0.199**
8800	18.96	9.15	162.16	97.44	0.91	0.202	1	**0.199**
9000	18.50	8.69	165.86	99.17	0.91	0.202	1	**0.200**
9200	18.52	8.71	169.57	100.92	0.91	0.202	1	**0.200**
9400	19.03	9.23	173.37	102.76	0.90	0.202	1	**0.200**
9600	18.37	8.57	177.05	104.48	0.90	0.202	1	**0.201**
9800	18.42	8.61	180.73	106.20	0.90	0.202	1	**0.201**
10000	17.85	8.04	184.30	107.81	0.90	0.202	1	**0.201**
10200	19.52	9.71	188.20	109.75	0.89	0.202	1	**0.201**
10400	18.98	9.17	192.00	111.58	0.89	0.202	1	**0.201**
10600	18.23	8.42	195.65	113.27	0.89	0.202	1	**0.201**
10800	18.04	8.24	199.26	114.92	0.88	0.202	1	**0.201**
11000	18.01	8.20	202.86	116.56	0.88	0.202	1	**0.201**
11200	18.15	8.34	206.49	118.22	0.88	0.202	1	**0.202**
11400	18.19	8.39	210.13	119.90	0.88	0.202	1	**0.202**
11600	18.85	9.05	213.90	121.71	0.87	0.202	1	**0.201**
11800	18.42	8.61	217.58	123.43	0.87	0.202	1	**0.201**
12000	18.23	8.43	221.23	125.12	0.87	0.202	1	**0.201**
12200	18.62	8.82	224.95	126.88	0.86	0.202	1	**0.201**
12400	18.30	8.49	228.61	128.58	0.86	0.202	1	**0.201**
12600	18.46	8.65	232.30	130.31	0.86	0.202	1	**0.201**
12800	18.56	8.75	236.01	132.06	0.86	0.202	1	**0.201**
13000	18.45	8.64	239.70	133.79	0.85	0.202	1	**0.200**
13200	19.25	9.44	243.55	135.68	0.85	0.202	1	**0.200**
13400	19.68	9.87	247.49	137.65	0.85	0.202	1	**0.200**

CPT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

SHEET : 7 OF 14

SOIL BEHAVIOUR TYPE INDEX CORRECTION

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		
REDUCE LEVEL	: - m	**OPERATOR**	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan	**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	q_c (kPa)	f_s (kPa)	γ (kN/m³)	σ_v (kN/m²)	σ'_v (kN/m²)	F	$Q_{(1)}$	$I_{c(1)}$	1st Screening	$Q_{(0.5)}$	$C_{Q(0.5)}$	$I_{c(2)}$	2nd Screening	$I_{c(3)}$	q_{c1N}
200	5920	67.70	21.09	4.22	4.22	0.01	1402.42	0.79	to the next step	286.1	1.7	1.2	<------------------------Use the Ic(2)	---------------	99.3
400	12040	251.25	21.92	8.60	8.60	0.02	1398.49	0.56	to the next step	407.5	1.7	1.0	<------------------------Use the Ic(2)	---------------	202.0
600	8650	209.00	21.50	12.90	12.90	0.02	669.39	0.76	to the next step	238.9	1.7	1.2	<------------------------Use the Ic(2)	---------------	145.1
800	3560	139.60	20.93	17.09	17.09	0.04	207.32	1.17	to the next step	85.1	1.7	1.6	<------------------------Use the Ic(2)	---------------	59.7
1000	2090	132.63	20.69	21.23	21.23	0.06	97.46	1.48	to the next step	44.6	1.7	1.8	<------------------------Use the Ic(2)	---------------	35.1
1200	4630	133.05	20.59	25.35	25.35	0.03	181.68	1.25	to the next step	90.9	1.7	1.5	<------------------------Use the Ic(2)	---------------	77.7
1400	5930	220.42	21.01	29.55	29.55	0.04	199.70	1.19	to the next step	107.8	1.7	1.5	<------------------------Use the Ic(2)	---------------	99.5
1600	4080	167.30	20.64	33.68	33.68	0.04	120.16	1.40	to the next step	69.3	1.7	1.6	<------------------------Use the Ic(2)	---------------	69.8
1800	4320	77.85	19.73	37.62	37.62	0.02	113.83	1.51	to the next step	69.4	1.6	1.7	<------------------------Use the Ic(2)	---------------	70.0
2000	1090	69.40	19.38	41.50	41.50	0.07	25.27	2.07	to the next step	16.2	1.6	2.3	<------------------------Use the Ic(2)	---------------	16.8
2200	940	27.32	18.25	45.15	45.15	0.03	19.82	2.19	to the next step	13.2	1.5	2.4	<------------------------Use the Ic(2)	---------------	13.9
2400	970	19.10	17.82	48.71	48.71	0.02	18.91	2.24	to the next step	13.1	1.4	2.4	<------------------------Use the Ic(2)	---------------	13.8
2600	1960	16.95	17.79	52.27	52.27	0.01	36.50	2.08	to the next step	26.2	1.4	2.2	<------------------------Use the Ic(2)	---------------	26.9
2800	2370	23.20	18.09	55.89	55.89	0.01	41.41	2.01	to the next step	30.8	1.3	2.1	<------------------------Use the Ic(2)	---------------	31.5
3000	2690	23.05	18.05	59.50	59.50	0.01	44.21	2.01	to the next step	33.9	1.3	2.1	<------------------------Use the Ic(2)	---------------	34.6
3200	2625	29.85	18.28	63.15	63.15	0.01	40.57	1.99	to the next step	32.0	1.3	2.1	<------------------------Use the Ic(2)	---------------	32.8
3400	2640	30.37	18.26	66.80	66.80	0.01	38.52	2.01	to the next step	31.3	1.2	2.1	<------------------------Use the Ic(2)	---------------	32.1
3600	1800	32.10	18.24	70.45	70.45	0.02	24.55	2.14	to the next step	20.5	1.2	2.2	<------------------------Use the Ic(2)	---------------	21.3
3800	710	19.80	17.41	73.93	73.93	0.03	8.60	2.55	to the next step	8.0	1.2	-------------	Use the Ic(3)------------------------>	2.6	8.2
4000	660	10.68	16.68	77.27	77.27	0.02	7.54	2.64	Lab check		1.3				8.5
4200	520	12.35	16.68	80.60	80.60	0.03	5.45	2.75	Lab check		1.3				6.5
4400	310	14.95	16.49	83.90	83.90	0.07	2.69	3.04	Lab check		1.2				3.7
4600	170	12.70	15.65	87.03	87.03	0.15	0.95	3.51	Lab check		1.2				2.0
4800	190	17.35	16.10	90.25	90.25	0.17	1.11	3.46	Lab check		1.1				2.1
5000	150	11.00	15.27	93.31	93.31	0.19	0.61	3.72	Lab check		1.1				1.6
5200	220	10.05	15.62	96.43	96.43	0.08	1.28	3.36	Lab check		1.1				2.3
5400	100	14.16	14.82	99.39	99.39	23.34	0.01	6.25	No Liquefaction						
5600	330	14.45	16.34	102.66	102.66	0.06	2.21	3.12	Lab check		1.0				3.2
5800	940	29.10	17.64	106.19	106.19	0.03	7.85	2.59	to the next step	8.0	1.0	2.6	<------------------------Use the Ic(2)	---------------	9.1
6000	620	96.60	18.75	109.94	109.94	0.19	4.64	2.85	Lab check		0.9				5.6
6200	10250	39.28	18.03	113.54	113.54	0.00	89.27	1.93	to the next step	94.5	0.9	1.9	<------------------------Use the Ic(2)	---------------	95.6
6400	10250	39.28	18.00	117.15	117.15	0.00	86.50	1.94	to the next step	93.0	0.9	1.9	<------------------------Use the Ic(2)	---------------	94.1
6600	14620	55.40	18.28	120.80	120.80	0.00	120.02	1.84	to the next step	131.1	0.9	1.8	<------------------------Use the Ic(2)	---------------	132.1
6800	15800	199.90	19.64	124.73	124.73	0.01	125.67	1.53	to the next step	139.4	0.9	1.5	<------------------------Use the Ic(2)	---------------	140.5
7000	13180	220.85	19.76	128.68	128.68	0.02	101.42	1.56	to the next step	114.3	0.9	1.5	<------------------------Use the Ic(2)	---------------	115.4
7200	12370	168.21	19.46	132.58	132.58	0.01	92.31	1.64	to the next step	105.6	0.9	1.6	<------------------------Use the Ic(2)	---------------	106.7
7400	11530	145.65	19.30	136.44	136.44	0.01	83.51	1.69	to the next step	96.9	0.9	1.6	<------------------------Use the Ic(2)	---------------	98.1
7600	11300	94.10	18.81	140.20	140.20	0.01	79.60	1.79	to the next step	93.6	0.9	1.7	<------------------------Use the Ic(2)	---------------	94.8
7800	8470	126.79	19.17	144.03	144.03	0.02	57.81	1.81	to the next step	68.9	0.8	1.7	<------------------------Use the Ic(2)	---------------	70.1
8000	4850	92.15	18.86	147.80	147.80	0.02	31.81	2.03	to the next step	38.4	0.8	1.9	<------------------------Use the Ic(2)	---------------	39.6
8200	4520	29.05	17.60	151.32	151.32	0.01	28.87	2.23	to the next step	35.3	0.8	2.1	<------------------------Use the Ic(2)	---------------	36.5
8400	2970	33.42	17.73	154.87	154.87	0.01	18.18	2.32	to the next step	22.5	0.8	2.2	<------------------------Use the Ic(2)	---------------	23.7
8600	4180	27.30	17.50	158.37	158.37	0.01	25.39	2.27	to the next step	31.7	0.8	2.2	<------------------------Use the Ic(2)	---------------	33.0
8800	6430	109.79	18.96	162.16	162.16	0.02	38.65	1.96	to the next step	48.9	0.8	1.9	<------------------------Use the Ic(2)	---------------	50.2
9000	1250	78.58	18.50	165.86	165.86	0.07	6.54	2.66	Lab check		0.6				7.5
9200	2020	75.10	18.52	169.57	169.57	0.04	10.91	2.44	to the next step	14.1	0.8	2.3	<------------------------Use the Ic(2)	---------------	15.4
9400	2150	121.58	19.03	173.37	173.37	0.06	11.40	2.41	to the next step	14.9	0.8	2.3	<------------------------Use the Ic(2)	---------------	16.2
9600	1700	69.00	18.37	177.05	177.05	0.05	8.60	2.54	to the next step	11.4	0.8	2.4	<------------------------Use the Ic(2)	---------------	12.7
9800	980	82.25	18.42	180.73	180.73	0.10	4.42	2.83	Lab check		0.6				5.4
10000	1180	47.00	17.85	184.30	184.30	0.05	5.40	2.74	Lab check		0.5				6.4
10200	5060	198.00	19.52	188.20	188.20	0.04	25.89	2.06	to the next step	35.3	0.7	1.9	<------------------------Use the Ic(2)	---------------	36.6
10400	950	144.80	18.98	192.00	192.00	0.19	3.95	2.92	Lab check		0.5				4.9
10600	1020	72.00	18.23	195.65	195.65	0.09	4.21	2.85	Lab check		0.5				5.2
10800	1010	61.54	18.04	199.26	199.26	0.08	4.07	2.86	Lab check		0.5				5.1
11000	1030	59.70	18.01	202.86	202.86	0.07	4.08	2.86	Lab check		0.5				5.1
11200	910	71.70	18.15	206.49	206.49	0.10	3.41	2.95	Lab check		0.5				4.4
11400	1670	65.53	18.19	210.13	210.13	0.04	6.95	2.63	Lab check		0.5				7.9
11600	2060	118.40	18.85	213.90	213.90	0.06	8.63	2.53	to the next step	12.5	0.7	2.4	<------------------------Use the Ic(2)	---------------	14.0
11800	3570	77.80	18.42	217.58	217.58	0.02	15.41	2.32	to the next step	22.6	0.7	2.2	<------------------------Use the Ic(2)	---------------	24.0
12000	1050	77.45	18.23	221.23	221.23	0.09	3.75	2.90	Lab check		0.5				4.7
12200	1230	107.85	18.62	224.95	224.95	0.11	4.47	2.83	Lab check		0.5				5.5
12400	940	86.95	18.30	228.61	228.61	0.12	3.11	2.99	Lab check		0.4				4.1
12600	1630	89.40	18.46	232.30	232.30	0.06	6.02	2.69	Lab check		0.4				7.0
12800	1390	101.95	18.56	236.01	236.01	0.09	4.89	2.79	Lab check		0.4				5.9
13000	2060	88.00	18.45	239.70	239.70	0.05	7.59	2.59	to the next step	11.7	0.7	2.4	<------------------------Use the Ic(2)	---------------	13.2
13200	3340	180.30	19.25	243.55	243.55	0.06	12.71	2.37	to the next step	19.7	0.6	2.2	<------------------------Use the Ic(2)	---------------	21.3
13400	3050	270.64	19.68	247.49	247.49	0.10	11.32	2.42	to the next step	17.7	0.6	2.2	<------------------------Use the Ic(2)	---------------	19.3

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

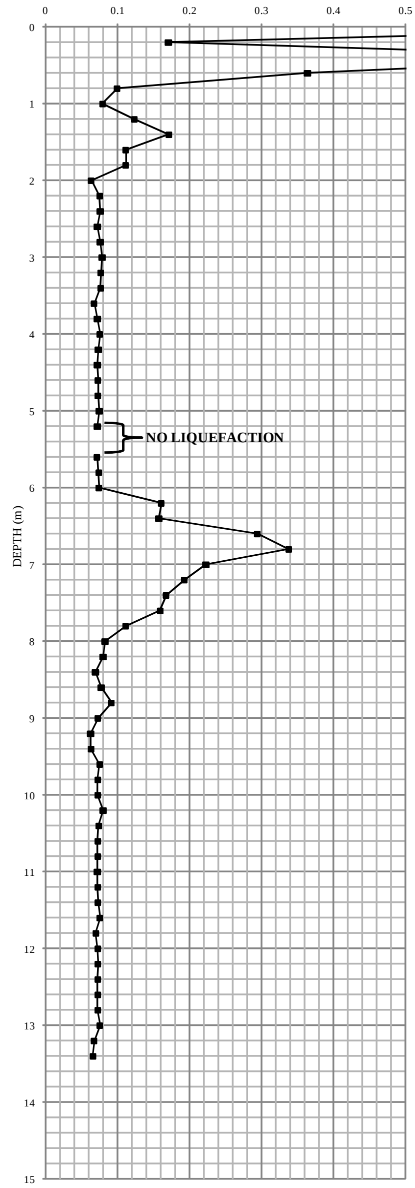
SHEET : 8 OF 14

CYCLIC RESISTANCE RATIO

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m	
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan	
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan	
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa	

DEPTH (mm)	q_c (MPa)	σ'_v (kN/m^2)	P_a (kN/m^2)	q_{c1N}	I_c	K_c	q_{c1Ncs}	$CRR_{M=7.5}$
200	5.92	4.22	101.325	99.32	1.24	1.00	99.32	**0.17**
400	12.04	8.60	101.325	202.00	0.98	1.00	202.00	**0.85**
600	8.65	12.90	101.325	145.13	1.16	1.00	145.13	**0.36**
800	3.56	17.09	101.325	59.73	1.55	1.00	59.73	**0.10**
1000	2.09	21.23	101.325	35.07	1.82	1.00	35.07	**0.08**
1200	4.63	25.35	101.325	77.68	1.54	1.00	77.68	**0.12**
1400	5.93	29.55	101.325	99.49	1.45	1.00	99.49	**0.17**
1600	4.08	33.68	101.325	69.85	1.64	1.00	69.85	**0.11**
1800	4.32	37.62	101.325	69.97	1.71	1.00	69.97	**0.11**
2000	1.09	41.50	101.325	16.81	2.26	1.00	16.81	**0.06**
2200	0.94	45.15	101.325	13.90	2.37	2.18	30.33	**0.08**
2400	0.97	46.75	101.325	13.81	2.40	2.30	31.79	**0.08**
2600	1.96	48.34	101.325	26.93	2.21	1.00	26.93	**0.07**
2800	2.37	50.00	101.325	31.49	2.13	1.00	31.49	**0.08**
3000	2.69	51.65	101.325	34.65	2.11	1.00	34.65	**0.08**
3200	2.625	53.34	101.325	32.82	2.09	1.00	32.82	**0.08**
3400	2.64	55.04	101.325	32.09	2.10	1.00	32.09	**0.08**
3600	1.8	56.72	101.325	21.30	2.22	1.00	21.30	**0.07**
3800	0.71	58.24	101.325	8.20	2.59	3.24	26.57	**0.07**
4000	0.66	59.62	101.325	8.54	2.64	3.60	30.79	**0.08**
4200	0.52	60.99	101.325	6.45	2.75	4.40	28.40	**0.07**
4400	0.31	62.33	101.325	3.69	3.04	7.20	26.59	**0.07**
4600	0.17	63.50	101.325	1.95	3.51	14.35	28.03	**0.07**
4800	0.19	64.75	101.325	2.11	3.46	13.32	28.04	**0.07**
5000	0.15	65.85	101.325	1.61	3.72	18.50	29.74	**0.07**
5200	0.22	67.01	101.325	2.28	3.36	11.74	26.79	**0.07**
5400	0.1	68.01	101.325	0.00	6.25	95.66	0.00	**NO LIQUEFACTION**
5600	0.33	69.32	101.325	3.21	3.12	8.24	26.49	**0.07**
5800	0.94	70.88	101.325	9.06	2.58	3.18	28.83	**0.07**
6000	0.62	72.67	101.325	5.64	2.85	5.20	29.33	**0.07**
6200	10.25	74.32	101.325	95.56	1.91	1.00	95.56	**0.16**
6400	10.25	75.96	101.325	94.08	1.92	1.00	94.08	**0.16**
6600	14.62	77.65	101.325	132.15	1.81	1.00	132.15	**0.29**
6800	15.8	79.62	101.325	140.54	1.49	1.00	140.54	**0.34**
7000	13.18	81.61	101.325	115.42	1.52	1.00	115.42	**0.22**
7200	12.37	83.54	101.325	106.73	1.58	1.00	106.73	**0.19**
7400	11.53	85.44	101.325	98.06	1.63	1.00	98.06	**0.17**
7600	11.3	87.24	101.325	94.81	1.72	1.00	94.81	**0.16**
7800	8.47	89.11	101.325	70.11	1.74	1.00	70.11	**0.11**
8000	4.85	90.92	101.325	39.63	1.95	1.00	39.63	**0.08**
8200	4.52	92.48	101.325	36.50	2.15	1.00	36.50	**0.08**
8400	2.97	94.07	101.325	23.71	2.23	1.00	23.71	**0.07**
8600	4.18	95.61	101.325	33.00	2.18	1.00	33.00	**0.08**
8800	6.43	97.44	101.325	50.16	1.86	1.00	50.16	**0.09**
9000	1.25	99.17	101.325	7.54	2.66	3.69	27.78	**0.07**
9200	2.02	100.92	101.325	15.41	2.33	1.00	15.41	**0.06**
9400	2.15	102.76	101.325	16.22	2.30	1.00	16.22	**0.06**
9600	1.7	104.48	101.325	12.69	2.42	2.38	30.27	**0.08**
9800	0.98	106.20	101.325	5.42	2.83	5.08	27.54	**0.07**
10000	1.18	107.81	101.325	6.40	2.74	4.29	27.48	**0.07**
10200	5.06	109.75	101.325	36.64	1.93	1.00	36.64	**0.08**
10400	0.95	111.58	101.325	4.95	2.92	5.87	29.03	**0.07**
10600	1.02	113.27	101.325	5.21	2.85	5.22	27.24	**0.07**
10800	1.01	114.92	101.325	5.07	2.86	5.34	27.06	**0.07**
11000	1.03	116.56	101.325	5.08	2.86	5.32	27.03	**0.07**
11200	0.91	118.22	101.325	4.41	2.95	6.17	27.18	**0.07**
11400	1.67	119.90	101.325	7.95	2.63	3.52	28.01	**0.07**
11600	2.06	121.71	101.325	13.99	2.37	2.20	30.80	**0.08**
11800	3.57	123.43	101.325	24.04	2.16	1.00	24.04	**0.07**
12000	1.05	125.12	101.325	4.75	2.90	5.72	27.17	**0.07**
12200	1.23	126.88	101.325	5.47	2.83	5.05	27.63	**0.07**
12400	0.94	128.58	101.325	4.11	2.99	6.66	27.40	**0.07**
12600	1.63	130.31	101.325	7.02	2.69	3.93	27.57	**0.07**
12800	1.39	132.06	101.325	5.89	2.79	4.66	27.47	**0.07**
13000	2.06	133.79	101.325	13.22	2.40	2.33	30.81	**0.08**
13200	3.34	135.68	101.325	21.26	2.18	1.00	21.26	**0.07**
13400	3.05	137.65	101.325	19.26	2.23	1.00	19.26	**0.07**

CPT PROFILE FOR CYCLIC RESISTANCE



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

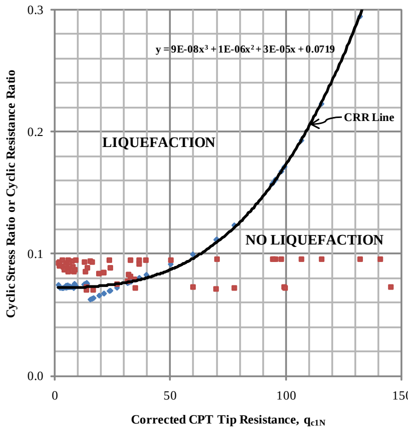
SHEET : 9 OF 14

ASSESSMENT RESULTS FOR M=5.0 & 5.5

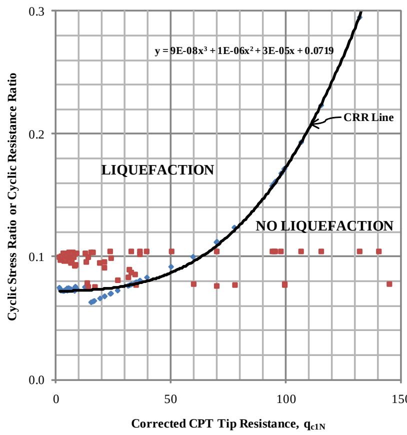
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=5.0}$**	**$CSR_{M=5.5}$**	**$CRR_{M=7.5}$**	**q_{c1N}**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.5
200	0.07	0.08	0.17	99.32	NO LIQUEFACTION	NO LIQUEFACTION
400	0.07	0.08	0.85	202.00	NO LIQUEFACTION	NO LIQUEFACTION
600	0.07	0.08	0.36	145.13	NO LIQUEFACTION	NO LIQUEFACTION
800	0.07	0.08	0.10	59.73	NO LIQUEFACTION	NO LIQUEFACTION
1000	0.07	0.08	0.08	35.07	NO LIQUEFACTION	NO LIQUEFACTION
1200	0.07	0.08	0.12	77.68	NO LIQUEFACTION	NO LIQUEFACTION
1400	0.07	0.08	0.17	99.49	NO LIQUEFACTION	NO LIQUEFACTION
1600	0.07	0.08	0.11	69.85	NO LIQUEFACTION	NO LIQUEFACTION
1800	0.07	0.08	0.11	69.97	NO LIQUEFACTION	NO LIQUEFACTION
2000	0.07	0.08	0.06	16.81	NO LIQUEFACTION	LIQUEFACTION
2200	0.07	0.08	0.08	13.90	NO LIQUEFACTION	LIQUEFACTION
2400	0.07	0.08	0.08	13.81	LIQUEFACTION	LIQUEFACTION
2600	0.08	0.08	0.07	26.93	LIQUEFACTION	LIQUEFACTION
2800	0.08	0.08	0.08	31.49	LIQUEFACTION	LIQUEFACTION
3000	0.08	0.09	0.08	34.65	LIQUEFACTION	LIQUEFACTION
3200	0.08	0.09	0.08	32.82	LIQUEFACTION	LIQUEFACTION
3400	0.08	0.09	0.08	32.09	LIQUEFACTION	LIQUEFACTION
3600	0.08	0.09	0.07	21.30	LIQUEFACTION	LIQUEFACTION
3800	0.09	0.09	0.07	8.20	LIQUEFACTION	LIQUEFACTION
4000	0.09	0.09	0.08	8.54	LIQUEFACTION	LIQUEFACTION
4200	0.09	0.10	0.07	6.45	LIQUEFACTION	LIQUEFACTION
4400	0.09	0.10	0.07	3.69	LIQUEFACTION	LIQUEFACTION
4600	0.09	0.10	0.07	1.95	LIQUEFACTION	LIQUEFACTION
4800	0.09	0.10	0.07	2.11	LIQUEFACTION	LIQUEFACTION
5000	0.09	0.10	0.07	1.61	LIQUEFACTION	LIQUEFACTION
5200	0.09	0.10	0.07	2.28	LIQUEFACTION	LIQUEFACTION
5400			NO LIQUEFACTION			
5600	0.09	0.10	0.07	3.21	LIQUEFACTION	LIQUEFACTION
5800	0.09	0.10	0.07	9.06	LIQUEFACTION	LIQUEFACTION
6000	0.10	0.10	0.07	5.64	LIQUEFACTION	LIQUEFACTION
6200	0.10	0.10	0.16	95.56	NO LIQUEFACTION	NO LIQUEFACTION
6400	0.10	0.10	0.16	94.08	NO LIQUEFACTION	NO LIQUEFACTION
6600	0.10	0.10	0.29	132.15	NO LIQUEFACTION	NO LIQUEFACTION
6800	0.10	0.10	0.34	140.54	NO LIQUEFACTION	NO LIQUEFACTION
7000	0.10	0.10	0.22	115.42	NO LIQUEFACTION	NO LIQUEFACTION
7200	0.10	0.10	0.19	106.73	NO LIQUEFACTION	NO LIQUEFACTION
7400	0.10	0.10	0.17	98.06	NO LIQUEFACTION	NO LIQUEFACTION
7600	0.10	0.10	0.16	94.81	NO LIQUEFACTION	NO LIQUEFACTION
7800	0.10	0.10	0.11	70.11	NO LIQUEFACTION	NO LIQUEFACTION
8000	0.10	0.10	0.08	39.63	LIQUEFACTION	LIQUEFACTION
8200	0.09	0.10	0.08	36.50	LIQUEFACTION	LIQUEFACTION
8400	0.09	0.10	0.07	23.71	LIQUEFACTION	LIQUEFACTION
8600	0.09	0.10	0.08	33.00	LIQUEFACTION	LIQUEFACTION
8800	0.09	0.10	0.09	50.16	LIQUEFACTION	LIQUEFACTION
9000	0.09	0.10	0.07	7.54	LIQUEFACTION	LIQUEFACTION
9200	0.09	0.10	0.06	15.41	LIQUEFACTION	LIQUEFACTION
9400	0.09	0.10	0.06	16.22	LIQUEFACTION	LIQUEFACTION
9600	0.09	0.10	0.08	12.69	LIQUEFACTION	LIQUEFACTION
9800	0.09	0.10	0.07	5.42	LIQUEFACTION	LIQUEFACTION
10000	0.09	0.10	0.07	6.40	LIQUEFACTION	LIQUEFACTION
10200	0.09	0.10	0.08	36.64	LIQUEFACTION	LIQUEFACTION
10400	0.09	0.10	0.07	4.95	LIQUEFACTION	LIQUEFACTION
10600	0.09	0.10	0.07	5.21	LIQUEFACTION	LIQUEFACTION
10800	0.09	0.10	0.07	5.07	LIQUEFACTION	LIQUEFACTION
11000	0.09	0.10	0.07	5.08	LIQUEFACTION	LIQUEFACTION
11200	0.09	0.10	0.07	4.41	LIQUEFACTION	LIQUEFACTION
11400	0.09	0.10	0.07	7.95	LIQUEFACTION	LIQUEFACTION
11600	0.09	0.10	0.08	13.99	LIQUEFACTION	LIQUEFACTION
11800	0.09	0.10	0.07	24.04	LIQUEFACTION	LIQUEFACTION
12000	0.09	0.10	0.07	4.75	LIQUEFACTION	LIQUEFACTION
12200	0.09	0.10	0.07	5.47	LIQUEFACTION	LIQUEFACTION
12400	0.09	0.10	0.07	4.11	LIQUEFACTION	LIQUEFACTION
12600	0.09	0.10	0.07	7.02	LIQUEFACTION	LIQUEFACTION
12800	0.09	0.10	0.07	5.89	LIQUEFACTION	LIQUEFACTION
13000	0.09	0.10	0.08	13.22	LIQUEFACTION	LIQUEFACTION
13200	0.08	0.10	0.07	21.26	LIQUEFACTION	LIQUEFACTION
13400	0.08	0.09	0.07	19.26	LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 5.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

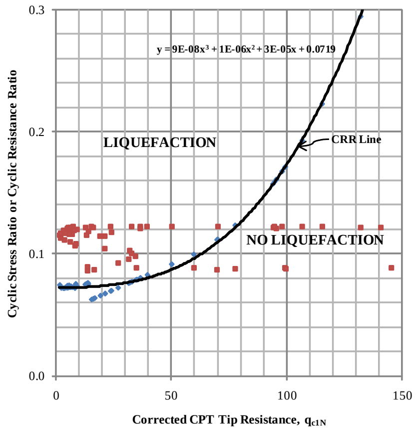
SHEET : 10 OF 14

ASSESSMENT RESULTS FOR M=6.0 & 6.5

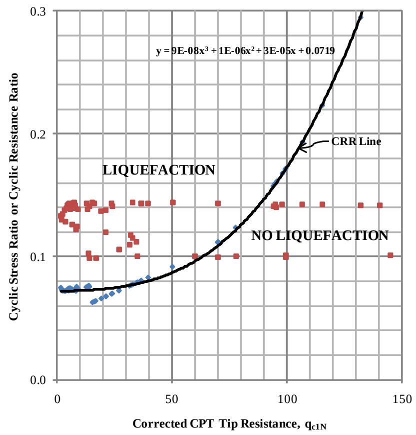
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	**$CSR_{M=6.0}$**	**$CSR_{M=6.5}$**	**$CRR_{M=7.5}$**	**q_{c1N}**	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.5
200	0.09	0.10	0.17	99.32	NO LIQUEFACTION	NO LIQUEFACTION
400	0.09	0.10	0.85	202.00	NO LIQUEFACTION	NO LIQUEFACTION
600	0.09	0.10	0.36	145.13	NO LIQUEFACTION	NO LIQUEFACTION
800	0.09	0.10	0.10	59.73	NO LIQUEFACTION	LIQUEFACTION
1000	0.09	0.10	0.08	35.07	LIQUEFACTION	LIQUEFACTION
1200	0.09	0.10	0.12	77.68	NO LIQUEFACTION	NO LIQUEFACTION
1400	0.09	0.10	0.17	99.49	NO LIQUEFACTION	NO LIQUEFACTION
1600	0.09	0.10	0.11	69.85	NO LIQUEFACTION	NO LIQUEFACTION
1800	0.09	0.10	0.11	69.97	NO LIQUEFACTION	NO LIQUEFACTION
2000	0.09	0.10	0.06	16.81	LIQUEFACTION	LIQUEFACTION
2200	0.09	0.10	0.08	13.90	LIQUEFACTION	LIQUEFACTION
2400	0.09	0.10	0.08	13.81	LIQUEFACTION	LIQUEFACTION
2600	0.09	0.11	0.07	26.93	LIQUEFACTION	LIQUEFACTION
2800	0.10	0.11	0.08	31.49	LIQUEFACTION	LIQUEFACTION
3000	0.10	0.11	0.08	34.65	LIQUEFACTION	LIQUEFACTION
3200	0.10	0.12	0.08	32.82	LIQUEFACTION	LIQUEFACTION
3400	0.10	0.12	0.08	32.09	LIQUEFACTION	LIQUEFACTION
3600	0.10	0.12	0.07	21.30	LIQUEFACTION	LIQUEFACTION
3800	0.11	0.12	0.07	8.20	LIQUEFACTION	LIQUEFACTION
4000	0.11	0.12	0.08	8.54	LIQUEFACTION	LIQUEFACTION
4200	0.11	0.13	0.07	6.45	LIQUEFACTION	LIQUEFACTION
4400	0.11	0.13	0.07	3.69	LIQUEFACTION	LIQUEFACTION
4600	0.11	0.13	0.07	1.95	LIQUEFACTION	LIQUEFACTION
4800	0.11	0.13	0.07	2.11	LIQUEFACTION	LIQUEFACTION
5000	0.12	0.13	0.07	1.61	LIQUEFACTION	LIQUEFACTION
5200	0.12	0.13	0.07	2.28	LIQUEFACTION	LIQUEFACTION
5400	NO LIQUEFACTION					
5600	0.12	0.14	0.07	3.21	LIQUEFACTION	LIQUEFACTION
5800	0.12	0.14	0.07	9.06	LIQUEFACTION	LIQUEFACTION
6000	0.12	0.14	0.07	5.64	LIQUEFACTION	LIQUEFACTION
6200	0.12	0.14	0.16	95.56	NO LIQUEFACTION	NO LIQUEFACTION
6400	0.12	0.14	0.16	94.08	NO LIQUEFACTION	NO LIQUEFACTION
6600	0.12	0.14	0.29	132.15	NO LIQUEFACTION	NO LIQUEFACTION
6800	0.12	0.14	0.34	140.54	NO LIQUEFACTION	NO LIQUEFACTION
7000	0.12	0.14	0.22	115.42	NO LIQUEFACTION	NO LIQUEFACTION
7200	0.12	0.14	0.19	106.73	NO LIQUEFACTION	NO LIQUEFACTION
7400	0.12	0.14	0.17	98.06	NO LIQUEFACTION	NO LIQUEFACTION
7600	0.12	0.14	0.16	94.81	NO LIQUEFACTION	NO LIQUEFACTION
7800	0.12	0.14	0.11	70.11	LIQUEFACTION	LIQUEFACTION
8000	0.12	0.14	0.08	39.63	LIQUEFACTION	LIQUEFACTION
8200	0.12	0.14	0.08	36.50	LIQUEFACTION	LIQUEFACTION
8400	0.12	0.14	0.07	23.71	LIQUEFACTION	LIQUEFACTION
8600	0.12	0.14	0.08	33.00	LIQUEFACTION	LIQUEFACTION
8800	0.12	0.14	0.09	50.16	LIQUEFACTION	LIQUEFACTION
9000	0.12	0.14	0.07	7.54	LIQUEFACTION	LIQUEFACTION
9200	0.12	0.14	0.06	15.41	LIQUEFACTION	LIQUEFACTION
9400	0.12	0.14	0.06	16.22	LIQUEFACTION	LIQUEFACTION
9600	0.12	0.14	0.08	12.69	LIQUEFACTION	LIQUEFACTION
9800	0.12	0.14	0.07	5.42	LIQUEFACTION	LIQUEFACTION
10000	0.12	0.14	0.07	6.40	LIQUEFACTION	LIQUEFACTION
10200	0.12	0.14	0.08	36.64	LIQUEFACTION	LIQUEFACTION
10400	0.12	0.14	0.07	4.95	LIQUEFACTION	LIQUEFACTION
10600	0.12	0.14	0.07	5.21	LIQUEFACTION	LIQUEFACTION
10800	0.12	0.14	0.07	5.07	LIQUEFACTION	LIQUEFACTION
11000	0.12	0.14	0.07	5.08	LIQUEFACTION	LIQUEFACTION
11200	0.12	0.14	0.07	4.41	LIQUEFACTION	LIQUEFACTION
11400	0.12	0.14	0.07	7.95	LIQUEFACTION	LIQUEFACTION
11600	0.12	0.14	0.08	13.99	LIQUEFACTION	LIQUEFACTION
11800	0.12	0.14	0.07	24.04	LIQUEFACTION	LIQUEFACTION
12000	0.12	0.14	0.07	4.75	LIQUEFACTION	LIQUEFACTION
12200	0.12	0.14	0.07	5.47	LIQUEFACTION	LIQUEFACTION
12400	0.12	0.14	0.07	4.11	LIQUEFACTION	LIQUEFACTION
12600	0.12	0.14	0.07	7.02	LIQUEFACTION	LIQUEFACTION
12800	0.12	0.14	0.07	5.89	LIQUEFACTION	LIQUEFACTION
13000	0.12	0.14	0.08	13.22	LIQUEFACTION	LIQUEFACTION
13200	0.11	0.14	0.07	21.26	LIQUEFACTION	LIQUEFACTION
13400	0.11	0.14	0.07	19.26	LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 6.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

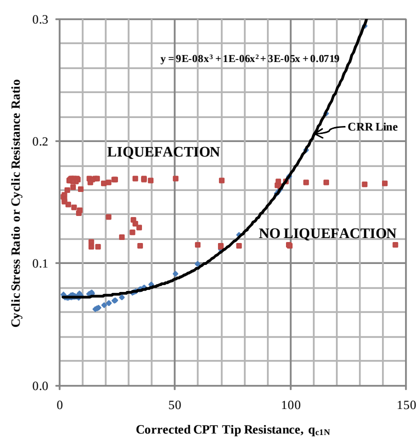
SHEET : 11 OF 14

ASSESSMENT RESULTS FOR M=7.0 & 7.5

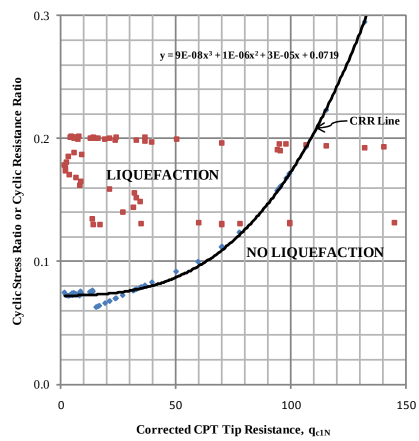
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m
REDUCE LEVEL	: - m		
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
OPERATOR	: Andrew/Brendan		
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
SUPERVISED BY	: B. Setiawan		
DATE	: 11 JUNE 2010 TO 11 JUNE 2010		
CHECKED BY	: A/Prof. Mark Jaksa		

DEPTH (mm)	$CSR_{M=7.0}$	$CSR_{M=7.5}$	$CRR_{M=7.5}$	q_{c1N}	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.5
200	0.12	0.13	0.17	99.32	NO LIQUEFACTION	NO LIQUEFACTION
400	0.12	0.13	0.85	202.00	NO LIQUEFACTION	NO LIQUEFACTION
600	0.12	0.13	0.36	145.13	NO LIQUEFACTION	NO LIQUEFACTION
800	0.12	0.13	0.10	59.73	LIQUEFACTION	LIQUEFACTION
1000	0.11	0.13	0.08	35.07	LIQUEFACTION	LIQUEFACTION
1200	0.11	0.13	0.12	77.68	NO LIQUEFACTION	LIQUEFACTION
1400	0.11	0.13	0.17	99.49	NO LIQUEFACTION	NO LIQUEFACTION
1600	0.11	0.13	0.11	69.85	LIQUEFACTION	LIQUEFACTION
1800	0.11	0.13	0.11	69.97	LIQUEFACTION	LIQUEFACTION
2000	0.11	0.13	0.06	16.81	LIQUEFACTION	LIQUEFACTION
2200	0.11	0.13	0.08	13.90	LIQUEFACTION	LIQUEFACTION
2400	0.12	0.14	0.08	13.81	LIQUEFACTION	LIQUEFACTION
2600	0.12	0.14	0.07	26.93	LIQUEFACTION	LIQUEFACTION
2800	0.13	0.14	0.08	31.49	LIQUEFACTION	LIQUEFACTION
3000	0.13	0.15	0.08	34.65	LIQUEFACTION	LIQUEFACTION
3200	0.13	0.15	0.08	32.82	LIQUEFACTION	LIQUEFACTION
3400	0.14	0.16	0.08	32.09	LIQUEFACTION	LIQUEFACTION
3600	0.14	0.16	0.07	21.30	LIQUEFACTION	LIQUEFACTION
3800	0.14	0.16	0.07	8.20	LIQUEFACTION	LIQUEFACTION
4000	0.14	0.17	0.08	8.54	LIQUEFACTION	LIQUEFACTION
4200	0.15	0.17	0.07	6.45	LIQUEFACTION	LIQUEFACTION
4400	0.15	0.17	0.07	3.69	LIQUEFACTION	LIQUEFACTION
4600	0.15	0.17	0.07	1.95	LIQUEFACTION	LIQUEFACTION
4800	0.15	0.18	0.07	2.11	LIQUEFACTION	LIQUEFACTION
5000	0.15	0.18	0.07	1.61	LIQUEFACTION	LIQUEFACTION
5200	0.16	0.18	0.07	2.28	LIQUEFACTION	LIQUEFACTION
5400			NO LIQUEFACTION			
5600	0.16	0.19	0.07	3.21	LIQUEFACTION	LIQUEFACTION
5800	0.16	0.19	0.07	9.06	LIQUEFACTION	LIQUEFACTION
6000	0.16	0.19	0.07	5.64	LIQUEFACTION	LIQUEFACTION
6200	0.16	0.19	0.16	95.56	LIQUEFACTION	LIQUEFACTION
6400	0.16	0.19	0.16	94.08	LIQUEFACTION	LIQUEFACTION
6600	0.16	0.19	0.29	132.15	NO LIQUEFACTION	NO LIQUEFACTION
6800	0.17	0.19	0.34	140.54	NO LIQUEFACTION	NO LIQUEFACTION
7000	0.17	0.19	0.22	115.42	NO LIQUEFACTION	NO LIQUEFACTION
7200	0.17	0.19	0.19	106.73	NO LIQUEFACTION	NO LIQUEFACTION
7400	0.17	0.20	0.17	98.06	NO LIQUEFACTION	LIQUEFACTION
7600	0.17	0.20	0.16	94.81	LIQUEFACTION	LIQUEFACTION
7800	0.17	0.20	0.11	70.11	LIQUEFACTION	LIQUEFACTION
8000	0.17	0.20	0.08	39.63	LIQUEFACTION	LIQUEFACTION
8200	0.17	0.20	0.08	36.50	LIQUEFACTION	LIQUEFACTION
8400	0.17	0.20	0.07	23.71	LIQUEFACTION	LIQUEFACTION
8600	0.17	0.20	0.08	33.00	LIQUEFACTION	LIQUEFACTION
8800	0.17	0.20	0.09	50.16	LIQUEFACTION	LIQUEFACTION
9000	0.17	0.20	0.07	7.54	LIQUEFACTION	LIQUEFACTION
9200	0.17	0.20	0.06	15.41	LIQUEFACTION	LIQUEFACTION
9400	0.17	0.20	0.06	16.22	LIQUEFACTION	LIQUEFACTION
9600	0.17	0.20	0.08	12.69	LIQUEFACTION	LIQUEFACTION
9800	0.17	0.20	0.07	5.42	LIQUEFACTION	LIQUEFACTION
10000	0.17	0.20	0.07	6.40	LIQUEFACTION	LIQUEFACTION
10200	0.17	0.20	0.08	36.64	LIQUEFACTION	LIQUEFACTION
10400	0.17	0.20	0.07	4.95	LIQUEFACTION	LIQUEFACTION
10600	0.17	0.20	0.07	5.21	LIQUEFACTION	LIQUEFACTION
10800	0.17	0.20	0.07	5.07	LIQUEFACTION	LIQUEFACTION
11000	0.17	0.20	0.07	5.08	LIQUEFACTION	LIQUEFACTION
11200	0.17	0.20	0.07	4.41	LIQUEFACTION	LIQUEFACTION
11400	0.17	0.20	0.07	7.95	LIQUEFACTION	LIQUEFACTION
11600	0.17	0.20	0.08	13.99	LIQUEFACTION	LIQUEFACTION
11800	0.17	0.20	0.07	24.04	LIQUEFACTION	LIQUEFACTION
12000	0.17	0.20	0.07	4.75	LIQUEFACTION	LIQUEFACTION
12200	0.17	0.20	0.07	5.47	LIQUEFACTION	LIQUEFACTION
12400	0.17	0.20	0.07	4.11	LIQUEFACTION	LIQUEFACTION
12600	0.17	0.20	0.07	7.02	LIQUEFACTION	LIQUEFACTION
12800	0.17	0.20	0.07	5.89	LIQUEFACTION	LIQUEFACTION
13000	0.17	0.20	0.08	13.22	LIQUEFACTION	LIQUEFACTION
13200	0.17	0.20	0.07	21.26	LIQUEFACTION	LIQUEFACTION
13400	0.17	0.20	0.07	19.26	LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 7.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

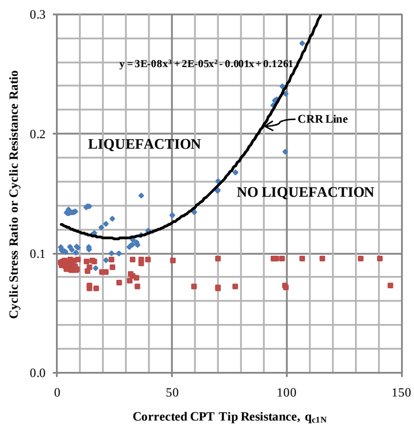
SHEET : 12 OF 14

ASSESSMENT RESULTS INC. AGEING FOR M=5.0 & 5.5

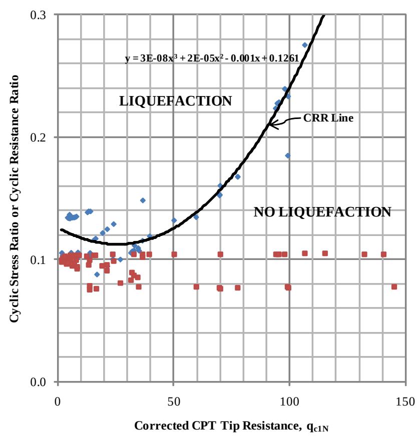
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m		
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan		
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan		
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa		

DEPTH (mm)	t (years)	K_{DR}	$CRR_{M=7.5}$	$CRR_{M=7.5,DR}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=5.5
200	30	1.08	0.17	0.185	NO LIQUEFACTION	NO LIQUEFACTION
400	30	1.08	0.85	0.915	NO LIQUEFACTION	NO LIQUEFACTION
600	30	1.08	0.36	0.394	NO LIQUEFACTION	NO LIQUEFACTION
800	1120	1.35	0.10	0.135	NO LIQUEFACTION	NO LIQUEFACTION
1000	1187	1.35	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
1200	1254	1.36	0.12	0.168	NO LIQUEFACTION	NO LIQUEFACTION
1400	1321	1.36	0.17	0.233	NO LIQUEFACTION	NO LIQUEFACTION
1600	1388	1.36	0.11	0.152	NO LIQUEFACTION	NO LIQUEFACTION
1800	1455	1.37	0.11	0.153	NO LIQUEFACTION	NO LIQUEFACTION
2000	1522	1.37	0.06	0.088	NO LIQUEFACTION	NO LIQUEFACTION
2200	1589	1.37	0.08	0.103	NO LIQUEFACTION	NO LIQUEFACTION
2400	1656	1.38	0.08	0.105	NO LIQUEFACTION	NO LIQUEFACTION
2600	1723	1.38	0.07	0.100	NO LIQUEFACTION	NO LIQUEFACTION
2800	1790	1.38	0.08	0.105	NO LIQUEFACTION	NO LIQUEFACTION
3000	1857	1.39	0.08	0.109	NO LIQUEFACTION	NO LIQUEFACTION
3200	1924	1.39	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
3400	1991	1.39	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
3600	2058	1.39	0.07	0.094	NO LIQUEFACTION	NO LIQUEFACTION
3800	2125	1.40	0.07	0.101	NO LIQUEFACTION	NO LIQUEFACTION
4000	2192	1.40	0.08	0.106	NO LIQUEFACTION	NO LIQUEFACTION
4200	2259	1.40	0.07	0.103	NO LIQUEFACTION	NO LIQUEFACTION
4400	2326	1.40	0.07	0.101	NO LIQUEFACTION	NO LIQUEFACTION
4600	2393	1.40	0.07	0.103	NO LIQUEFACTION	NO LIQUEFACTION
4800	2460	1.41	0.07	0.103	NO LIQUEFACTION	NO LIQUEFACTION
5000	2527	1.41	0.07	0.105	NO LIQUEFACTION	NO LIQUEFACTION
5200	2594	1.41	0.07	0.102	NO LIQUEFACTION	NO LIQUEFACTION
5400	2661	NO LIQUEFACTION				
5600	2728	1.41	0.07	0.102	NO LIQUEFACTION	NO LIQUEFACTION
5800	2795	1.42	0.07	0.105	NO LIQUEFACTION	NO LIQUEFACTION
6000	2862	1.42	0.07	0.106	NO LIQUEFACTION	NO LIQUEFACTION
6200	2929	1.42	0.16	0.229	NO LIQUEFACTION	NO LIQUEFACTION
6400	2996	1.42	0.16	0.224	NO LIQUEFACTION	NO LIQUEFACTION
6600	3063	1.42	0.29	0.419	NO LIQUEFACTION	NO LIQUEFACTION
6800	3130	1.42	0.34	0.482	NO LIQUEFACTION	NO LIQUEFACTION
7000	3197	1.43	0.22	0.318	NO LIQUEFACTION	NO LIQUEFACTION
7200	3264	1.43	0.19	0.276	NO LIQUEFACTION	NO LIQUEFACTION
7400	3331	1.43	0.17	0.240	NO LIQUEFACTION	NO LIQUEFACTION
7600	3398	1.43	0.16	0.228	NO LIQUEFACTION	NO LIQUEFACTION
7800	3465	1.43	0.11	0.160	NO LIQUEFACTION	NO LIQUEFACTION
8000	3532	1.43	0.08	0.119	NO LIQUEFACTION	NO LIQUEFACTION
8200	3599	1.43	0.08	0.115	NO LIQUEFACTION	NO LIQUEFACTION
8400	3666	1.44	0.07	0.100	NO LIQUEFACTION	NO LIQUEFACTION
8600	3733	1.44	0.08	0.111	NO LIQUEFACTION	NO LIQUEFACTION
8800	3800	1.44	0.09	0.132	NO LIQUEFACTION	NO LIQUEFACTION
9000	900000	1.84	0.07	0.135	NO LIQUEFACTION	NO LIQUEFACTION
9200	900100	1.84	0.06	0.116	NO LIQUEFACTION	NO LIQUEFACTION
9400	900200	1.84	0.06	0.117	NO LIQUEFACTION	NO LIQUEFACTION
9600	900300	1.84	0.08	0.139	NO LIQUEFACTION	NO LIQUEFACTION
9800	900400	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
10000	900500	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
10200	900600	1.84	0.08	0.148	NO LIQUEFACTION	NO LIQUEFACTION
10400	900700	1.84	0.07	0.137	NO LIQUEFACTION	NO LIQUEFACTION
10600	900800	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
10800	900900	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
11000	901000	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
11200	901100	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
11400	901200	1.84	0.07	0.135	NO LIQUEFACTION	NO LIQUEFACTION
11600	901300	1.84	0.08	0.139	NO LIQUEFACTION	NO LIQUEFACTION
11800	901400	1.84	0.07	0.129	NO LIQUEFACTION	NO LIQUEFACTION
12000	901500	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
12200	901600	1.84	0.07	0.135	NO LIQUEFACTION	NO LIQUEFACTION
12400	901700	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
12600	901800	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
12800	901900	1.84	0.07	0.134	NO LIQUEFACTION	NO LIQUEFACTION
13000	902000	1.84	0.08	0.139	NO LIQUEFACTION	NO LIQUEFACTION
13200	902100	1.84	0.07	0.125	NO LIQUEFACTION	NO LIQUEFACTION
13400	902200	1.84	0.07	0.122	NO LIQUEFACTION	NO LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 5.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

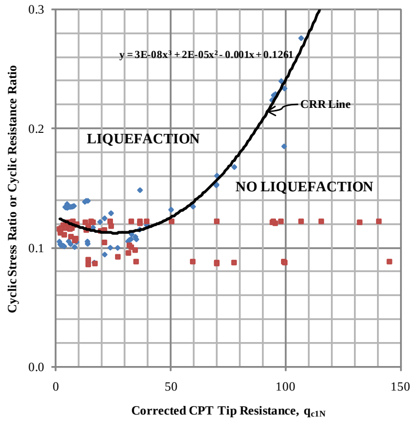
SHEET : 13 OF 14

ASSESSMENT RESULTS INC. AGEING FOR M=6.0 & 6.5

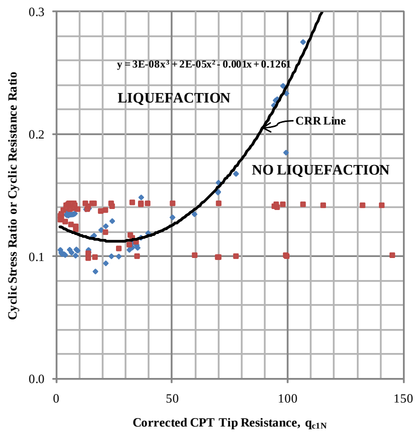
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	t (years)	K_{DR}	$CRR_{M=7.5}$	$CRR_{M=7.5,DR}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=6.5
200	30	1.08	0.17	0.185	NO LIQUEFACTION	NO LIQUEFACTION
400	30	1.08	0.85	0.915	NO LIQUEFACTION	NO LIQUEFACTION
600	30	1.08	0.36	0.394	NO LIQUEFACTION	NO LIQUEFACTION
800	1120	1.35	0.10	0.135	NO LIQUEFACTION	NO LIQUEFACTION
1000	1187	1.35	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
1200	1254	1.36	0.12	0.168	NO LIQUEFACTION	NO LIQUEFACTION
1400	1321	1.36	0.17	0.233	NO LIQUEFACTION	NO LIQUEFACTION
1600	1388	1.36	0.11	0.152	NO LIQUEFACTION	NO LIQUEFACTION
1800	1455	1.37	0.11	0.153	NO LIQUEFACTION	NO LIQUEFACTION
2000	1522	1.37	0.06	0.088	NO LIQUEFACTION	NO LIQUEFACTION
2200	1589	1.37	0.08	0.103	NO LIQUEFACTION	NO LIQUEFACTION
2400	1656	1.38	0.08	0.105	NO LIQUEFACTION	NO LIQUEFACTION
2600	1723	1.38	0.07	0.100	NO LIQUEFACTION	NO LIQUEFACTION
2800	1790	1.38	0.08	0.105	NO LIQUEFACTION	NO LIQUEFACTION
3000	1857	1.39	0.08	0.109	NO LIQUEFACTION	NO LIQUEFACTION
3200	1924	1.39	0.08	0.107	NO LIQUEFACTION	NO LIQUEFACTION
3400	1991	1.39	0.08	0.107	NO LIQUEFACTION	LIQUEFACTION
3600	2058	1.39	0.07	0.094	NO LIQUEFACTION	LIQUEFACTION
3800	2125	1.40	0.07	0.101	NO LIQUEFACTION	LIQUEFACTION
4000	2192	1.40	0.08	0.106	NO LIQUEFACTION	LIQUEFACTION
4200	2259	1.40	0.07	0.103	NO LIQUEFACTION	LIQUEFACTION
4400	2326	1.40	0.07	0.101	NO LIQUEFACTION	LIQUEFACTION
4600	2393	1.40	0.07	0.103	NO LIQUEFACTION	LIQUEFACTION
4800	2460	1.41	0.07	0.103	NO LIQUEFACTION	LIQUEFACTION
5000	2527	1.41	0.07	0.105	NO LIQUEFACTION	LIQUEFACTION
5200	2594	1.41	0.07	0.102	NO LIQUEFACTION	LIQUEFACTION
5400	2661	NO LIQUEFACTION				
5600	2728	1.41	0.07	0.102	NO LIQUEFACTION	LIQUEFACTION
5800	2795	1.42	0.07	0.105	LIQUEFACTION	LIQUEFACTION
6000	2862	1.42	0.07	0.106	NO LIQUEFACTION	LIQUEFACTION
6200	2929	1.42	0.16	0.229	NO LIQUEFACTION	NO LIQUEFACTION
6400	2996	1.42	0.16	0.224	NO LIQUEFACTION	NO LIQUEFACTION
6600	3063	1.42	0.29	0.419	NO LIQUEFACTION	NO LIQUEFACTION
6800	3130	1.42	0.34	0.482	NO LIQUEFACTION	NO LIQUEFACTION
7000	3197	1.43	0.22	0.318	NO LIQUEFACTION	NO LIQUEFACTION
7200	3264	1.43	0.19	0.276	NO LIQUEFACTION	NO LIQUEFACTION
7400	3331	1.43	0.17	0.240	NO LIQUEFACTION	NO LIQUEFACTION
7600	3398	1.43	0.16	0.228	NO LIQUEFACTION	NO LIQUEFACTION
7800	3465	1.43	0.11	0.160	NO LIQUEFACTION	NO LIQUEFACTION
8000	3532	1.43	0.08	0.119	LIQUEFACTION	LIQUEFACTION
8200	3599	1.43	0.08	0.115	LIQUEFACTION	LIQUEFACTION
8400	3666	1.44	0.07	0.100	LIQUEFACTION	LIQUEFACTION
8600	3733	1.44	0.08	0.111	LIQUEFACTION	LIQUEFACTION
8800	3800	1.44	0.09	0.132	NO LIQUEFACTION	LIQUEFACTION
9000	900000	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
9200	900100	1.84	0.06	0.116	LIQUEFACTION	LIQUEFACTION
9400	900200	1.84	0.06	0.117	LIQUEFACTION	LIQUEFACTION
9600	900300	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
9800	900400	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
10000	900500	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
10200	900600	1.84	0.08	0.148	LIQUEFACTION	LIQUEFACTION
10400	900700	1.84	0.07	0.137	NO LIQUEFACTION	LIQUEFACTION
10600	900800	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION
10800	900900	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION
11000	901000	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION
11200	901100	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION
11400	901200	1.84	0.07	0.135	NO LIQUEFACTION	LIQUEFACTION
11600	901300	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
11800	901400	1.84	0.07	0.129	LIQUEFACTION	LIQUEFACTION
12000	901500	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION
12200	901600	1.84	0.07	0.135	NO LIQUEFACTION	LIQUEFACTION
12400	901700	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION
12600	901800	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION
12800	901900	1.84	0.07	0.134	NO LIQUEFACTION	LIQUEFACTION
13000	902000	1.84	0.08	0.139	NO LIQUEFACTION	LIQUEFACTION
13200	902100	1.84	0.07	0.125	LIQUEFACTION	LIQUEFACTION
13400	902200	1.84	0.07	0.122	NO LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 6.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

CONE PENETRATION TEST (CPT)
SIMPLIFIED PROCEDURE LIQUEFACTION ASSESSMENT

CPT#3

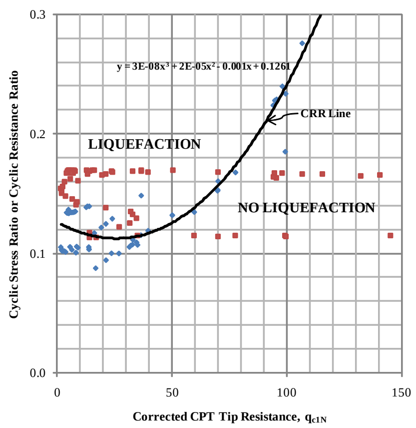
SHEET : 14 OF 14

ASSESSMENT RESULTS INC. AGEING FOR M=7.0 & 7.5

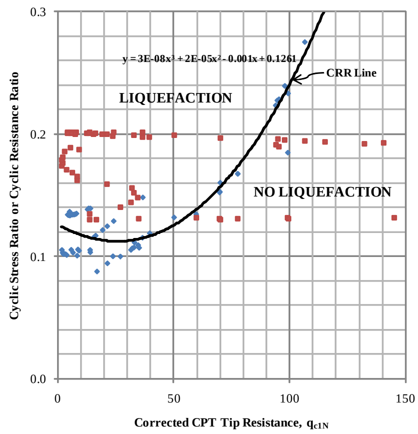
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m		
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan		
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan		
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa		

DEPTH (mm)	t (years)	K_{DR}	$CRR_{M=7.5}$	$CRR_{M=7.5,DR}$	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.0	DESCRIPTION OF EACH LAYER IF EARTHQUAKE MAGNITUDE M=7.5
200	30	1.08	0.17	0.185	NO LIQUEFACTION	NO LIQUEFACTION
400	30	1.08	0.85	0.915	NO LIQUEFACTION	NO LIQUEFACTION
600	30	1.08	0.36	0.394	NO LIQUEFACTION	NO LIQUEFACTION
800	1120	1.35	0.10	0.135	NO LIQUEFACTION	NO LIQUEFACTION
1000	1187	1.35	0.08	0.107	NO LIQUEFACTION	LIQUEFACTION
1200	1254	1.36	0.12	0.168	NO LIQUEFACTION	NO LIQUEFACTION
1400	1321	1.36	0.17	0.233	NO LIQUEFACTION	NO LIQUEFACTION
1600	1388	1.36	0.11	0.152	NO LIQUEFACTION	NO LIQUEFACTION
1800	1455	1.37	0.11	0.153	NO LIQUEFACTION	NO LIQUEFACTION
2000	1522	1.37	0.06	0.088	NO LIQUEFACTION	LIQUEFACTION
2200	1589	1.37	0.08	0.103	NO LIQUEFACTION	LIQUEFACTION
2400	1656	1.38	0.08	0.105	LIQUEFACTION	LIQUEFACTION
2600	1723	1.38	0.07	0.100	LIQUEFACTION	LIQUEFACTION
2800	1790	1.38	0.08	0.105	LIQUEFACTION	LIQUEFACTION
3000	1857	1.39	0.08	0.109	LIQUEFACTION	LIQUEFACTION
3200	1924	1.39	0.08	0.107	LIQUEFACTION	LIQUEFACTION
3400	1991	1.39	0.08	0.107	LIQUEFACTION	LIQUEFACTION
3600	2058	1.39	0.07	0.094	LIQUEFACTION	LIQUEFACTION
3800	2125	1.40	0.07	0.101	LIQUEFACTION	LIQUEFACTION
4000	2192	1.40	0.08	0.106	LIQUEFACTION	LIQUEFACTION
4200	2259	1.40	0.07	0.103	LIQUEFACTION	LIQUEFACTION
4400	2326	1.40	0.07	0.101	LIQUEFACTION	LIQUEFACTION
4600	2393	1.40	0.07	0.103	LIQUEFACTION	LIQUEFACTION
4800	2460	1.41	0.07	0.103	LIQUEFACTION	LIQUEFACTION
5000	2527	1.41	0.07	0.105	LIQUEFACTION	LIQUEFACTION
5200	2594	1.41	0.07	0.102	LIQUEFACTION	LIQUEFACTION
5400	2661	NO LIQUEFACTION				
5600	2728	1.41	0.07	0.102	LIQUEFACTION	LIQUEFACTION
5800	2795	1.42	0.07	0.105	LIQUEFACTION	LIQUEFACTION
6000	2862	1.42	0.07	0.106	LIQUEFACTION	LIQUEFACTION
6200	2929	1.42	0.16	0.229	NO LIQUEFACTION	NO LIQUEFACTION
6400	2996	1.42	0.16	0.224	NO LIQUEFACTION	NO LIQUEFACTION
6600	3063	1.42	0.29	0.419	NO LIQUEFACTION	NO LIQUEFACTION
6800	3130	1.42	0.34	0.482	NO LIQUEFACTION	NO LIQUEFACTION
7000	3197	1.43	0.22	0.318	NO LIQUEFACTION	NO LIQUEFACTION
7200	3264	1.43	0.19	0.276	NO LIQUEFACTION	NO LIQUEFACTION
7400	3331	1.43	0.17	0.240	NO LIQUEFACTION	NO LIQUEFACTION
7600	3398	1.43	0.16	0.228	NO LIQUEFACTION	NO LIQUEFACTION
7800	3465	1.43	0.11	0.160	LIQUEFACTION	LIQUEFACTION
8000	3532	1.43	0.08	0.119	LIQUEFACTION	LIQUEFACTION
8200	3599	1.43	0.08	0.115	LIQUEFACTION	LIQUEFACTION
8400	3666	1.44	0.07	0.100	LIQUEFACTION	LIQUEFACTION
8600	3733	1.44	0.08	0.111	LIQUEFACTION	LIQUEFACTION
8800	3800	1.44	0.09	0.132	LIQUEFACTION	LIQUEFACTION
9000	900000	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
9200	900100	1.84	0.06	0.116	LIQUEFACTION	LIQUEFACTION
9400	900200	1.84	0.06	0.117	LIQUEFACTION	LIQUEFACTION
9600	900300	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
9800	900400	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
10000	900500	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
10200	900600	1.84	0.08	0.148	LIQUEFACTION	LIQUEFACTION
10400	900700	1.84	0.07	0.137	LIQUEFACTION	LIQUEFACTION
10600	900800	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
10800	900900	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
11000	901000	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
11200	901100	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
11400	901200	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
11600	901300	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
11800	901400	1.84	0.07	0.129	LIQUEFACTION	LIQUEFACTION
12000	901500	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
12200	901600	1.84	0.07	0.135	LIQUEFACTION	LIQUEFACTION
12400	901700	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
12600	901800	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
12800	901900	1.84	0.07	0.134	LIQUEFACTION	LIQUEFACTION
13000	902000	1.84	0.08	0.139	LIQUEFACTION	LIQUEFACTION
13200	902100	1.84	0.07	0.125	LIQUEFACTION	LIQUEFACTION
13400	902200	1.84	0.07	0.122	LIQUEFACTION	LIQUEFACTION

GRAPHS OF CPT LIQUEFACTION ASSESSMENT



Graph 1. CPT liquefaction assessment if earthquake magnitude scale is 7.0



Graph 2. CPT liquefaction assessment if earthquake magnitude scale is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

APPENDIX K

DMT LIQUEFACTION ASSESSMENT RESULTS

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FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT

DMT#1

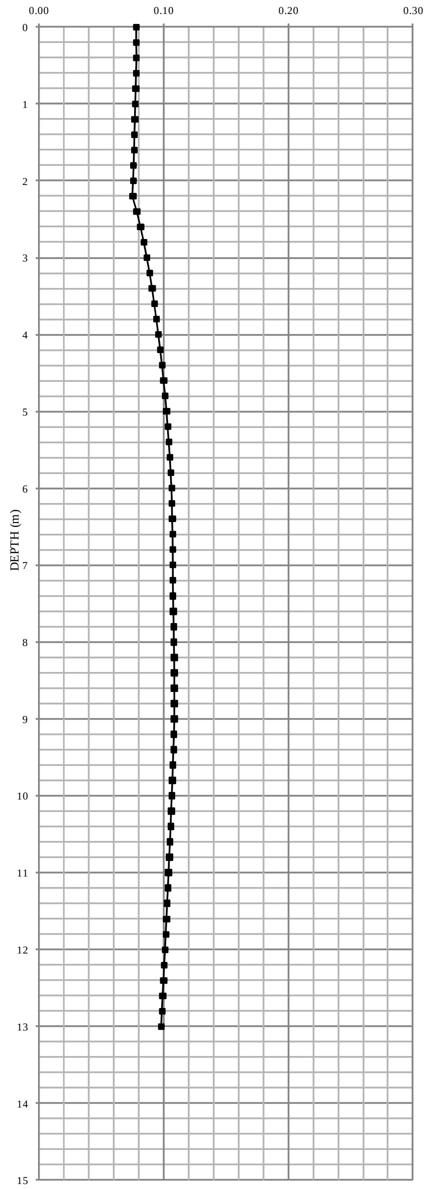
SHEET : 1 OF 13

CYCLIC STRESS RATIO FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010	TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m³)	γ' (kN/m³)	σ_v (kN/m²)	σ'_v (kN/m²)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	14.72	14.72	2.94	2.94	1.00	0.217	1.80	**0.08**
400	19.13	19.13	6.77	6.77	1.00	0.217	1.80	**0.08**
600	17.66	17.66	10.30	10.30	1.00	0.217	1.80	**0.08**
800	17.66	17.66	13.83	13.83	0.99	0.217	1.80	**0.08**
1000	17.66	17.66	17.36	17.36	0.99	0.217	1.80	**0.08**
1200	19.13	19.13	21.19	21.19	0.99	0.217	1.80	**0.08**
1400	19.13	19.13	25.02	25.02	0.98	0.217	1.80	**0.08**
1600	17.66	17.66	28.55	28.55	0.98	0.217	1.80	**0.08**
1800	17.66	17.66	32.08	32.08	0.97	0.217	1.80	**0.08**
2000	17.66	17.66	35.61	35.61	0.97	0.217	1.80	**0.08**
2200	17.66	17.66	39.14	39.14	0.96	0.217	1.80	**0.08**
2400	17.66	7.85	42.67	40.71	0.96	0.217	1.80	**0.08**
2600	17.66	7.85	46.21	42.28	0.95	0.217	1.80	**0.08**
2800	17.66	7.85	49.74	43.85	0.95	0.217	1.80	**0.08**
3000	17.66	7.85	53.27	45.42	0.94	0.217	1.80	**0.09**
3200	17.66	7.85	56.80	46.99	0.94	0.217	1.80	**0.09**
3400	17.66	7.85	60.33	48.56	0.93	0.217	1.80	**0.09**
3600	17.66	7.85	63.86	50.13	0.93	0.217	1.80	**0.09**
3800	17.66	7.85	67.39	51.70	0.92	0.217	1.80	**0.09**
4000	15.70	5.89	70.53	52.88	0.92	0.217	1.80	**0.10**
4200	15.70	5.89	73.67	54.06	0.91	0.217	1.80	**0.10**
4400	15.70	5.89	76.81	55.24	0.91	0.217	1.80	**0.10**
4600	15.70	5.89	79.95	56.41	0.90	0.217	1.80	**0.10**
4800	14.72	4.91	82.89	57.40	0.90	0.217	1.80	**0.10**
5000	15.70	5.89	86.03	58.57	0.89	0.217	1.80	**0.10**
5200	15.70	5.89	89.17	59.75	0.89	0.217	1.80	**0.10**
5400	15.70	5.89	92.31	60.93	0.88	0.217	1.80	**0.10**
5600	15.70	5.89	95.45	62.11	0.87	0.217	1.80	**0.11**
5800	15.70	5.89	98.59	63.29	0.87	0.217	1.80	**0.11**
6000	15.70	5.89	101.73	64.46	0.86	0.217	1.80	**0.11**
6200	17.66	7.85	105.26	66.03	0.86	0.217	1.80	**0.11**
6400	18.64	8.83	108.99	67.80	0.85	0.217	1.80	**0.11**
6600	16.68	6.87	112.32	69.17	0.84	0.217	1.80	**0.11**
6800	17.66	7.85	115.86	70.74	0.84	0.217	1.80	**0.11**
7000	17.66	7.85	119.39	72.31	0.83	0.217	1.80	**0.11**
7200	17.66	7.85	122.92	73.88	0.83	0.217	1.80	**0.11**
7400	16.68	6.87	126.25	75.26	0.82	0.217	1.80	**0.11**
7600	14.72	4.91	129.20	76.24	0.81	0.217	1.80	**0.11**
7800	14.72	4.91	132.14	77.22	0.81	0.217	1.80	**0.11**
8000	14.72	4.91	135.08	78.20	0.80	0.217	1.80	**0.11**
8200	14.72	4.91	138.03	79.18	0.80	0.217	1.80	**0.11**
8400	14.72	4.91	140.97	80.17	0.79	0.217	1.80	**0.11**
8600	14.72	4.91	143.91	81.15	0.78	0.217	1.80	**0.11**
8800	15.70	5.89	147.05	82.33	0.78	0.217	1.80	**0.11**
9000	14.72	4.91	149.99	83.31	0.77	0.217	1.80	**0.11**
9200	16.68	6.87	153.33	84.68	0.77	0.217	1.80	**0.11**
9400	17.66	7.85	156.86	86.25	0.76	0.217	1.80	**0.11**
9600	17.66	7.85	160.39	87.82	0.75	0.217	1.80	**0.11**
9800	17.66	7.85	163.93	89.39	0.75	0.217	1.80	**0.11**
10000	17.66	7.85	167.46	90.96	0.74	0.217	1.80	**0.11**
10200	17.66	7.85	170.99	92.53	0.73	0.217	1.80	**0.11**
10400	17.66	7.85	174.52	94.10	0.73	0.217	1.80	**0.11**
10600	17.66	7.85	178.05	95.67	0.72	0.217	1.80	**0.11**
10800	17.66	7.85	181.58	97.24	0.72	0.217	1.80	**0.10**
11000	17.66	7.85	185.11	98.81	0.71	0.217	1.80	**0.10**
11200	17.66	7.85	188.65	100.38	0.70	0.217	1.80	**0.10**
11400	17.66	7.85	192.18	101.95	0.70	0.217	1.80	**0.10**
11600	17.66	7.85	195.71	103.52	0.69	0.217	1.80	**0.10**
11800	17.66	7.85	199.24	105.09	0.69	0.217	1.80	**0.10**
12000	17.66	7.85	202.77	106.66	0.68	0.217	1.80	**0.10**
12200	17.66	7.85	206.30	108.23	0.67	0.217	1.80	**0.10**
12400	17.66	7.85	209.84	109.80	0.67	0.217	1.80	**0.10**
12600	17.66	7.85	213.37	111.37	0.66	0.217	1.80	**0.10**
12800	17.66	7.85	216.90	112.94	0.66	0.217	1.80	**0.10**
13000	17.66	7.85	220.43	114.52	0.65	0.217	1.80	**0.10**

DMT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature : ____________

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT

DMT#1

SHEET : 2 OF 13

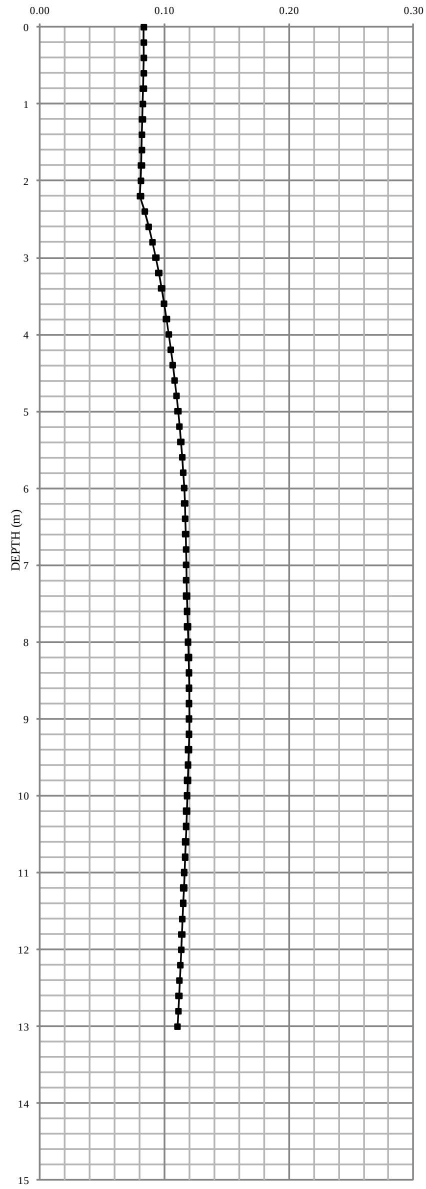
CYCLIC STRESS RATIO FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		
LOCATION	: GILLMAN, SOUTH AUSTRALIA		
COORDINATE	X : -	Y : -	
DATE	: 28 JUNE 2010	TO 28 JUNE 2010	

DEPTH	: 0 - 13 m	**REDUCE LEVEL**	: - m
INCLINATION	: Vertical	**OPERATOR**	: Andrew/Brendan
PUSHING SYSTEM	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
		CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	14.72	14.72	2.94	2.94	1.00	0.217	1.69	**0.08**
400	19.13	19.13	6.77	6.77	1.00	0.217	1.69	**0.08**
600	17.66	17.66	10.30	10.30	1.00	0.217	1.69	**0.08**
800	17.66	17.66	13.83	13.83	1.00	0.217	1.69	**0.08**
1000	17.66	17.66	17.36	17.36	0.99	0.217	1.69	**0.08**
1200	19.13	19.13	21.19	21.19	0.99	0.217	1.69	**0.08**
1400	19.13	19.13	25.02	25.02	0.98	0.217	1.69	**0.08**
1600	17.66	17.66	28.55	28.55	0.98	0.217	1.69	**0.08**
1800	17.66	17.66	32.08	32.08	0.98	0.217	1.69	**0.08**
2000	17.66	17.66	35.61	35.61	0.97	0.217	1.69	**0.08**
2200	17.66	17.66	39.14	39.14	0.97	0.217	1.69	**0.08**
2400	17.66	7.85	42.67	40.71	0.96	0.217	1.69	**0.08**
2600	17.66	7.85	46.21	42.28	0.96	0.217	1.69	**0.09**
2800	17.66	7.85	49.74	43.85	0.96	0.217	1.69	**0.09**
3000	17.66	7.85	53.27	45.42	0.95	0.217	1.69	**0.09**
3200	17.66	7.85	56.80	46.99	0.95	0.217	1.69	**0.10**
3400	17.66	7.85	60.33	48.56	0.94	0.217	1.69	**0.10**
3600	17.66	7.85	63.86	50.13	0.94	0.217	1.69	**0.10**
3800	17.66	7.85	67.39	51.70	0.93	0.217	1.69	**0.10**
4000	15.70	5.89	70.53	52.88	0.93	0.217	1.69	**0.10**
4200	15.70	5.89	73.67	54.06	0.92	0.217	1.69	**0.11**
4400	15.70	5.89	76.81	55.24	0.92	0.217	1.69	**0.11**
4600	15.70	5.89	79.95	56.41	0.91	0.217	1.69	**0.11**
4800	14.72	4.91	82.89	57.40	0.91	0.217	1.69	**0.11**
5000	15.70	5.89	86.03	58.57	0.90	0.217	1.69	**0.11**
5200	15.70	5.89	89.17	59.75	0.90	0.217	1.69	**0.11**
5400	15.70	5.89	92.31	60.93	0.89	0.217	1.69	**0.11**
5600	15.70	5.89	95.45	62.11	0.89	0.217	1.69	**0.11**
5800	15.70	5.89	98.59	63.29	0.88	0.217	1.69	**0.12**
6000	15.70	5.89	101.73	64.46	0.88	0.217	1.69	**0.12**
6200	17.66	7.85	105.26	66.03	0.87	0.217	1.69	**0.12**
6400	18.64	8.83	108.99	67.80	0.87	0.217	1.69	**0.12**
6600	16.68	6.87	112.32	69.17	0.86	0.217	1.69	**0.12**
6800	17.66	7.85	115.86	70.74	0.86	0.217	1.69	**0.12**
7000	17.66	7.85	119.39	72.31	0.85	0.217	1.69	**0.12**
7200	17.66	7.85	122.92	73.88	0.85	0.217	1.69	**0.12**
7400	16.68	6.87	126.25	75.26	0.84	0.217	1.69	**0.12**
7600	14.72	4.91	129.20	76.24	0.84	0.217	1.69	**0.12**
7800	14.72	4.91	132.14	77.22	0.83	0.217	1.69	**0.12**
8000	14.72	4.91	135.08	78.20	0.82	0.217	1.69	**0.12**
8200	14.72	4.91	138.03	79.18	0.82	0.217	1.69	**0.12**
8400	14.72	4.91	140.97	80.17	0.81	0.217	1.69	**0.12**
8600	14.72	4.91	143.91	81.15	0.81	0.217	1.69	**0.12**
8800	15.70	5.89	147.05	82.33	0.80	0.217	1.69	**0.12**
9000	14.72	4.91	149.99	83.31	0.80	0.217	1.69	**0.12**
9200	16.68	6.87	153.33	84.68	0.79	0.217	1.69	**0.12**
9400	17.66	7.85	156.86	86.25	0.79	0.217	1.69	**0.12**
9600	17.66	7.85	160.39	87.82	0.78	0.217	1.69	**0.12**
9800	17.66	7.85	163.93	89.39	0.77	0.217	1.69	**0.12**
10000	17.66	7.85	167.46	90.96	0.77	0.217	1.69	**0.12**
10200	17.66	7.85	170.99	92.53	0.76	0.217	1.69	**0.12**
10400	17.66	7.85	174.52	94.10	0.76	0.217	1.69	**0.12**
10600	17.66	7.85	178.05	95.67	0.75	0.217	1.69	**0.12**
10800	17.66	7.85	181.58	97.24	0.75	0.217	1.69	**0.12**
11000	17.66	7.85	185.11	98.81	0.74	0.217	1.69	**0.12**
11200	17.66	7.85	188.65	100.38	0.74	0.217	1.69	**0.12**
11400	17.66	7.85	192.18	101.95	0.73	0.217	1.69	**0.12**
11600	17.66	7.85	195.71	103.52	0.73	0.217	1.69	**0.11**
11800	17.66	7.85	199.24	105.09	0.72	0.217	1.69	**0.11**
12000	17.66	7.85	202.77	106.66	0.71	0.217	1.69	**0.11**
12200	17.66	7.85	206.30	108.23	0.71	0.217	1.69	**0.11**
12400	17.66	7.85	209.84	109.80	0.70	0.217	1.69	**0.11**
12600	17.66	7.85	213.37	111.37	0.70	0.217	1.69	**0.11**
12800	17.66	7.85	216.90	112.94	0.69	0.217	1.69	**0.11**
13000	17.66	7.85	220.43	114.52	0.69	0.217	1.69	**0.11**

DMT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT

DMT#1

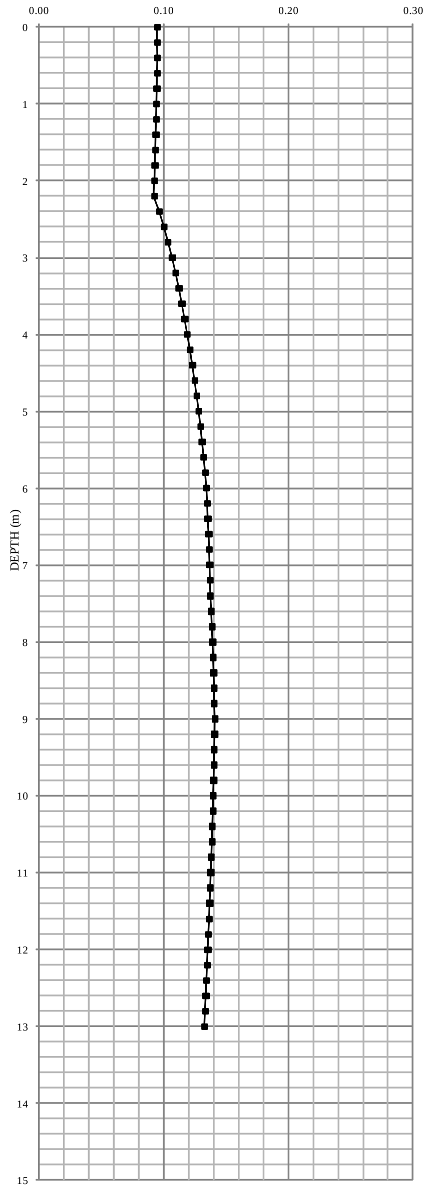
SHEET : 3 OF 13

CYCLIC STRESS RATIO FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	14.72	14.72	2.94	2.94	1.00	0.217	1.48	**0.10**
400	19.13	19.13	6.77	6.77	1.00	0.217	1.48	**0.10**
600	17.66	17.66	10.30	10.30	1.00	0.217	1.48	**0.10**
800	17.66	17.66	13.83	13.83	1.00	0.217	1.48	**0.09**
1000	17.66	17.66	17.36	17.36	0.99	0.217	1.48	**0.09**
1200	19.13	19.13	21.19	21.19	0.99	0.217	1.48	**0.09**
1400	19.13	19.13	25.02	25.02	0.99	0.217	1.48	**0.09**
1600	17.66	17.66	28.55	28.55	0.98	0.217	1.48	**0.09**
1800	17.66	17.66	32.08	32.08	0.98	0.217	1.48	**0.09**
2000	17.66	17.66	35.61	35.61	0.98	0.217	1.48	**0.09**
2200	17.66	17.66	39.14	39.14	0.97	0.217	1.48	**0.09**
2400	17.66	7.85	42.67	40.71	0.97	0.217	1.48	**0.10**
2600	17.66	7.85	46.21	42.28	0.97	0.217	1.48	**0.10**
2800	17.66	7.85	49.74	43.85	0.96	0.217	1.48	**0.10**
3000	17.66	7.85	53.27	45.42	0.96	0.217	1.48	**0.11**
3200	17.66	7.85	56.80	46.99	0.96	0.217	1.48	**0.11**
3400	17.66	7.85	60.33	48.56	0.95	0.217	1.48	**0.11**
3600	17.66	7.85	63.86	50.13	0.95	0.217	1.48	**0.11**
3800	17.66	7.85	67.39	51.70	0.94	0.217	1.48	**0.12**
4000	15.70	5.89	70.53	52.88	0.94	0.217	1.48	**0.12**
4200	15.70	5.89	73.67	54.06	0.94	0.217	1.48	**0.12**
4400	15.70	5.89	76.81	55.24	0.93	0.217	1.48	**0.12**
4600	15.70	5.89	79.95	56.41	0.93	0.217	1.48	**0.13**
4800	14.72	4.91	82.89	57.40	0.92	0.217	1.48	**0.13**
5000	15.70	5.89	86.03	58.57	0.92	0.217	1.48	**0.13**
5200	15.70	5.89	89.17	59.75	0.91	0.217	1.48	**0.13**
5400	15.70	5.89	92.31	60.93	0.91	0.217	1.48	**0.13**
5600	15.70	5.89	95.45	62.11	0.91	0.217	1.48	**0.13**
5800	15.70	5.89	98.59	63.29	0.90	0.217	1.48	**0.13**
6000	15.70	5.89	101.73	64.46	0.90	0.217	1.48	**0.13**
6200	17.66	7.85	105.26	66.03	0.89	0.217	1.48	**0.14**
6400	18.64	8.83	108.99	67.80	0.89	0.217	1.48	**0.14**
6600	16.68	6.87	112.32	69.17	0.88	0.217	1.48	**0.14**
6800	17.66	7.85	115.86	70.74	0.88	0.217	1.48	**0.14**
7000	17.66	7.85	119.39	72.31	0.87	0.217	1.48	**0.14**
7200	17.66	7.85	122.92	73.88	0.87	0.217	1.48	**0.14**
7400	16.68	6.87	126.25	75.26	0.86	0.217	1.48	**0.14**
7600	14.72	4.91	129.20	76.24	0.86	0.217	1.48	**0.14**
7800	14.72	4.91	132.14	77.22	0.85	0.217	1.48	**0.14**
8000	14.72	4.91	135.08	78.20	0.85	0.217	1.48	**0.14**
8200	14.72	4.91	138.03	79.18	0.84	0.217	1.48	**0.14**
8400	14.72	4.91	140.97	80.17	0.84	0.217	1.48	**0.14**
8600	14.72	4.91	143.91	81.15	0.83	0.217	1.48	**0.14**
8800	15.70	5.89	147.05	82.33	0.83	0.217	1.48	**0.14**
9000	14.72	4.91	149.99	83.31	0.82	0.217	1.48	**0.14**
9200	16.68	6.87	153.33	84.68	0.82	0.217	1.48	**0.14**
9400	17.66	7.85	156.86	86.25	0.81	0.217	1.48	**0.14**
9600	17.66	7.85	160.39	87.82	0.81	0.217	1.48	**0.14**
9800	17.66	7.85	163.93	89.39	0.80	0.217	1.48	**0.14**
10000	17.66	7.85	167.46	90.96	0.80	0.217	1.48	**0.14**
10200	17.66	7.85	170.99	92.53	0.79	0.217	1.48	**0.14**
10400	17.66	7.85	174.52	94.10	0.79	0.217	1.48	**0.14**
10600	17.66	7.85	178.05	95.67	0.78	0.217	1.48	**0.14**
10800	17.66	7.85	181.58	97.24	0.78	0.217	1.48	**0.14**
11000	17.66	7.85	185.11	98.81	0.77	0.217	1.48	**0.14**
11200	17.66	7.85	188.65	100.38	0.77	0.217	1.48	**0.14**
11400	17.66	7.85	192.18	101.95	0.76	0.217	1.48	**0.14**
11600	17.66	7.85	195.71	103.52	0.76	0.217	1.48	**0.14**
11800	17.66	7.85	199.24	105.09	0.75	0.217	1.48	**0.14**
12000	17.66	7.85	202.77	106.66	0.75	0.217	1.48	**0.14**
12200	17.66	7.85	206.30	108.23	0.74	0.217	1.48	**0.14**
12400	17.66	7.85	209.84	109.80	0.74	0.217	1.48	**0.13**
12600	17.66	7.85	213.37	111.37	0.74	0.217	1.48	**0.13**
12800	17.66	7.85	216.90	112.94	0.73	0.217	1.48	**0.13**
13000	17.66	7.85	220.43	114.52	0.73	0.217	1.48	**0.13**

DMT PROFILE FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT

DMT#1

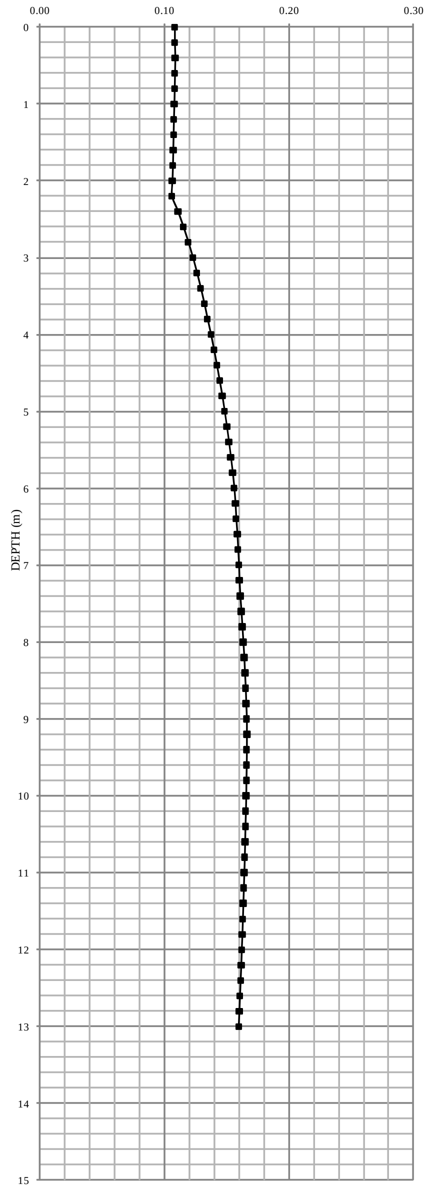
SHEET : 4 OF 13

CYCLIC STRESS RATIO FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010	TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	14.72	14.72	2.94	2.94	1.00	0.217	1.30	**0.11**
400	19.13	19.13	6.77	6.77	1.00	0.217	1.30	**0.11**
600	17.66	17.66	10.30	10.30	1.00	0.217	1.30	**0.11**
800	17.66	17.66	13.83	13.83	1.00	0.217	1.30	**0.11**
1000	17.66	17.66	17.36	17.36	1.00	0.217	1.30	**0.11**
1200	19.13	19.13	21.19	21.19	0.99	0.217	1.30	**0.11**
1400	19.13	19.13	25.02	25.02	0.99	0.217	1.30	**0.11**
1600	17.66	17.66	28.55	28.55	0.99	0.217	1.30	**0.11**
1800	17.66	17.66	32.08	32.08	0.98	0.217	1.30	**0.11**
2000	17.66	17.66	35.61	35.61	0.98	0.217	1.30	**0.11**
2200	17.66	17.66	39.14	39.14	0.98	0.217	1.30	**0.11**
2400	17.66	7.85	42.67	40.71	0.98	0.217	1.30	**0.11**
2600	17.66	7.85	46.21	42.28	0.97	0.217	1.30	**0.12**
2800	17.66	7.85	49.74	43.85	0.97	0.217	1.30	**0.12**
3000	17.66	7.85	53.27	45.42	0.97	0.217	1.30	**0.12**
3200	17.66	7.85	56.80	46.99	0.96	0.217	1.30	**0.13**
3400	17.66	7.85	60.33	48.56	0.96	0.217	1.30	**0.13**
3600	17.66	7.85	63.86	50.13	0.96	0.217	1.30	**0.13**
3800	17.66	7.85	67.39	51.70	0.95	0.217	1.30	**0.13**
4000	15.70	5.89	70.53	52.88	0.95	0.217	1.30	**0.14**
4200	15.70	5.89	73.67	54.06	0.95	0.217	1.30	**0.14**
4400	15.70	5.89	76.81	55.24	0.94	0.217	1.30	**0.14**
4600	15.70	5.89	79.95	56.41	0.94	0.217	1.30	**0.14**
4800	14.72	4.91	82.89	57.40	0.94	0.217	1.30	**0.15**
5000	15.70	5.89	86.03	58.57	0.93	0.217	1.30	**0.15**
5200	15.70	5.89	89.17	59.75	0.93	0.217	1.30	**0.15**
5400	15.70	5.89	92.31	60.93	0.92	0.217	1.30	**0.15**
5600	15.70	5.89	95.45	62.11	0.92	0.217	1.30	**0.15**
5800	15.70	5.89	98.59	63.29	0.92	0.217	1.30	**0.15**
6000	15.70	5.89	101.73	64.46	0.91	0.217	1.30	**0.16**
6200	17.66	7.85	105.26	66.03	0.91	0.217	1.30	**0.16**
6400	18.64	8.83	108.99	67.80	0.91	0.217	1.30	**0.16**
6600	16.68	6.87	112.32	69.17	0.90	0.217	1.30	**0.16**
6800	17.66	7.85	115.86	70.74	0.90	0.217	1.30	**0.16**
7000	17.66	7.85	119.39	72.31	0.89	0.217	1.30	**0.16**
7200	17.66	7.85	122.92	73.88	0.89	0.217	1.30	**0.16**
7400	16.68	6.87	126.25	75.26	0.89	0.217	1.30	**0.16**
7600	14.72	4.91	129.20	76.24	0.88	0.217	1.30	**0.16**
7800	14.72	4.91	132.14	77.22	0.88	0.217	1.30	**0.16**
8000	14.72	4.91	135.08	78.20	0.87	0.217	1.30	**0.16**
8200	14.72	4.91	138.03	79.18	0.87	0.217	1.30	**0.16**
8400	14.72	4.91	140.97	80.17	0.86	0.217	1.30	**0.16**
8600	14.72	4.91	143.91	81.15	0.86	0.217	1.30	**0.17**
8800	15.70	5.89	147.05	82.33	0.86	0.217	1.30	**0.17**
9000	14.72	4.91	149.99	83.31	0.85	0.217	1.30	**0.17**
9200	16.68	6.87	153.33	84.68	0.85	0.217	1.30	**0.17**
9400	17.66	7.85	156.86	86.25	0.84	0.217	1.30	**0.17**
9600	17.66	7.85	160.39	87.82	0.84	0.217	1.30	**0.17**
9800	17.66	7.85	163.93	89.39	0.83	0.217	1.30	**0.17**
10000	17.66	7.85	167.46	90.96	0.83	0.217	1.30	**0.17**
10200	17.66	7.85	170.99	92.53	0.83	0.217	1.30	**0.17**
10400	17.66	7.85	174.52	94.10	0.82	0.217	1.30	**0.17**
10600	17.66	7.85	178.05	95.67	0.82	0.217	1.30	**0.16**
10800	17.66	7.85	181.58	97.24	0.81	0.217	1.30	**0.16**
11000	17.66	7.85	185.11	98.81	0.81	0.217	1.30	**0.16**
11200	17.66	7.85	188.65	100.38	0.80	0.217	1.30	**0.16**
11400	17.66	7.85	192.18	101.95	0.80	0.217	1.30	**0.16**
11600	17.66	7.85	195.71	103.52	0.80	0.217	1.30	**0.16**
11800	17.66	7.85	199.24	105.09	0.79	0.217	1.30	**0.16**
12000	17.66	7.85	202.77	106.66	0.79	0.217	1.30	**0.16**
12200	17.66	7.85	206.30	108.23	0.78	0.217	1.30	**0.16**
12400	17.66	7.85	209.84	109.80	0.78	0.217	1.30	**0.16**
12600	17.66	7.85	213.37	111.37	0.77	0.217	1.30	**0.16**
12800	17.66	7.85	216.90	112.94	0.77	0.217	1.30	**0.16**
13000	17.66	7.85	220.43	114.52	0.77	0.217	1.30	**0.16**

DMT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT

DMT#1

SHEET : 5 OF 13

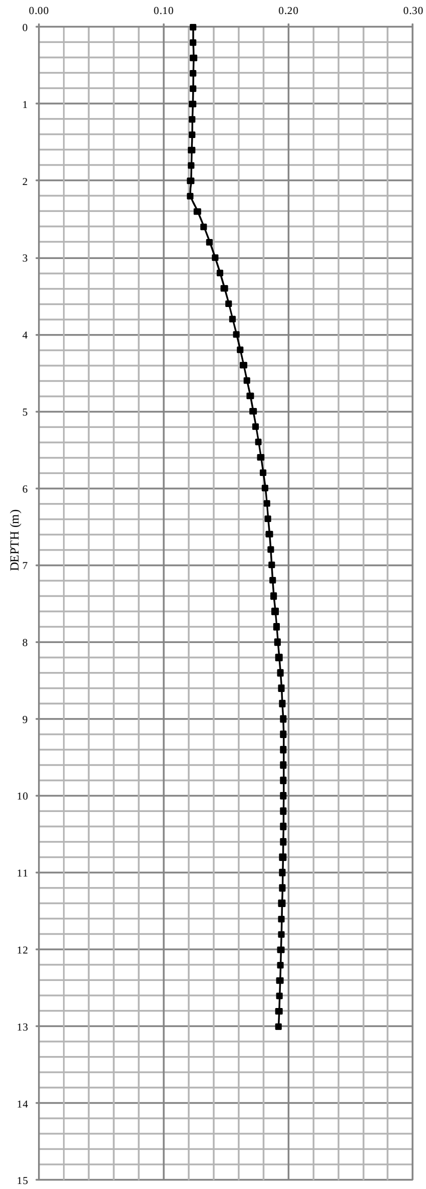
CYCLIC STRESS RATIO FOR M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 28 JUNE 2010 TO 28 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m³)	γ' (kN/m³)	σ_v (kN/m²)	σ'_v (kN/m²)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	14.72	14.72	2.94	2.94	1.00	0.217	1.14	**0.12**
400	19.13	19.13	6.77	6.77	1.00	0.217	1.14	**0.12**
600	17.66	17.66	10.30	10.30	1.00	0.217	1.14	**0.12**
800	17.66	17.66	13.83	13.83	1.00	0.217	1.14	**0.12**
1000	17.66	17.66	17.36	17.36	1.00	0.217	1.14	**0.12**
1200	19.13	19.13	21.19	21.19	1.00	0.217	1.14	**0.12**
1400	19.13	19.13	25.02	25.02	0.99	0.217	1.14	**0.12**
1600	17.66	17.66	28.55	28.55	0.99	0.217	1.14	**0.12**
1800	17.66	17.66	32.08	32.08	0.99	0.217	1.14	**0.12**
2000	17.66	17.66	35.61	35.61	0.99	0.217	1.14	**0.12**
2200	17.66	17.66	39.14	39.14	0.98	0.217	1.14	**0.12**
2400	17.66	7.85	42.67	40.71	0.98	0.217	1.14	**0.13**
2600	17.66	7.85	46.21	42.28	0.98	0.217	1.14	**0.13**
2800	17.66	7.85	49.74	43.85	0.98	0.217	1.14	**0.14**
3000	17.66	7.85	53.27	45.42	0.97	0.217	1.14	**0.14**
3200	17.66	7.85	56.80	46.99	0.97	0.217	1.14	**0.15**
3400	17.66	7.85	60.33	48.56	0.97	0.217	1.14	**0.15**
3600	17.66	7.85	63.86	50.13	0.97	0.217	1.14	**0.15**
3800	17.66	7.85	67.39	51.70	0.96	0.217	1.14	**0.16**
4000	15.70	5.89	70.53	52.88	0.96	0.217	1.14	**0.16**
4200	15.70	5.89	73.67	54.06	0.96	0.217	1.14	**0.16**
4400	15.70	5.89	76.81	55.24	0.96	0.217	1.14	**0.16**
4600	15.70	5.89	79.95	56.41	0.95	0.217	1.14	**0.17**
4800	14.72	4.91	82.89	57.40	0.95	0.217	1.14	**0.17**
5000	15.70	5.89	86.03	58.57	0.95	0.217	1.14	**0.17**
5200	15.70	5.89	89.17	59.75	0.94	0.217	1.14	**0.17**
5400	15.70	5.89	92.31	60.93	0.94	0.217	1.14	**0.18**
5600	15.70	5.89	95.45	62.11	0.94	0.217	1.14	**0.18**
5800	15.70	5.89	98.59	63.29	0.93	0.217	1.14	**0.18**
6000	15.70	5.89	101.73	64.46	0.93	0.217	1.14	**0.18**
6200	17.66	7.85	105.26	66.03	0.93	0.217	1.14	**0.18**
6400	18.64	8.83	108.99	67.80	0.92	0.217	1.14	**0.18**
6600	16.68	6.87	112.32	69.17	0.92	0.217	1.14	**0.18**
6800	17.66	7.85	115.86	70.74	0.92	0.217	1.14	**0.19**
7000	17.66	7.85	119.39	72.31	0.91	0.217	1.14	**0.19**
7200	17.66	7.85	122.92	73.88	0.91	0.217	1.14	**0.19**
7400	16.68	6.87	126.25	75.26	0.91	0.217	1.14	**0.19**
7600	14.72	4.91	129.20	76.24	0.90	0.217	1.14	**0.19**
7800	14.72	4.91	132.14	77.22	0.90	0.217	1.14	**0.19**
8000	14.72	4.91	135.08	78.20	0.90	0.217	1.14	**0.19**
8200	14.72	4.91	138.03	79.18	0.89	0.217	1.14	**0.19**
8400	14.72	4.91	140.97	80.17	0.89	0.217	1.14	**0.19**
8600	14.72	4.91	143.91	81.15	0.89	0.217	1.14	**0.19**
8800	15.70	5.89	147.05	82.33	0.88	0.217	1.14	**0.20**
9000	14.72	4.91	149.99	83.31	0.88	0.217	1.14	**0.20**
9200	16.68	6.87	153.33	84.68	0.88	0.217	1.14	**0.20**
9400	17.66	7.85	156.86	86.25	0.87	0.217	1.14	**0.20**
9600	17.66	7.85	160.39	87.82	0.87	0.217	1.14	**0.20**
9800	17.66	7.85	163.93	89.39	0.87	0.217	1.14	**0.20**
10000	17.66	7.85	167.46	90.96	0.86	0.217	1.14	**0.20**
10200	17.66	7.85	170.99	92.53	0.86	0.217	1.14	**0.20**
10400	17.66	7.85	174.52	94.10	0.86	0.217	1.14	**0.20**
10600	17.66	7.85	178.05	95.67	0.85	0.217	1.14	**0.20**
10800	17.66	7.85	181.58	97.24	0.85	0.217	1.14	**0.20**
11000	17.66	7.85	185.11	98.81	0.84	0.217	1.14	**0.20**
11200	17.66	7.85	188.65	100.38	0.84	0.217	1.14	**0.20**
11400	17.66	7.85	192.18	101.95	0.84	0.217	1.14	**0.20**
11600	17.66	7.85	195.71	103.52	0.83	0.217	1.14	**0.19**
11800	17.66	7.85	199.24	105.09	0.83	0.217	1.14	**0.19**
12000	17.66	7.85	202.77	106.66	0.83	0.217	1.14	**0.19**
12200	17.66	7.85	206.30	108.23	0.82	0.217	1.14	**0.19**
12400	17.66	7.85	209.84	109.80	0.82	0.217	1.14	**0.19**
12600	17.66	7.85	213.37	111.37	0.82	0.217	1.14	**0.19**
12800	17.66	7.85	216.90	112.94	0.81	0.217	1.14	**0.19**
13000	17.66	7.85	220.43	114.52	0.81	0.217	1.14	**0.19**

DMT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT

DMT#1

SHEET : 6 OF 13

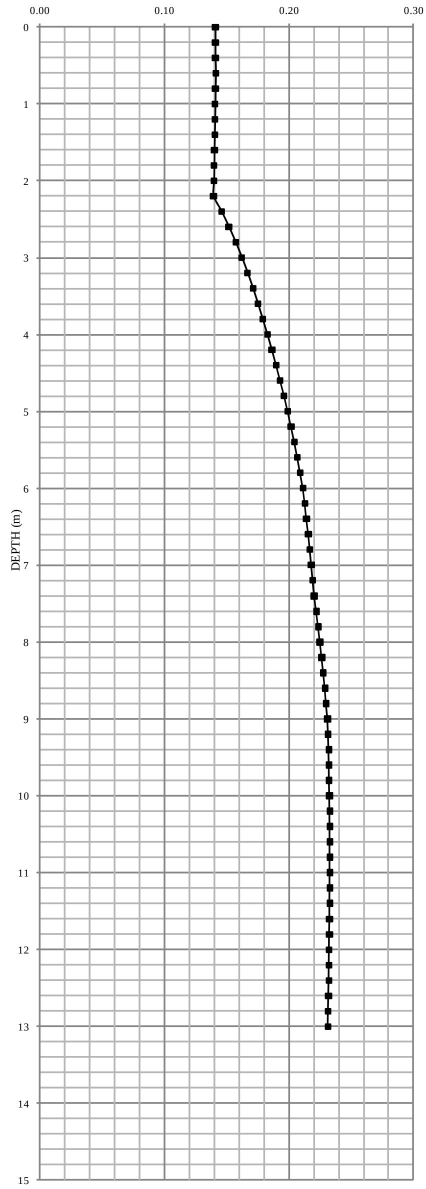
CYCLIC STRESS RATIO FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
DATE	: 28 JUNE 2010 TO 28 JUNE 2010		

REDUCE LEVEL	: - m
OPERATOR	: Andrew/Brendan
SUPERVISED BY	: B. Setiawan
CHECKED BY	: A/Prof. Mark Jaksa

DEPTH (mm)	γ (kN/m^3)	γ' (kN/m^3)	σ_v (kN/m^2)	σ'_v (kN/m^2)	r_d	a_{max}	MSF	$CSR_{M=7.5}$
200	14.72	14.72	2.94	2.94	1.00	0.217	1	**0.14**
400	19.13	19.13	6.77	6.77	1.00	0.217	1	**0.14**
600	17.66	17.66	10.30	10.30	1.00	0.217	1	**0.14**
800	17.66	17.66	13.83	13.83	1.00	0.217	1	**0.14**
1000	17.66	17.66	17.36	17.36	1.00	0.217	1	**0.14**
1200	19.13	19.13	21.19	21.19	1.00	0.217	1	**0.14**
1400	19.13	19.13	25.02	25.02	1.00	0.217	1	**0.14**
1600	17.66	17.66	28.55	28.55	0.99	0.217	1	**0.14**
1800	17.66	17.66	32.08	32.08	0.99	0.217	1	**0.14**
2000	17.66	17.66	35.61	35.61	0.99	0.217	1	**0.14**
2200	17.66	17.66	39.14	39.14	0.99	0.217	1	**0.14**
2400	17.66	7.85	42.67	40.71	0.99	0.217	1	**0.15**
2600	17.66	7.85	46.21	42.28	0.99	0.217	1	**0.15**
2800	17.66	7.85	49.74	43.85	0.98	0.217	1	**0.16**
3000	17.66	7.85	53.27	45.42	0.98	0.217	1	**0.16**
3200	17.66	7.85	56.80	46.99	0.98	0.217	1	**0.17**
3400	17.66	7.85	60.33	48.56	0.98	0.217	1	**0.17**
3600	17.66	7.85	63.86	50.13	0.98	0.217	1	**0.18**
3800	17.66	7.85	67.39	51.70	0.97	0.217	1	**0.18**
4000	15.70	5.89	70.53	52.88	0.97	0.217	1	**0.18**
4200	15.70	5.89	73.67	54.06	0.97	0.217	1	**0.19**
4400	15.70	5.89	76.81	55.24	0.97	0.217	1	**0.19**
4600	15.70	5.89	79.95	56.41	0.97	0.217	1	**0.19**
4800	14.72	4.91	82.89	57.40	0.96	0.217	1	**0.20**
5000	15.70	5.89	86.03	58.57	0.96	0.217	1	**0.20**
5200	15.70	5.89	89.17	59.75	0.96	0.217	1	**0.20**
5400	15.70	5.89	92.31	60.93	0.96	0.217	1	**0.20**
5600	15.70	5.89	95.45	62.11	0.95	0.217	1	**0.21**
5800	15.70	5.89	98.59	63.29	0.95	0.217	1	**0.21**
6000	15.70	5.89	101.73	64.46	0.95	0.217	1	**0.21**
6200	17.66	7.85	105.26	66.03	0.95	0.217	1	**0.21**
6400	18.64	8.83	108.99	67.80	0.94	0.217	1	**0.21**
6600	16.68	6.87	112.32	69.17	0.94	0.217	1	**0.22**
6800	17.66	7.85	115.86	70.74	0.94	0.217	1	**0.22**
7000	17.66	7.85	119.39	72.31	0.94	0.217	1	**0.22**
7200	17.66	7.85	122.92	73.88	0.93	0.217	1	**0.22**
7400	16.68	6.87	126.25	75.26	0.93	0.217	1	**0.22**
7600	14.72	4.91	129.20	76.24	0.93	0.217	1	**0.22**
7800	14.72	4.91	132.14	77.22	0.93	0.217	1	**0.22**
8000	14.72	4.91	135.08	78.20	0.92	0.217	1	**0.23**
8200	14.72	4.91	138.03	79.18	0.92	0.217	1	**0.23**
8400	14.72	4.91	140.97	80.17	0.92	0.217	1	**0.23**
8600	14.72	4.91	143.91	81.15	0.92	0.217	1	**0.23**
8800	15.70	5.89	147.05	82.33	0.91	0.217	1	**0.23**
9000	14.72	4.91	149.99	83.31	0.91	0.217	1	**0.23**
9200	16.68	6.87	153.33	84.68	0.91	0.217	1	**0.23**
9400	17.66	7.85	156.86	86.25	0.90	0.217	1	**0.23**
9600	17.66	7.85	160.39	87.82	0.90	0.217	1	**0.23**
9800	17.66	7.85	163.93	89.39	0.90	0.217	1	**0.23**
10000	17.66	7.85	167.46	90.96	0.90	0.217	1	**0.23**
10200	17.66	7.85	170.99	92.53	0.89	0.217	1	**0.23**
10400	17.66	7.85	174.52	94.10	0.89	0.217	1	**0.23**
10600	17.66	7.85	178.05	95.67	0.89	0.217	1	**0.23**
10800	17.66	7.85	181.58	97.24	0.88	0.217	1	**0.23**
11000	17.66	7.85	185.11	98.81	0.88	0.217	1	**0.23**
11200	17.66	7.85	188.65	100.38	0.88	0.217	1	**0.23**
11400	17.66	7.85	192.18	101.95	0.88	0.217	1	**0.23**
11600	17.66	7.85	195.71	103.52	0.87	0.217	1	**0.23**
11800	17.66	7.85	199.24	105.09	0.87	0.217	1	**0.23**
12000	17.66	7.85	202.77	106.66	0.87	0.217	1	**0.23**
12200	17.66	7.85	206.30	108.23	0.86	0.217	1	**0.23**
12400	17.66	7.85	209.84	109.80	0.86	0.217	1	**0.23**
12600	17.66	7.85	213.37	111.37	0.86	0.217	1	**0.23**
12800	17.66	7.85	216.90	112.94	0.86	0.217	1	**0.23**
13000	17.66	7.85	220.43	114.52	0.85	0.217	1	**0.23**

DMT PROFILE
FOR CYCLIC STRESS RATIO



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT

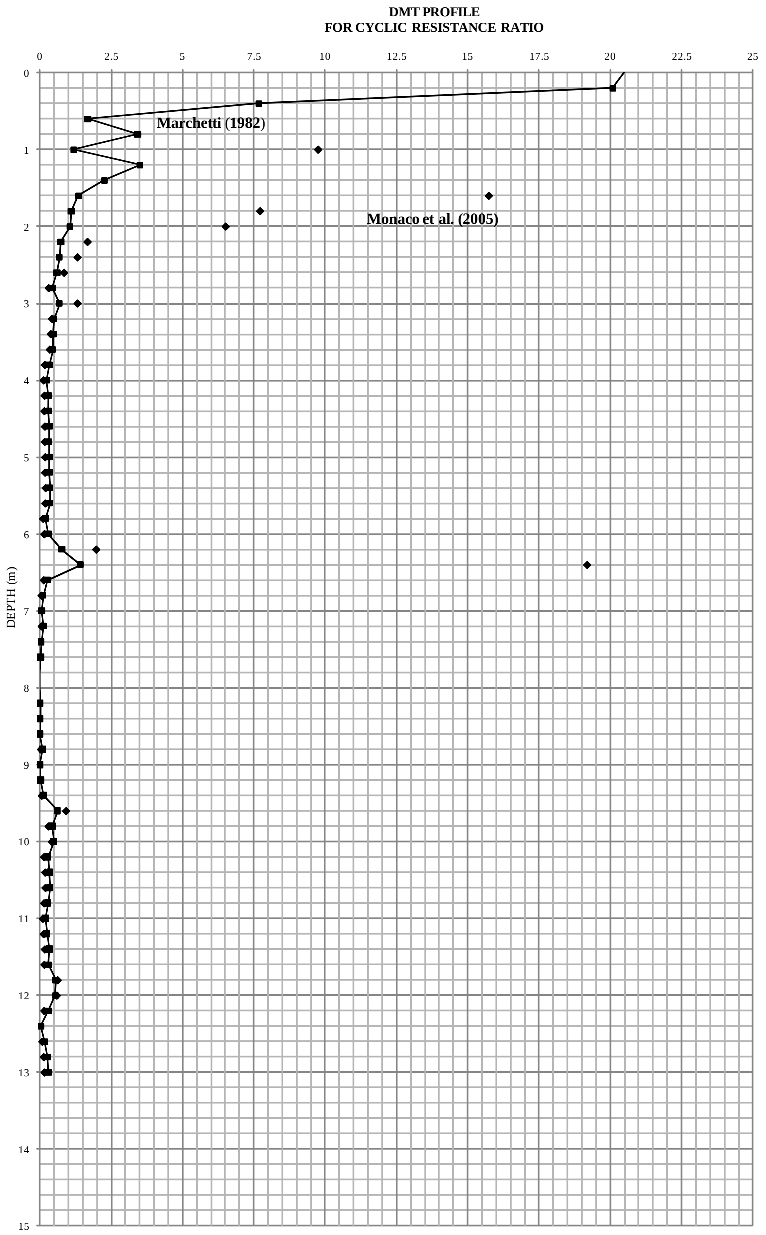
DMT#1

SHEET : 7 OF 13

CYCLIC RESISTANCE RATIO

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m	
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew	
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan	
DATE	: 28 JUNE 2010	TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa	

DEPTH (mm)	**K_D**	**$CRR_{M=7.5}$ (Marchetti, 1982)**	**$CRR_{M=7.5}$ (Monaco et al., 2005)**
200	200.90	20.09	83814.08
400	76.71	7.67	4410.59
600	16.72	1.67	32.81
800	34.29	3.43	351.46
1000	11.82	1.18	9.75
1200	35.12	3.51	379.70
1400	22.56	2.26	89.85
1600	13.53	1.35	15.74
1800	11.07	1.11	7.72
2000	10.57	1.06	6.51
2200	7.29	0.73	1.66
2400	6.84	0.68	1.31
2600	6.04	0.60	0.83
2800	4.37	0.44	0.29
3000	6.84	0.68	1.31
3200	4.91	0.49	0.41
3400	4.73	0.47	0.37
3600	4.56	0.46	0.33
3800	3.27	0.33	0.16
4000	2.46	0.25	0.11
4200	3.11	0.31	0.15
4400	3.02	0.30	0.14
4600	3.28	0.33	0.16
4800	3.21	0.32	0.16
5000	3.42	0.34	0.17
5200	3.34	0.33	0.17
5400	3.57	0.36	0.19
5600	3.47	0.35	0.18
5800	2.10	0.21	0.10
6000	2.97	0.30	0.14
6200	7.63	0.76	1.96
6400	14.32	1.43	19.20
6600	2.64	0.26	0.12
6800	1.19	0.12	0.04
7000	0.58	0.06	-0.03
7200	1.25	0.12	0.05
7400	0.51	0.05	-0.04
7600	0.23	0.02	-0.09
7800	-0.06	-0.01	-0.14
8000	-0.08	-0.01	-0.15
8200	0.15	0.01	-0.10
8400	0.12	0.01	-0.11
8600	0.09	0.01	-0.11
8800	0.99	0.10	0.02
9000	0.05	0.00	-0.12
9200	0.24	0.02	-0.08
9400	1.32	0.13	0.05
9600	6.18	0.62	0.91
9800	4.33	0.43	0.29
10000	4.88	0.49	0.41
10200	2.80	0.28	0.13
10400	3.40	0.34	0.17
10600	3.54	0.35	0.18
10800	2.85	0.29	0.13
11000	1.95	0.19	0.09
11200	2.54	0.25	0.12
11400	3.25	0.33	0.16
11600	3.02	0.30	0.14
11800	5.52	0.55	0.61
12000	5.45	0.54	0.58
12200	2.96	0.30	0.14
12400	0.42	0.04	-0.05
12600	1.60	0.16	0.07
12800	2.60	0.26	0.12
13000	3.08	0.31	0.15



REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT BASED ON MARCHETTI (1982)

DMT#1

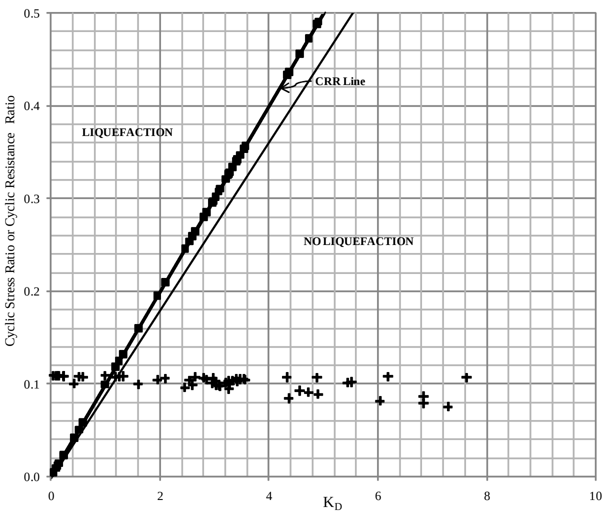
SHEET : 8 OF 13

ASSESSMENT RESULTS FOR M=5.0 & 5.5

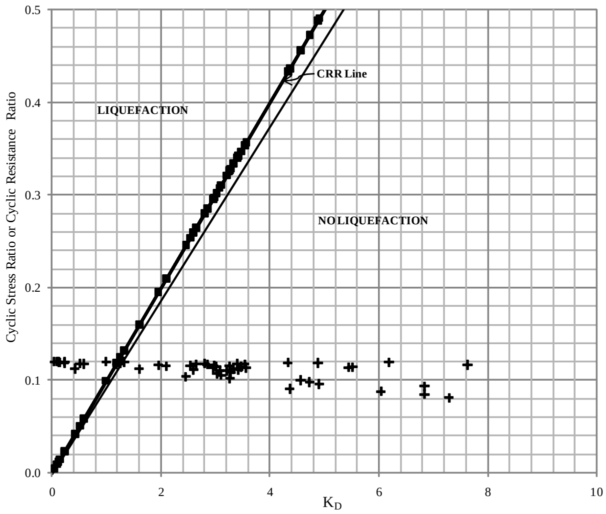
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CRR_{M=7.5}$	CSR M=5.0	Criterion	CSR M=5.5	Criterion
200	20.09	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
400	7.67	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
600	1.67	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
800	3.43	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1000	1.18	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1200	3.51	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1400	2.26	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1600	1.35	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1800	1.11	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
2000	1.06	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
2200	0.73	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
2400	0.68	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
2600	0.60	0.08	NO LIQUEFACTION	0.09	NO LIQUEFACTION
2800	0.44	0.08	NO LIQUEFACTION	0.09	NO LIQUEFACTION
3000	0.68	0.09	NO LIQUEFACTION	0.09	NO LIQUEFACTION
3200	0.49	0.09	NO LIQUEFACTION	0.10	NO LIQUEFACTION
3400	0.47	0.09	NO LIQUEFACTION	0.10	NO LIQUEFACTION
3600	0.46	0.09	NO LIQUEFACTION	0.10	NO LIQUEFACTION
3800	0.33	0.09	NO LIQUEFACTION	0.10	NO LIQUEFACTION
4000	0.25	0.10	NO LIQUEFACTION	0.10	NO LIQUEFACTION
4200	0.31	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
4400	0.30	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
4600	0.33	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
4800	0.32	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5000	0.34	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5200	0.33	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5400	0.36	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5600	0.35	0.11	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5800	0.21	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
6000	0.30	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
6200	0.76	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
6400	1.43	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
6600	0.26	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
6800	0.12	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
7000	0.06	0.11	LIQUEFACTION	0.12	LIQUEFACTION
7200	0.12	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
7400	0.05	0.11	LIQUEFACTION	0.12	LIQUEFACTION
7600	0.02	0.11	LIQUEFACTION	0.12	LIQUEFACTION
7800	-0.01	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8000	-0.01	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8200	0.01	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8400	0.01	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8600	0.01	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8800	0.10	0.11	LIQUEFACTION	0.12	LIQUEFACTION
9000	0.00	0.11	LIQUEFACTION	0.12	LIQUEFACTION
9200	0.02	0.11	LIQUEFACTION	0.12	LIQUEFACTION
9400	0.13	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
9600	0.62	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
9800	0.43	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10000	0.49	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10200	0.28	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10400	0.34	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10600	0.35	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10800	0.29	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
11000	0.19	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
11200	0.25	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
11400	0.33	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
11600	0.30	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
11800	0.55	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
12000	0.54	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
12200	0.30	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
12400	0.04	0.10	LIQUEFACTION	0.11	LIQUEFACTION
12600	0.16	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
12800	0.26	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
13000	0.31	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION

GRAPHS



Graph 1. DMT liquefaction assessment if earthquake magnitude is 5.0



Graph 2. DMT liquefaction assessment if earthquake magnitude is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT BASED ON MARCHETTI (1982)

DMT#1

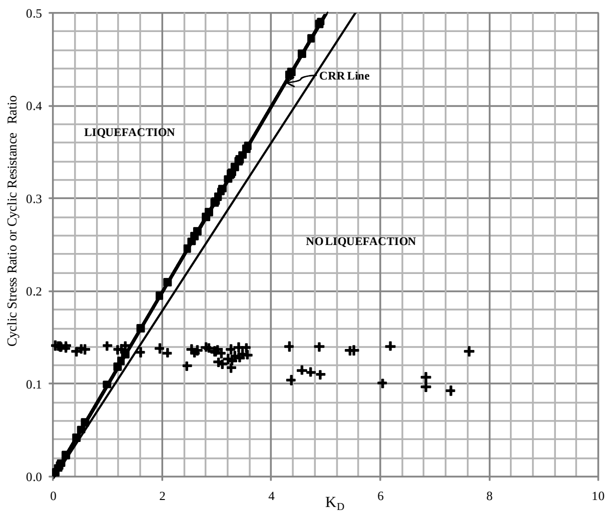
SHEET : 9 OF 13

ASSESSMENT RESULTS FOR M=6.0 & 6.5

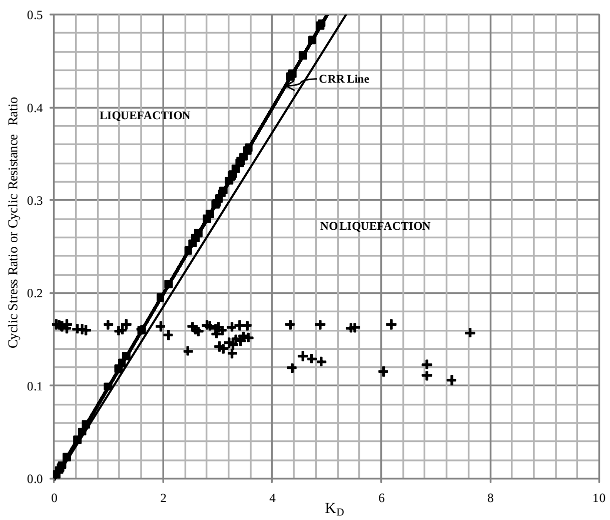
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CRR_{M=7.5}$	**CSR**			
		M=6.0	**Criterion**	**M=6.5**	**Criterion**
200	20.09	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
400	7.67	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
600	1.67	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
800	3.43	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1000	1.18	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1200	3.51	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1400	2.26	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1600	1.35	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1800	1.11	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
2000	1.06	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
2200	0.73	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
2400	0.68	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
2600	0.60	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
2800	0.44	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
3000	0.68	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
3200	0.49	0.11	NO LIQUEFACTION	0.13	NO LIQUEFACTION
3400	0.47	0.11	NO LIQUEFACTION	0.13	NO LIQUEFACTION
3600	0.46	0.11	NO LIQUEFACTION	0.13	NO LIQUEFACTION
3800	0.33	0.12	NO LIQUEFACTION	0.13	NO LIQUEFACTION
4000	0.25	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
4200	0.31	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
4400	0.30	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
4600	0.33	0.13	NO LIQUEFACTION	0.14	NO LIQUEFACTION
4800	0.32	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5000	0.34	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5200	0.33	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5400	0.36	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5600	0.35	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5800	0.21	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
6000	0.30	0.13	NO LIQUEFACTION	0.16	NO LIQUEFACTION
6200	0.76	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
6400	1.43	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
6600	0.26	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
6800	0.12	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7000	0.06	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7200	0.12	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7400	0.05	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7600	0.02	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7800	-0.01	0.14	LIQUEFACTION	0.16	LIQUEFACTION
8000	-0.01	0.14	LIQUEFACTION	0.16	LIQUEFACTION
8200	0.01	0.14	LIQUEFACTION	0.16	LIQUEFACTION
8400	0.01	0.14	LIQUEFACTION	0.16	LIQUEFACTION
8600	0.01	0.14	LIQUEFACTION	0.17	LIQUEFACTION
8800	0.10	0.14	LIQUEFACTION	0.17	LIQUEFACTION
9000	0.00	0.14	LIQUEFACTION	0.17	LIQUEFACTION
9200	0.02	0.14	LIQUEFACTION	0.17	LIQUEFACTION
9400	0.13	0.14	LIQUEFACTION	0.17	LIQUEFACTION
9600	0.62	0.14	NO LIQUEFACTION	0.17	NO LIQUEFACTION
9800	0.43	0.14	NO LIQUEFACTION	0.17	NO LIQUEFACTION
10000	0.49	0.14	NO LIQUEFACTION	0.17	NO LIQUEFACTION
10200	0.28	0.14	NO LIQUEFACTION	0.17	NO LIQUEFACTION
10400	0.34	0.14	NO LIQUEFACTION	0.17	NO LIQUEFACTION
10600	0.35	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
10800	0.29	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
11000	0.19	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
11200	0.25	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
11400	0.33	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
11600	0.30	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
11800	0.55	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
12000	0.54	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
12200	0.30	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
12400	0.04	0.13	LIQUEFACTION	0.16	LIQUEFACTION
12600	0.16	0.13	NO LIQUEFACTION	0.16	LIQUEFACTION
12800	0.26	0.13	NO LIQUEFACTION	0.16	NO LIQUEFACTION
13000	0.31	0.13	NO LIQUEFACTION	0.16	NO LIQUEFACTION

GRAPHS



Graph 1. DMT liquefaction assessment if earthquake magnitude is 6.0



Graph 2. DMT liquefaction assessment if earthquake magnitude is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT BASED ON MARCHETTI (1982)

DMT#1

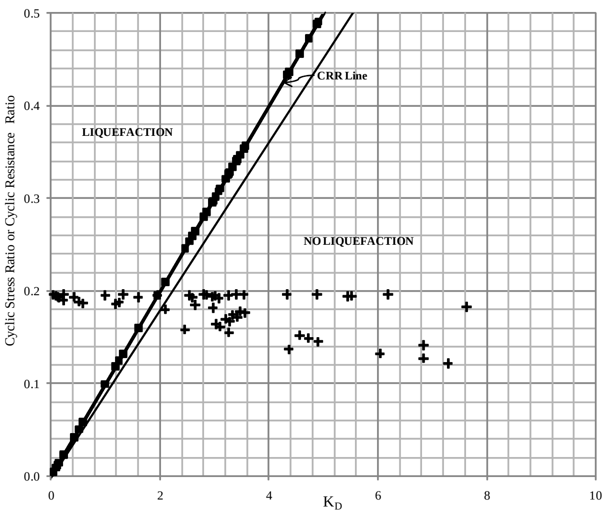
SHEET : 10 OF 13

ASSESSMENT RESULTS FOR M=7.0 & 7.5

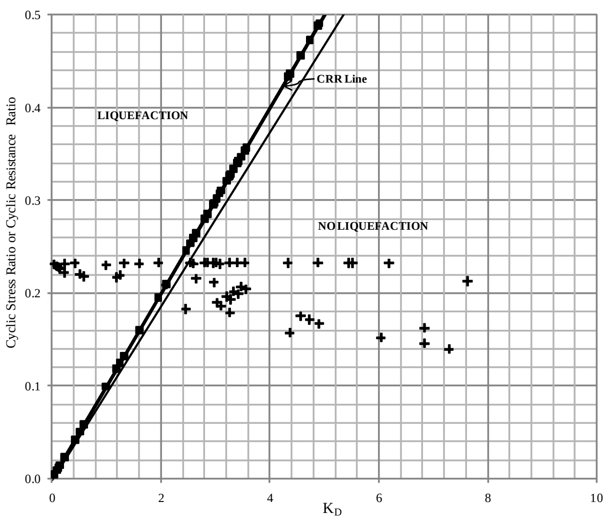
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CRR_{M=7.5}$	CSR M=7.0	Criterion	CSR M=7.5	Criterion
200	20.09	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
400	7.67	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
600	1.67	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
800	3.43	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1000	1.18	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1200	3.51	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1400	2.26	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1600	1.35	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1800	1.11	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
2000	1.06	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
2200	0.73	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
2400	0.68	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
2600	0.60	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
2800	0.44	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
3000	0.68	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
3200	0.49	0.15	NO LIQUEFACTION	0.17	NO LIQUEFACTION
3400	0.47	0.15	NO LIQUEFACTION	0.17	NO LIQUEFACTION
3600	0.46	0.15	NO LIQUEFACTION	0.18	NO LIQUEFACTION
3800	0.33	0.16	NO LIQUEFACTION	0.18	NO LIQUEFACTION
4000	0.25	0.16	NO LIQUEFACTION	0.18	NO LIQUEFACTION
4200	0.31	0.16	NO LIQUEFACTION	0.19	NO LIQUEFACTION
4400	0.30	0.16	NO LIQUEFACTION	0.19	NO LIQUEFACTION
4600	0.33	0.17	NO LIQUEFACTION	0.19	NO LIQUEFACTION
4800	0.32	0.17	NO LIQUEFACTION	0.20	NO LIQUEFACTION
5000	0.34	0.17	NO LIQUEFACTION	0.20	NO LIQUEFACTION
5200	0.33	0.17	NO LIQUEFACTION	0.20	NO LIQUEFACTION
5400	0.36	0.18	NO LIQUEFACTION	0.20	NO LIQUEFACTION
5600	0.35	0.18	NO LIQUEFACTION	0.21	NO LIQUEFACTION
5800	0.21	0.18	NO LIQUEFACTION	0.21	NO LIQUEFACTION
6000	0.30	0.18	NO LIQUEFACTION	0.21	NO LIQUEFACTION
6200	0.76	0.18	NO LIQUEFACTION	0.21	NO LIQUEFACTION
6400	1.43	0.18	NO LIQUEFACTION	0.21	NO LIQUEFACTION
6600	0.26	0.18	NO LIQUEFACTION	0.22	NO LIQUEFACTION
6800	0.12	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7000	0.06	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7200	0.12	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7400	0.05	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7600	0.02	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7800	-0.01	0.19	LIQUEFACTION	0.22	LIQUEFACTION
8000	-0.01	0.19	LIQUEFACTION	0.23	LIQUEFACTION
8200	0.01	0.19	LIQUEFACTION	0.23	LIQUEFACTION
8400	0.01	0.19	LIQUEFACTION	0.23	LIQUEFACTION
8600	0.01	0.19	LIQUEFACTION	0.23	LIQUEFACTION
8800	0.10	0.20	LIQUEFACTION	0.23	LIQUEFACTION
9000	0.00	0.20	LIQUEFACTION	0.23	LIQUEFACTION
9200	0.02	0.20	LIQUEFACTION	0.23	LIQUEFACTION
9400	0.13	0.20	LIQUEFACTION	0.23	LIQUEFACTION
9600	0.62	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
9800	0.43	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
10000	0.49	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
10200	0.28	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
10400	0.34	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
10600	0.35	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
10800	0.29	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
11000	0.19	0.20	LIQUEFACTION	0.23	LIQUEFACTION
11200	0.25	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
11400	0.33	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
11600	0.30	0.19	NO LIQUEFACTION	0.23	NO LIQUEFACTION
11800	0.55	0.19	NO LIQUEFACTION	0.23	NO LIQUEFACTION
12000	0.54	0.19	NO LIQUEFACTION	0.23	NO LIQUEFACTION
12200	0.30	0.19	NO LIQUEFACTION	0.23	NO LIQUEFACTION
12400	0.04	0.19	LIQUEFACTION	0.23	LIQUEFACTION
12600	0.16	0.19	LIQUEFACTION	0.23	LIQUEFACTION
12800	0.26	0.19	NO LIQUEFACTION	0.23	NO LIQUEFACTION
13000	0.31	0.19	NO LIQUEFACTION	0.23	NO LIQUEFACTION

GRAPHS



Graph 1. DMT liquefaction assessment if earthquake magnitude is 5.5



Graph 2. DMT liquefaction assessment if earthquake magnitude is 7.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT BASED ON MONACO ET AL. (2005)

DMT#1

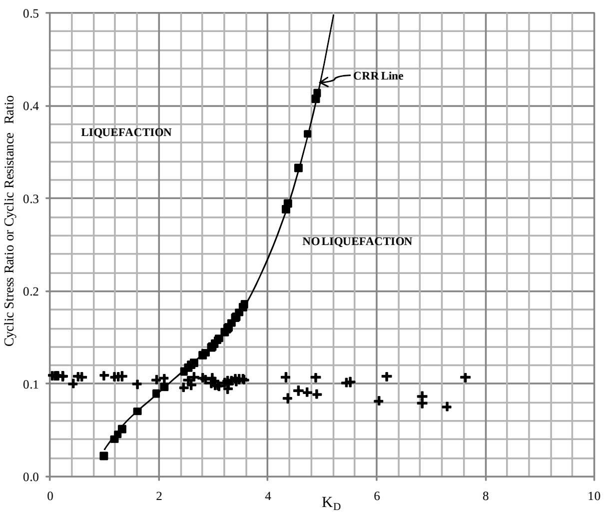
SHEET : 11 OF 13

ASSESSMENT RESULTS FOR M=5.0 & 5.5

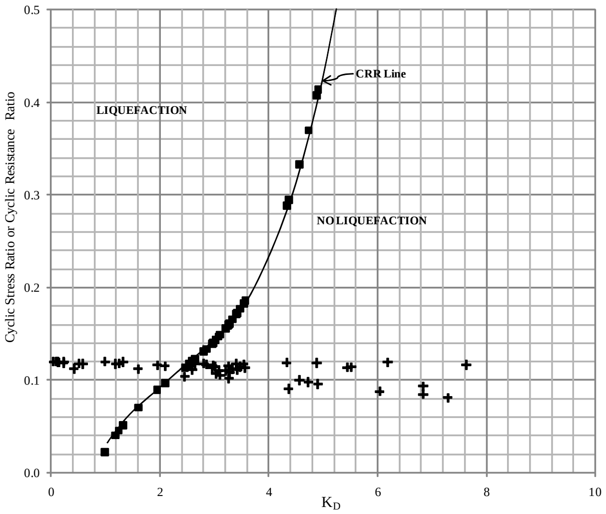
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m
		REDUCE LEVEL	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical
		OPERATOR	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE
		SUPERVISED BY	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010	**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CRR_{M=7.5}$	CSR M=5.0	Criterion	CSR M=5.5	Criterion
200	83814.08	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
400	4410.59	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
600	32.81	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
800	351.46	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1000	9.75	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1200	379.70	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1400	89.85	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1600	15.74	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
1800	7.72	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
2000	6.51	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
2200	1.66	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
2400	1.31	0.08	NO LIQUEFACTION	0.08	NO LIQUEFACTION
2600	0.83	0.08	NO LIQUEFACTION	0.09	NO LIQUEFACTION
2800	0.29	0.08	NO LIQUEFACTION	0.09	NO LIQUEFACTION
3000	1.31	0.09	NO LIQUEFACTION	0.09	NO LIQUEFACTION
3200	0.41	0.09	NO LIQUEFACTION	0.10	NO LIQUEFACTION
3400	0.37	0.09	NO LIQUEFACTION	0.10	NO LIQUEFACTION
3600	0.33	0.09	NO LIQUEFACTION	0.10	NO LIQUEFACTION
3800	0.16	0.09	NO LIQUEFACTION	0.10	NO LIQUEFACTION
4000	0.11	0.10	NO LIQUEFACTION	0.10	NO LIQUEFACTION
4200	0.15	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
4400	0.14	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
4600	0.16	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
4800	0.16	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5000	0.17	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5200	0.17	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5400	0.19	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5600	0.18	0.11	NO LIQUEFACTION	0.11	NO LIQUEFACTION
5800	0.10	0.11	LIQUEFACTION	0.12	LIQUEFACTION
6000	0.14	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
6200	1.96	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
6400	19.20	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
6600	0.12	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
6800	0.04	0.11	LIQUEFACTION	0.12	LIQUEFACTION
7000	-0.03	0.11	LIQUEFACTION	0.12	LIQUEFACTION
7200	0.05	0.11	LIQUEFACTION	0.12	LIQUEFACTION
7400	-0.04	0.11	LIQUEFACTION	0.12	LIQUEFACTION
7600	-0.09	0.11	LIQUEFACTION	0.12	LIQUEFACTION
7800	-0.14	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8000	-0.15	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8200	-0.10	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8400	-0.11	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8600	-0.11	0.11	LIQUEFACTION	0.12	LIQUEFACTION
8800	0.02	0.11	LIQUEFACTION	0.12	LIQUEFACTION
9000	-0.12	0.11	LIQUEFACTION	0.12	LIQUEFACTION
9200	-0.08	0.11	LIQUEFACTION	0.12	LIQUEFACTION
9400	0.05	0.11	LIQUEFACTION	0.12	LIQUEFACTION
9600	0.91	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
9800	0.29	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10000	0.41	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10200	0.13	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10400	0.17	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10600	0.18	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
10800	0.13	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
11000	0.09	0.10	LIQUEFACTION	0.12	LIQUEFACTION
11200	0.12	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
11400	0.16	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
11600	0.14	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
11800	0.61	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
12000	0.58	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
12200	0.14	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
12400	-0.05	0.10	LIQUEFACTION	0.11	LIQUEFACTION
12600	0.07	0.10	LIQUEFACTION	0.11	LIQUEFACTION
12800	0.12	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
13000	0.15	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION

GRAPHS



Graph 1. DMT liquefaction assessment if earthquake magnitude is 5.0



Graph 2. DMT liquefaction assessment if earthquake magnitude is 5.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT BASED ON MONACO ET AL. (2005)

DMT#1

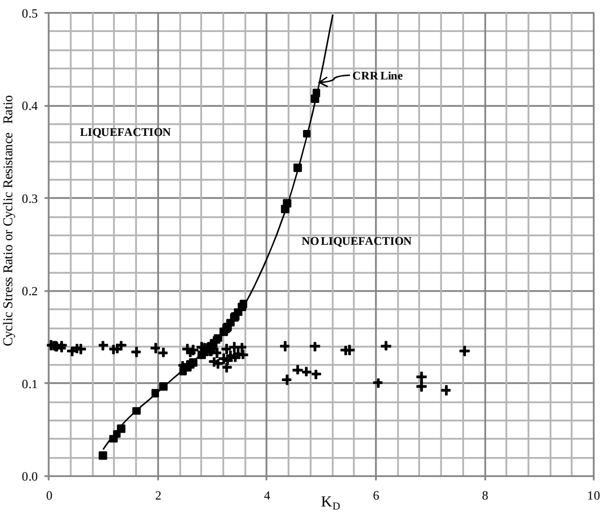
SHEET : 12 OF 13

ASSESSMENT RESULTS FOR M=6.0 & 6.5

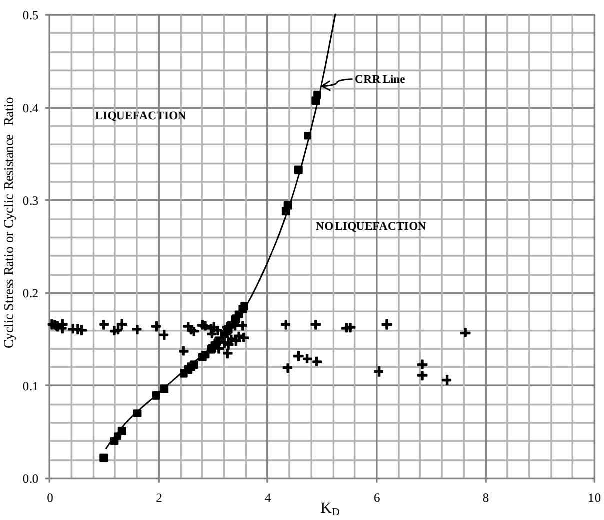
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CRR_{M=7.5}$	CSR M=6.0	Criterion	CSR M=6.5	Criterion
200	83814.08	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
400	4410.59	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
600	32.81	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
800	351.46	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1000	9.75	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1200	379.70	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1400	89.85	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1600	15.74	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
1800	7.72	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
2000	6.51	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
2200	1.66	0.09	NO LIQUEFACTION	0.11	NO LIQUEFACTION
2400	1.31	0.10	NO LIQUEFACTION	0.11	NO LIQUEFACTION
2600	0.83	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
2800	0.29	0.10	NO LIQUEFACTION	0.12	NO LIQUEFACTION
3000	1.31	0.11	NO LIQUEFACTION	0.12	NO LIQUEFACTION
3200	0.41	0.11	NO LIQUEFACTION	0.13	NO LIQUEFACTION
3400	0.37	0.11	NO LIQUEFACTION	0.13	NO LIQUEFACTION
3600	0.33	0.11	NO LIQUEFACTION	0.13	NO LIQUEFACTION
3800	0.16	0.12	NO LIQUEFACTION	0.13	NO LIQUEFACTION
4000	0.11	0.12	LIQUEFACTION	0.14	LIQUEFACTION
4200	0.15	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
4400	0.14	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
4600	0.16	0.13	NO LIQUEFACTION	0.14	NO LIQUEFACTION
4800	0.16	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5000	0.17	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5200	0.17	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5400	0.19	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5600	0.18	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
5800	0.10	0.13	LIQUEFACTION	0.15	LIQUEFACTION
6000	0.14	0.13	NO LIQUEFACTION	0.16	LIQUEFACTION
6200	1.96	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
6400	19.20	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
6600	0.12	0.14	LIQUEFACTION	0.16	LIQUEFACTION
6800	0.04	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7000	-0.03	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7200	0.05	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7400	-0.04	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7600	-0.09	0.14	LIQUEFACTION	0.16	LIQUEFACTION
7800	-0.14	0.14	LIQUEFACTION	0.16	LIQUEFACTION
8000	-0.15	0.14	LIQUEFACTION	0.16	LIQUEFACTION
8200	-0.10	0.14	LIQUEFACTION	0.16	LIQUEFACTION
8400	-0.11	0.14	LIQUEFACTION	0.16	LIQUEFACTION
8600	-0.11	0.14	LIQUEFACTION	0.17	LIQUEFACTION
8800	0.02	0.14	LIQUEFACTION	0.17	LIQUEFACTION
9000	-0.12	0.14	LIQUEFACTION	0.17	LIQUEFACTION
9200	-0.08	0.14	LIQUEFACTION	0.17	LIQUEFACTION
9400	0.05	0.14	LIQUEFACTION	0.17	LIQUEFACTION
9600	0.91	0.14	NO LIQUEFACTION	0.17	NO LIQUEFACTION
9800	0.29	0.14	NO LIQUEFACTION	0.17	NO LIQUEFACTION
10000	0.41	0.14	NO LIQUEFACTION	0.17	NO LIQUEFACTION
10200	0.13	0.14	LIQUEFACTION	0.17	LIQUEFACTION
10400	0.17	0.14	NO LIQUEFACTION	0.17	NO LIQUEFACTION
10600	0.18	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
10800	0.13	0.14	LIQUEFACTION	0.16	LIQUEFACTION
11000	0.09	0.14	LIQUEFACTION	0.16	LIQUEFACTION
11200	0.12	0.14	LIQUEFACTION	0.16	LIQUEFACTION
11400	0.16	0.14	NO LIQUEFACTION	0.16	LIQUEFACTION
11600	0.14	0.14	NO LIQUEFACTION	0.16	LIQUEFACTION
11800	0.61	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
12000	0.58	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
12200	0.14	0.14	NO LIQUEFACTION	0.16	LIQUEFACTION
12400	-0.05	0.13	LIQUEFACTION	0.16	LIQUEFACTION
12600	0.07	0.13	LIQUEFACTION	0.16	LIQUEFACTION
12800	0.12	0.13	LIQUEFACTION	0.16	LIQUEFACTION
13000	0.15	0.13	NO LIQUEFACTION	0.16	LIQUEFACTION

GRAPHS



Graph 1. DMT liquefaction assessment if earthquake magnitude is 6.0



Graph 2. DMT liquefaction assessment if earthquake magnitude is 6.5

REMARKS:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Reported by: Bambang Setiawan

Signature :

Date : 20 August 2011

FLAT DILATOMETER TEST (DMT)
LIQUEFACTION ASSESSMENT BASED ON MONACO ET AL. (2005)

DMT#1

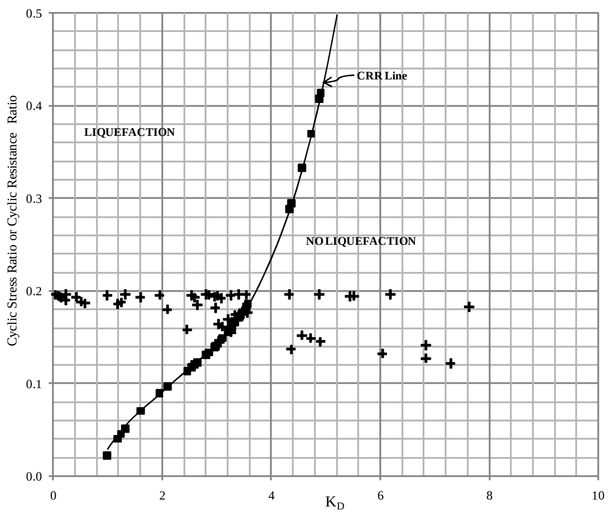
SHEET : 13 OF 13

ASSESSMENT RESULTS FOR M=7.0 & 7.5

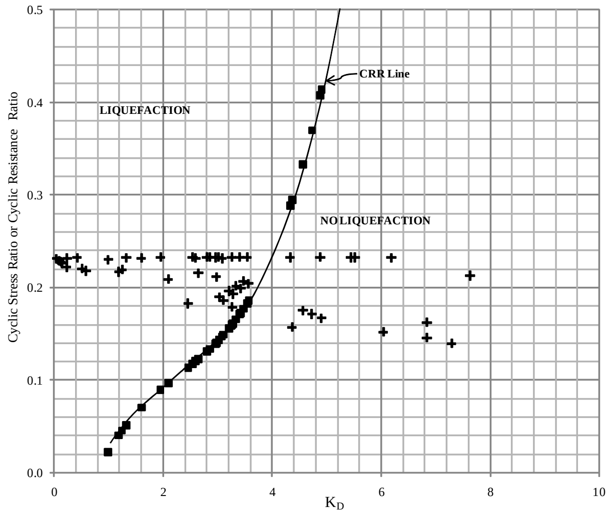
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Adam/Gary/Andrew
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 28 JUNE 2010 TO 28 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa

DEPTH (mm)	$CRR_{M=7.5}$	CSR M=7.0	CSR Criterion	CSR M=7.5	CSR Criterion
200	83814.08	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
400	4410.59	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
600	32.81	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
800	351.46	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1000	9.75	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1200	379.70	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1400	89.85	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1600	15.74	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
1800	7.72	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
2000	6.51	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
2200	1.66	0.12	NO LIQUEFACTION	0.14	NO LIQUEFACTION
2400	1.31	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
2600	0.83	0.13	NO LIQUEFACTION	0.15	NO LIQUEFACTION
2800	0.29	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
3000	1.31	0.14	NO LIQUEFACTION	0.16	NO LIQUEFACTION
3200	0.41	0.15	NO LIQUEFACTION	0.17	NO LIQUEFACTION
3400	0.37	0.15	NO LIQUEFACTION	0.17	NO LIQUEFACTION
3600	0.33	0.15	NO LIQUEFACTION	0.18	NO LIQUEFACTION
3800	0.16	0.16	NO LIQUEFACTION	0.18	LIQUEFACTION
4000	0.11	0.16	LIQUEFACTION	0.18	LIQUEFACTION
4200	0.15	0.16	LIQUEFACTION	0.19	LIQUEFACTION
4400	0.14	0.16	LIQUEFACTION	0.19	LIQUEFACTION
4600	0.16	0.17	LIQUEFACTION	0.19	LIQUEFACTION
4800	0.16	0.17	LIQUEFACTION	0.20	LIQUEFACTION
5000	0.17	0.17	NO LIQUEFACTION	0.20	LIQUEFACTION
5200	0.17	0.17	LIQUEFACTION	0.20	LIQUEFACTION
5400	0.19	0.18	NO LIQUEFACTION	0.20	LIQUEFACTION
5600	0.18	0.18	LIQUEFACTION	0.21	LIQUEFACTION
5800	0.10	0.18	LIQUEFACTION	0.21	LIQUEFACTION
6000	0.14	0.18	LIQUEFACTION	0.21	LIQUEFACTION
6200	1.96	0.18	NO LIQUEFACTION	0.21	NO LIQUEFACTION
6400	19.20	0.18	NO LIQUEFACTION	0.21	NO LIQUEFACTION
6600	0.12	0.18	LIQUEFACTION	0.22	LIQUEFACTION
6800	0.04	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7000	-0.03	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7200	0.05	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7400	-0.04	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7600	-0.09	0.19	LIQUEFACTION	0.22	LIQUEFACTION
7800	-0.14	0.19	LIQUEFACTION	0.22	LIQUEFACTION
8000	-0.15	0.19	LIQUEFACTION	0.23	LIQUEFACTION
8200	-0.10	0.19	LIQUEFACTION	0.23	LIQUEFACTION
8400	-0.11	0.19	LIQUEFACTION	0.23	LIQUEFACTION
8600	-0.11	0.19	LIQUEFACTION	0.23	LIQUEFACTION
8800	0.02	0.20	LIQUEFACTION	0.23	LIQUEFACTION
9000	-0.12	0.20	LIQUEFACTION	0.23	LIQUEFACTION
9200	-0.08	0.20	LIQUEFACTION	0.23	LIQUEFACTION
9400	0.05	0.20	LIQUEFACTION	0.23	LIQUEFACTION
9600	0.91	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
9800	0.29	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
10000	0.41	0.20	NO LIQUEFACTION	0.23	NO LIQUEFACTION
10200	0.13	0.20	LIQUEFACTION	0.23	LIQUEFACTION
10400	0.17	0.20	LIQUEFACTION	0.23	LIQUEFACTION
10600	0.18	0.20	LIQUEFACTION	0.23	LIQUEFACTION
10800	0.13	0.20	LIQUEFACTION	0.23	LIQUEFACTION
11000	0.09	0.20	LIQUEFACTION	0.23	LIQUEFACTION
11200	0.12	0.20	LIQUEFACTION	0.23	LIQUEFACTION
11400	0.16	0.20	LIQUEFACTION	0.23	LIQUEFACTION
11600	0.14	0.19	LIQUEFACTION	0.23	LIQUEFACTION
11800	0.61	0.19	NO LIQUEFACTION	0.23	NO LIQUEFACTION
12000	0.58	0.19	NO LIQUEFACTION	0.23	NO LIQUEFACTION
12200	0.14	0.19	LIQUEFACTION	0.23	LIQUEFACTION
12400	-0.05	0.19	LIQUEFACTION	0.23	LIQUEFACTION
12600	0.07	0.19	LIQUEFACTION	0.23	LIQUEFACTION
12800	0.12	0.19	LIQUEFACTION	0.23	LIQUEFACTION
13000	0.15	0.19	LIQUEFACTION	0.23	LIQUEFACTION

GRAPHS



Graph 1. DMT liquefaction assessment if earthquake magnitude is 7.0



Graph 2. DMT liquefaction assessment if earthquake magnitude is 7.5

REMARKS:

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APPENDIX L

VERTICAL GROUND SETTLEMENT ASSESSMENT RESULTS

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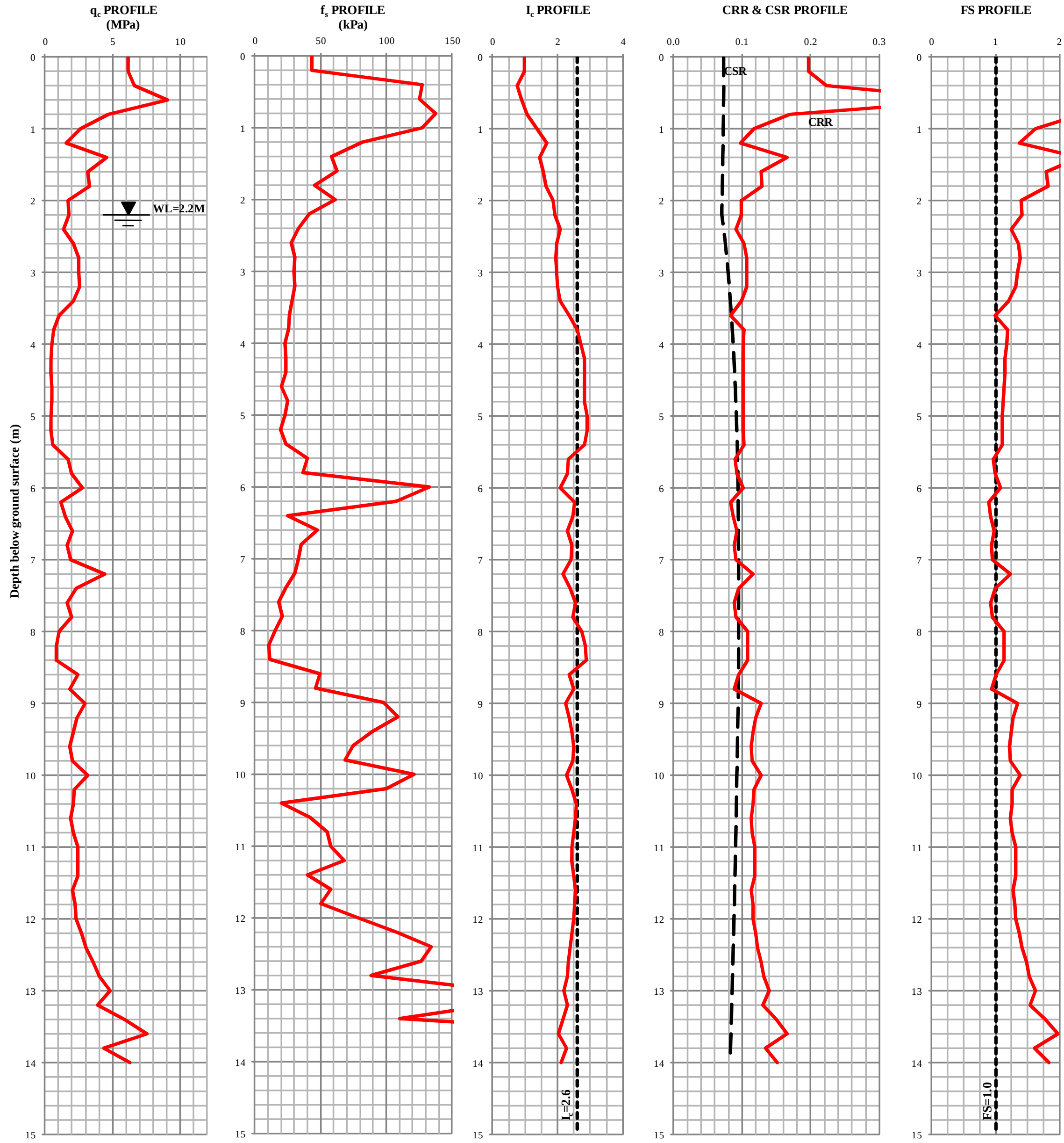
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 1 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

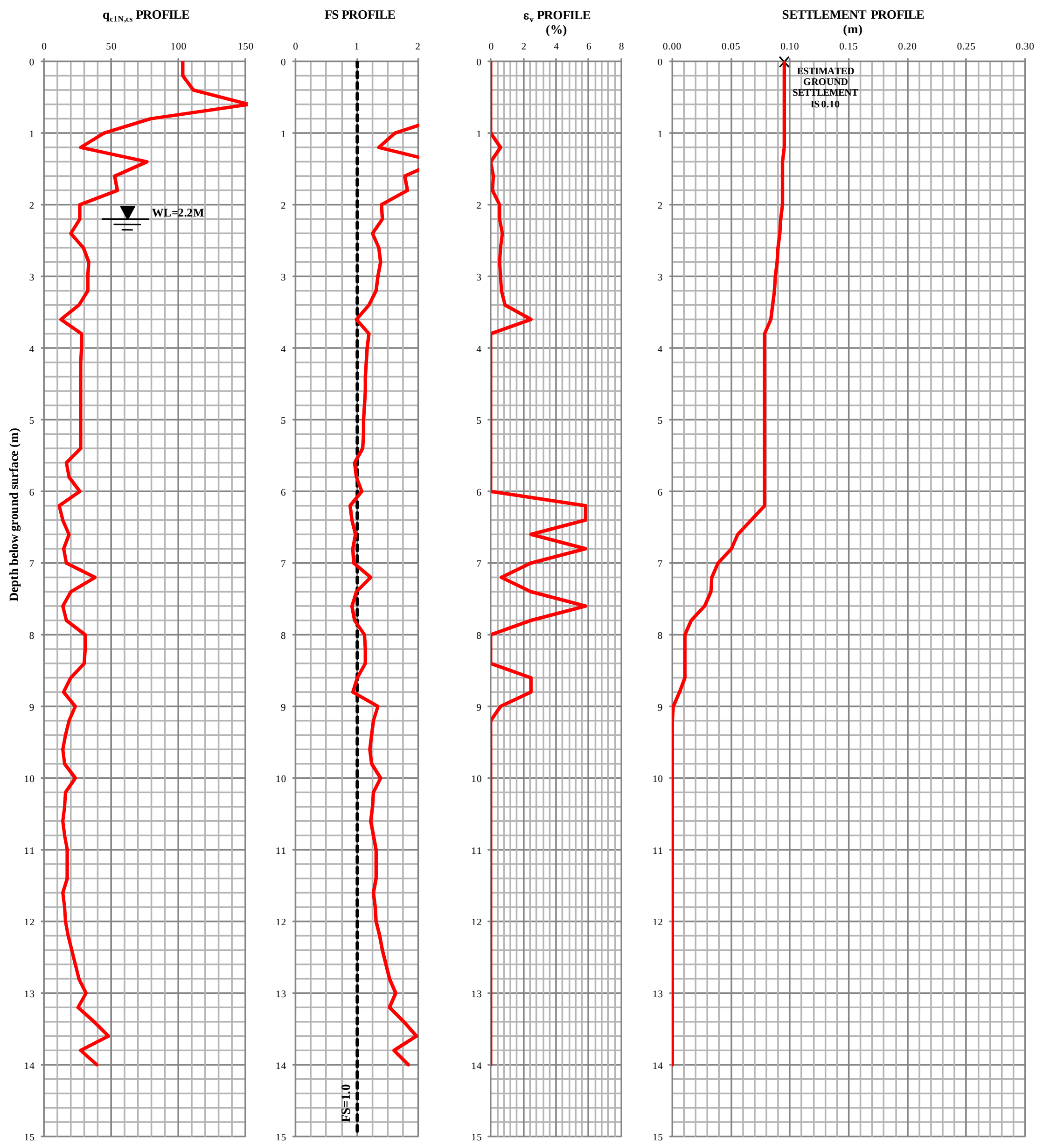
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 2 OF 12

RESULT OF THE ESTIMATION FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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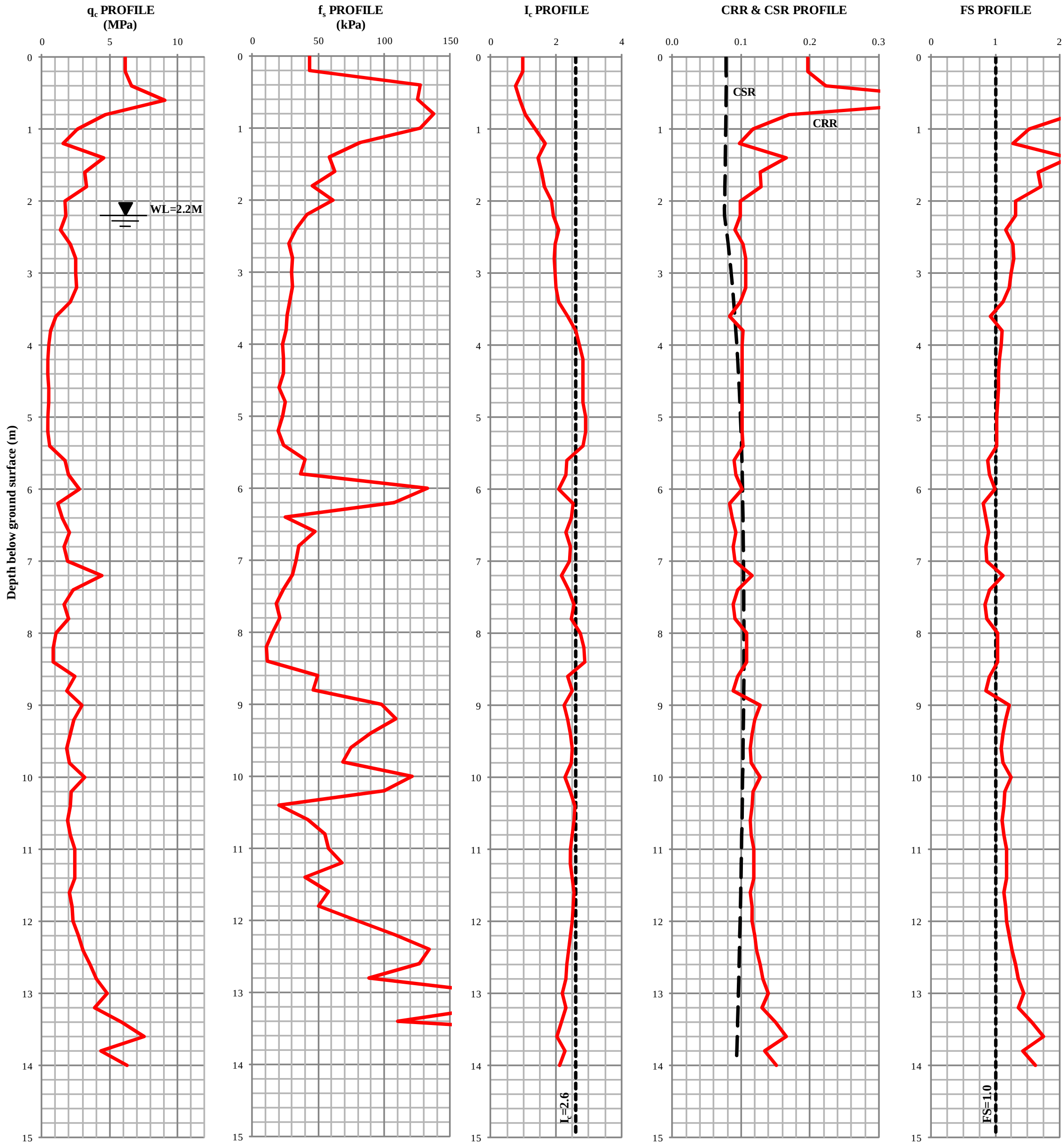
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 3 OF 12

PLOTS OF q_C, f_s, I_C, CRR & CSR AND FS FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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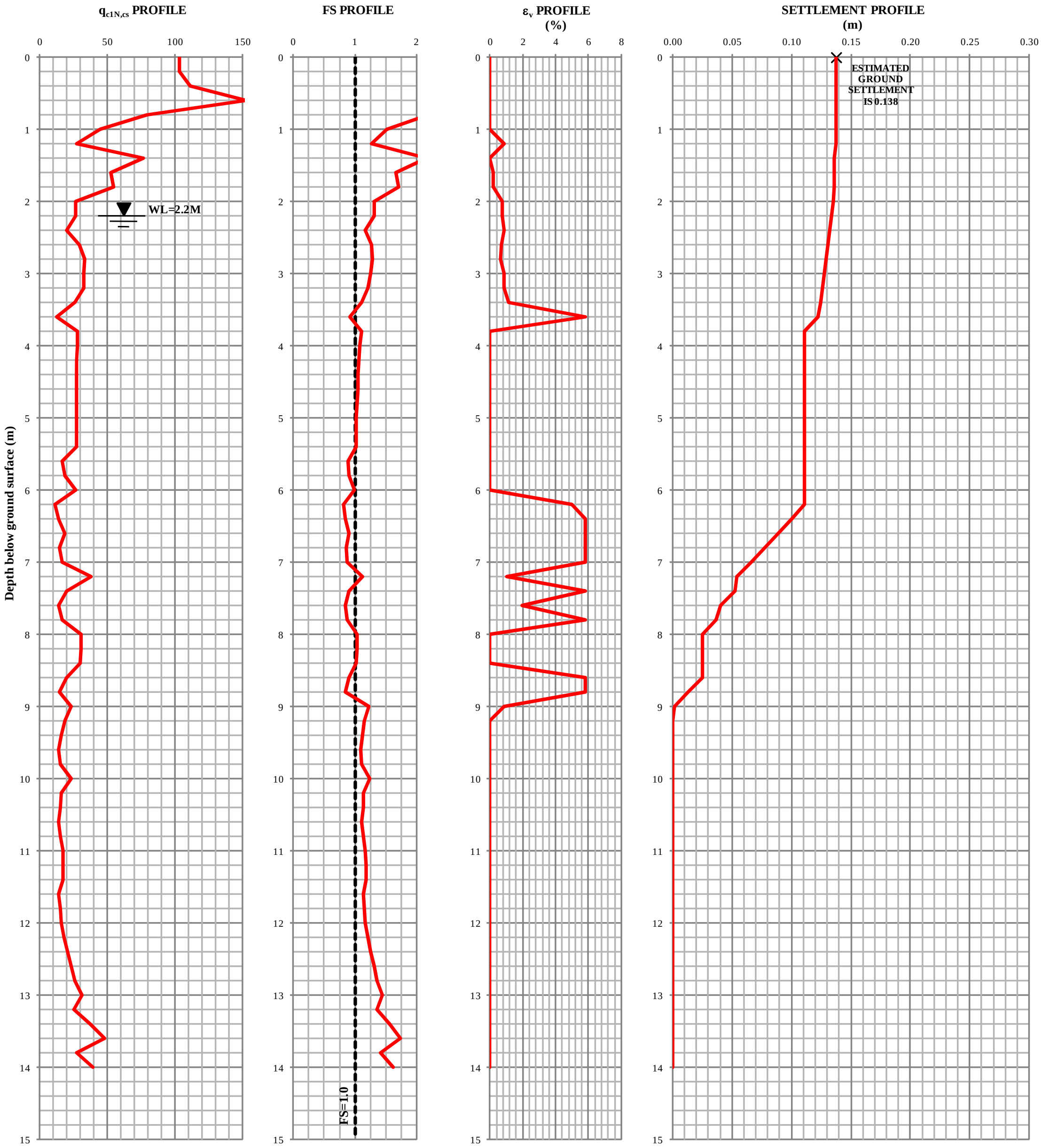
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 4 OF 12

RESULT OF THE ESTIMATION FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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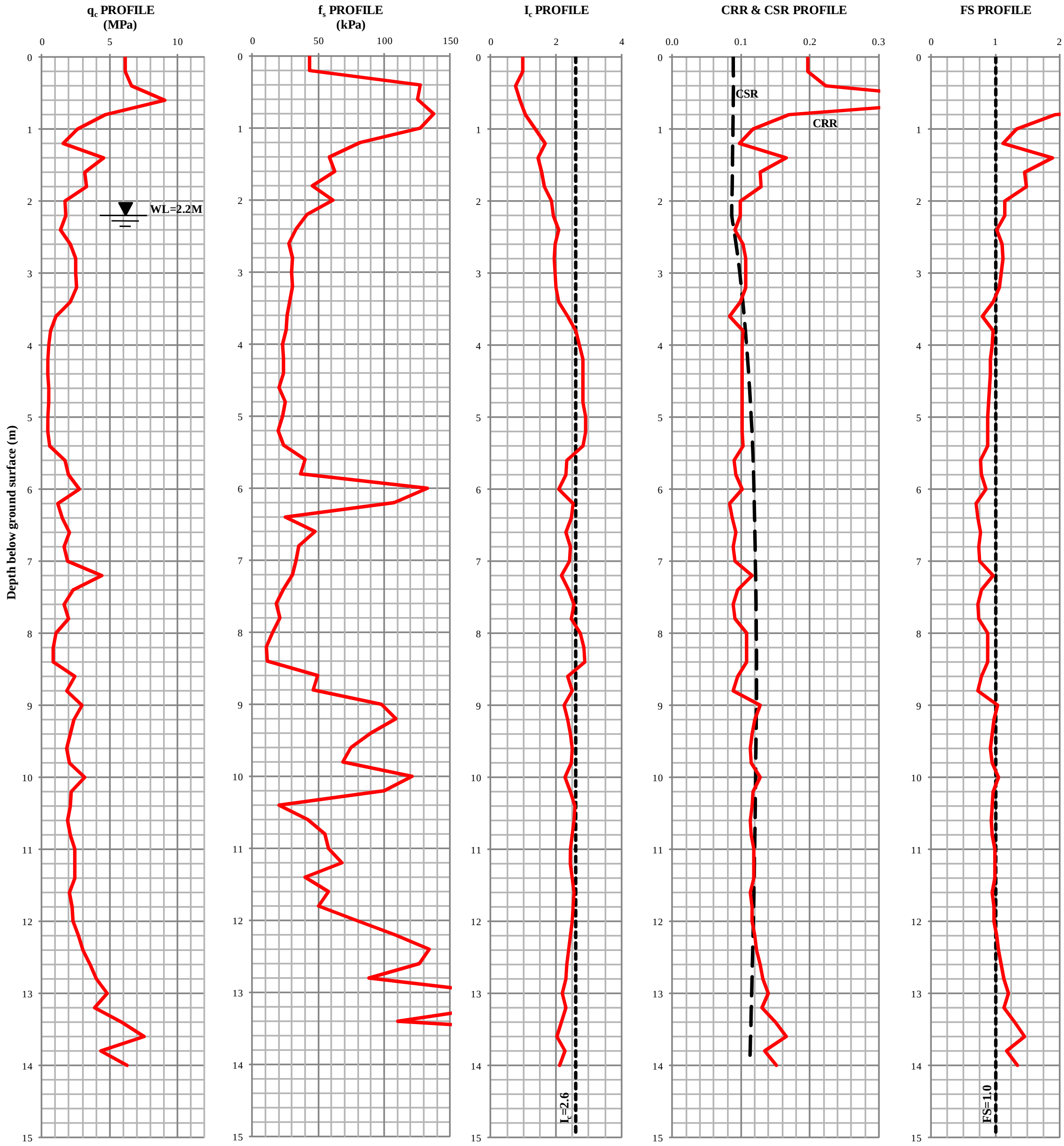
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 5 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

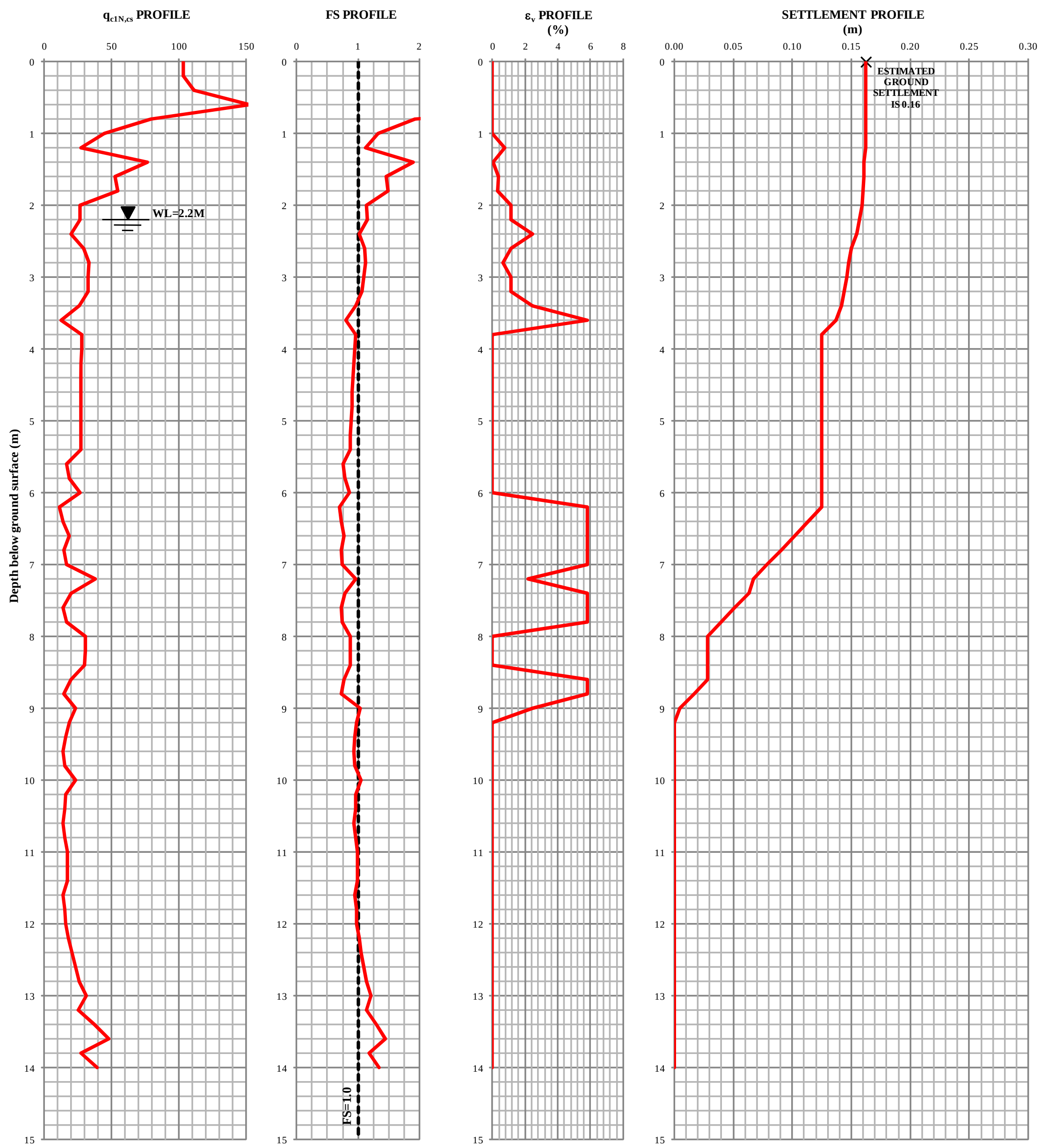
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 6 OF 12

RESULT OF THE ESTIMATION FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

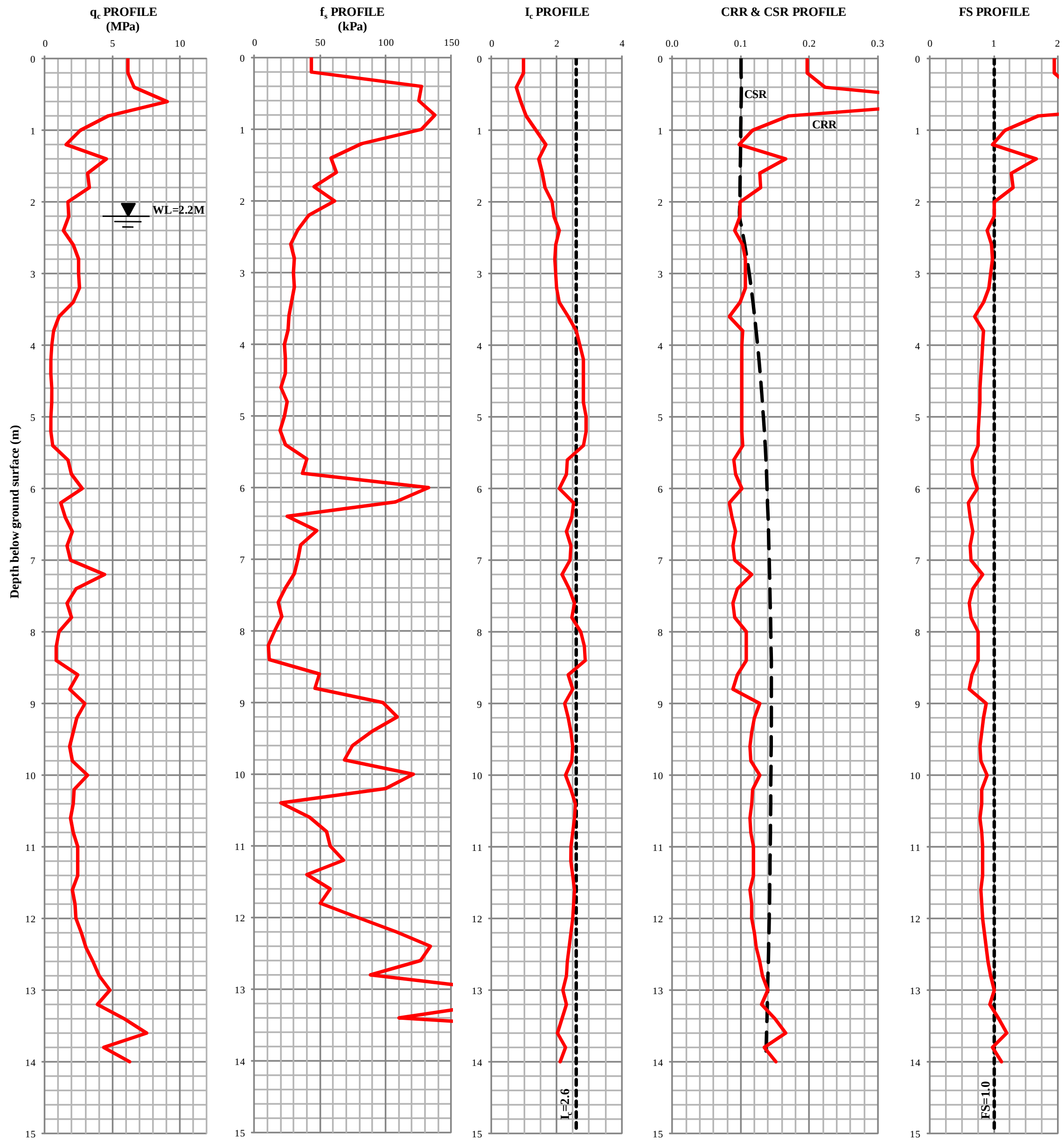
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 7 OF 12

PLOTS OF q_C, f_S, I_C, CRR & CSR AND FS FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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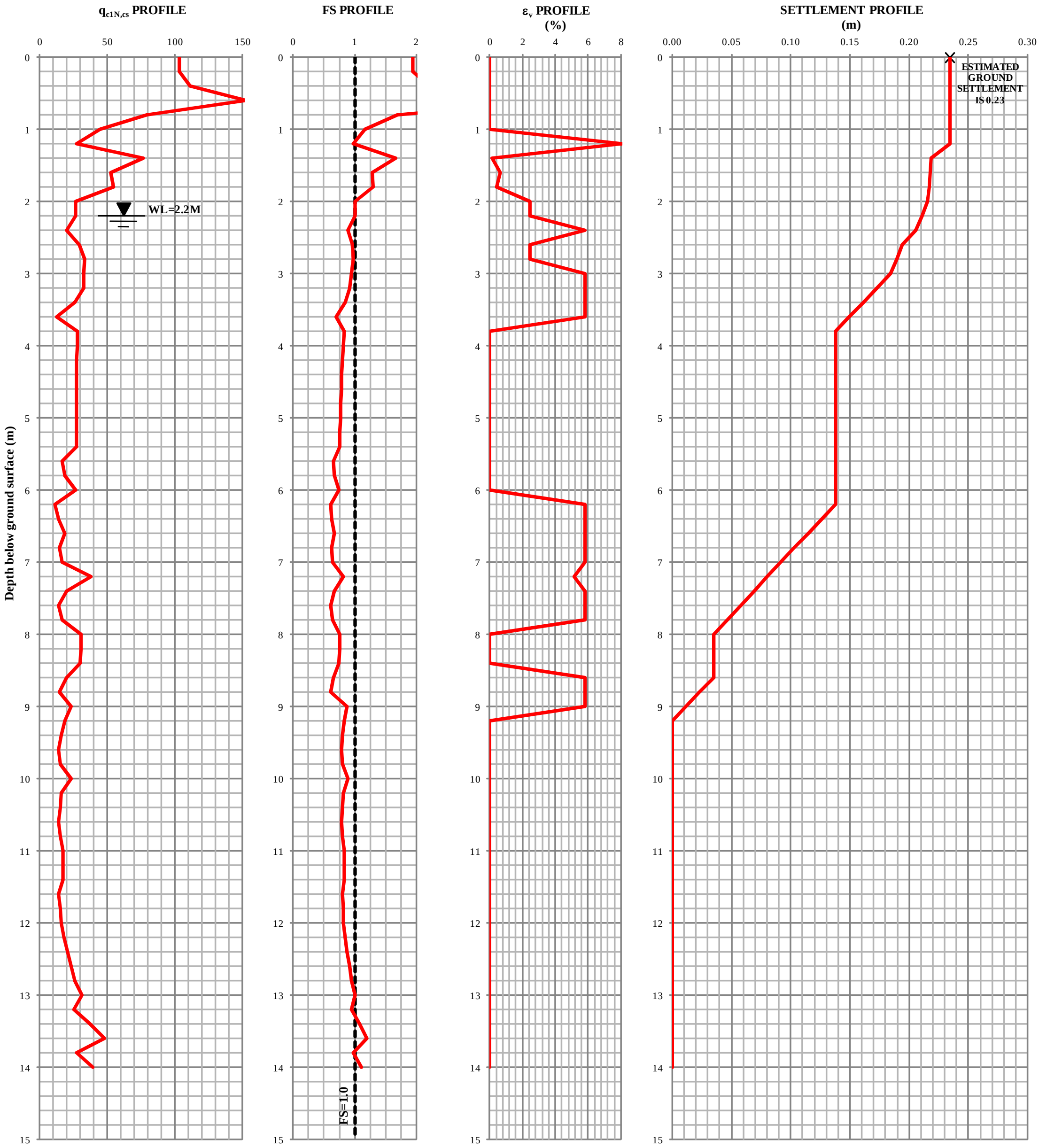
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 8 OF 12

RESULT OF THE ESTIMATION FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	DEPTH	: 0 - 14 m	REDUCE LEVEL	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	INCLINATION	: Vertical	OPERATOR	: Andrew/Brendan
COORDINATE	X : - Y : -	PUSHING SYSTEM	: ISUZU EZY PROBE	SUPERVISED BY	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			CHECKED BY	: A/Prof. Mark Jaksa



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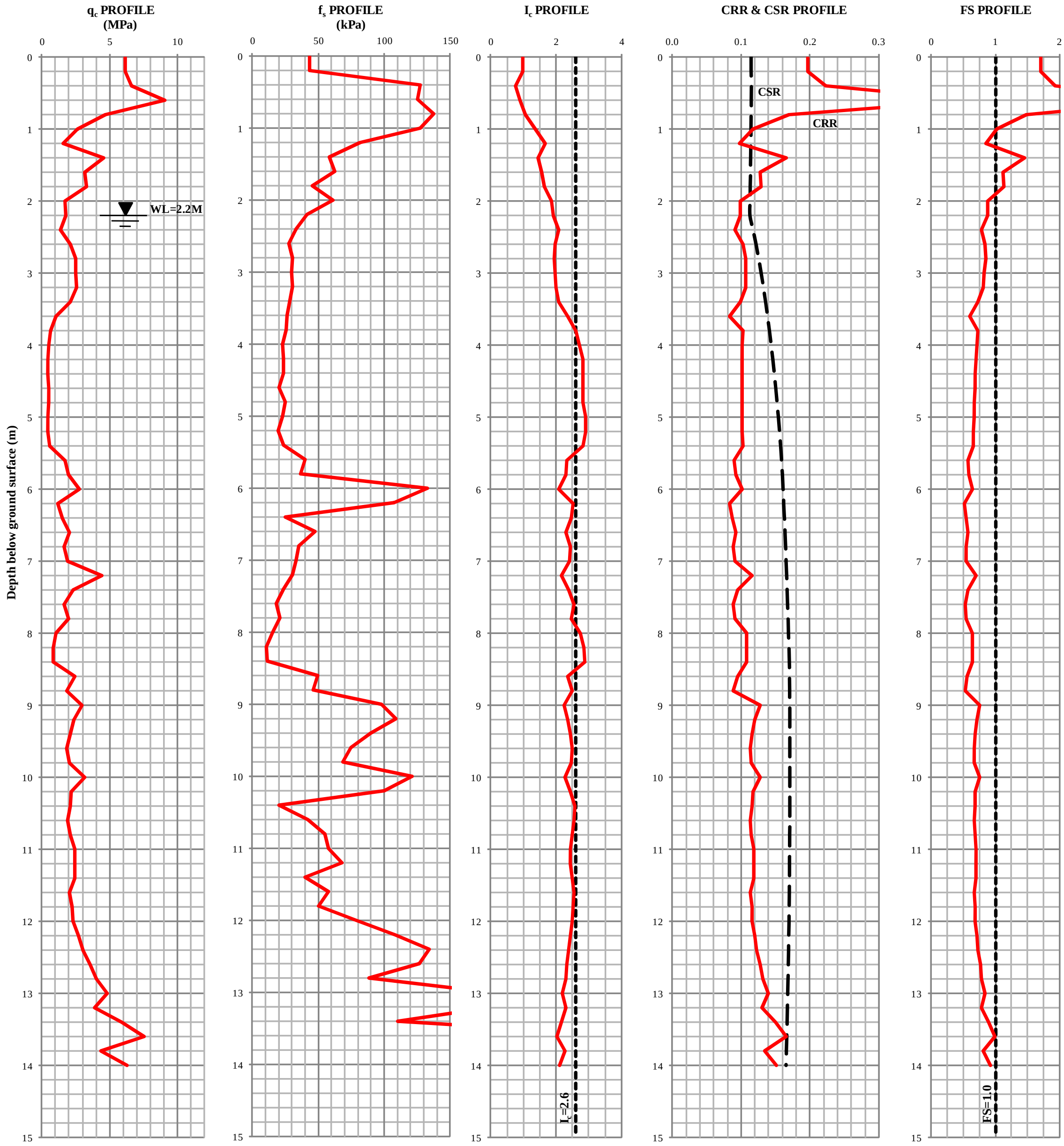
CONE PENETRATION TESTING (CPT) ***GROUND SETTLEMENT ESTIMATION***		**CPT#1**		**SHEET : 9 OF 12** PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=7.0	
PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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	Date : 20 August 2011

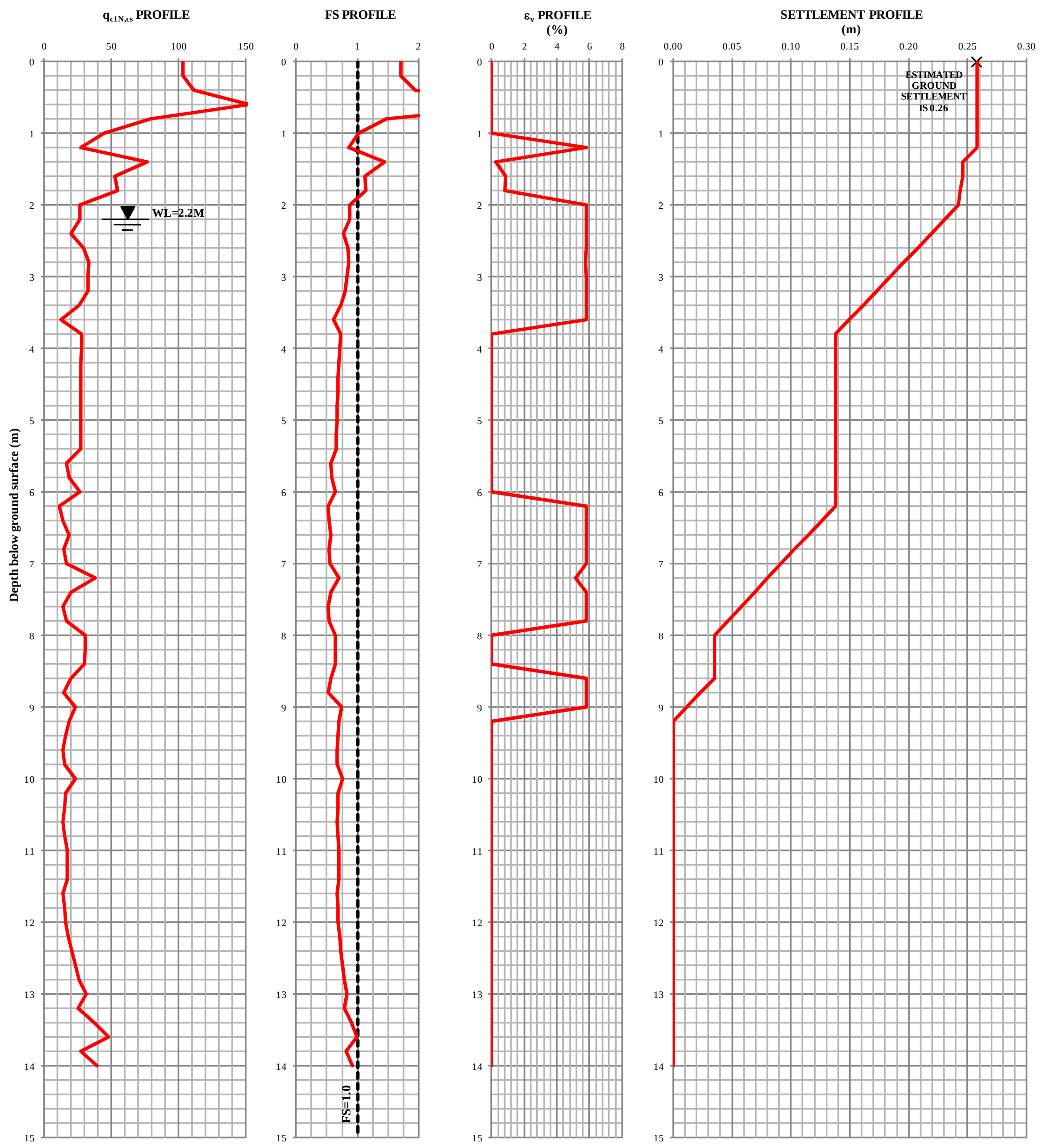
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 10 OF 12

RESULT OF THE ESTIMATION FOR M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

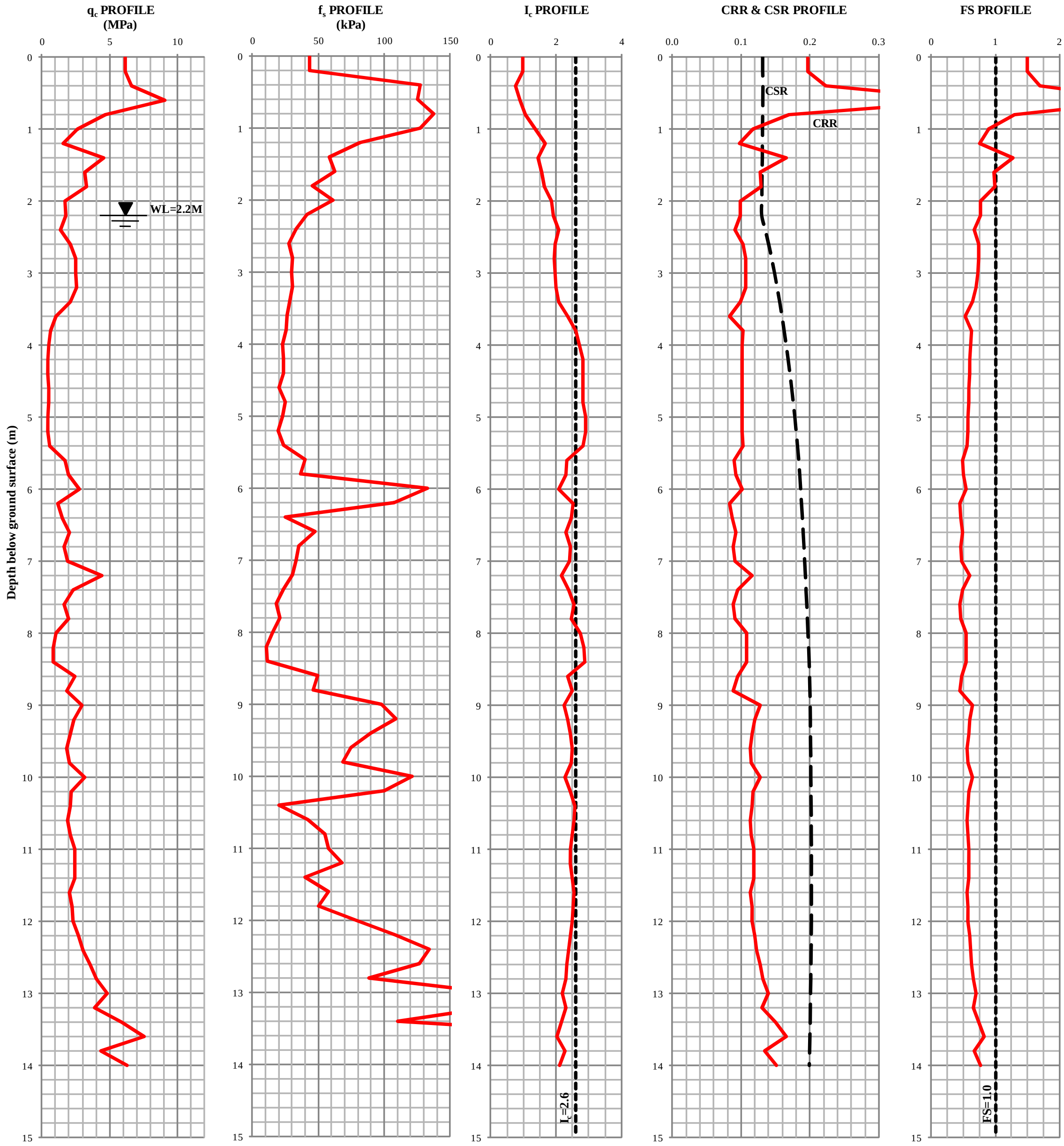
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 11 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

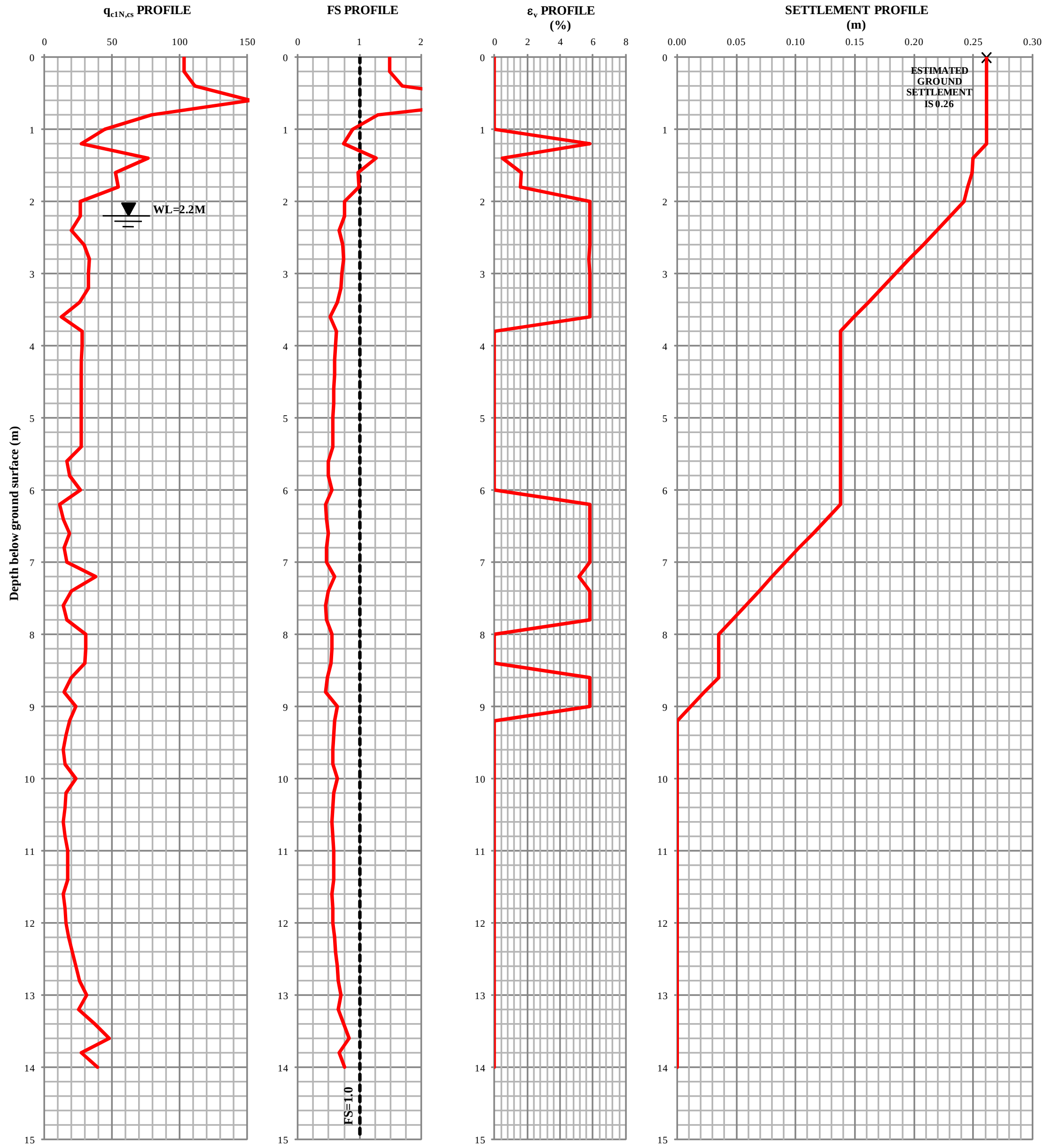
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#1

SHEET : 12 OF 12

RESULT OF THE ESTIMATION FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 14 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Reported by: Bambang Setiawan

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Date : 20 August 2011

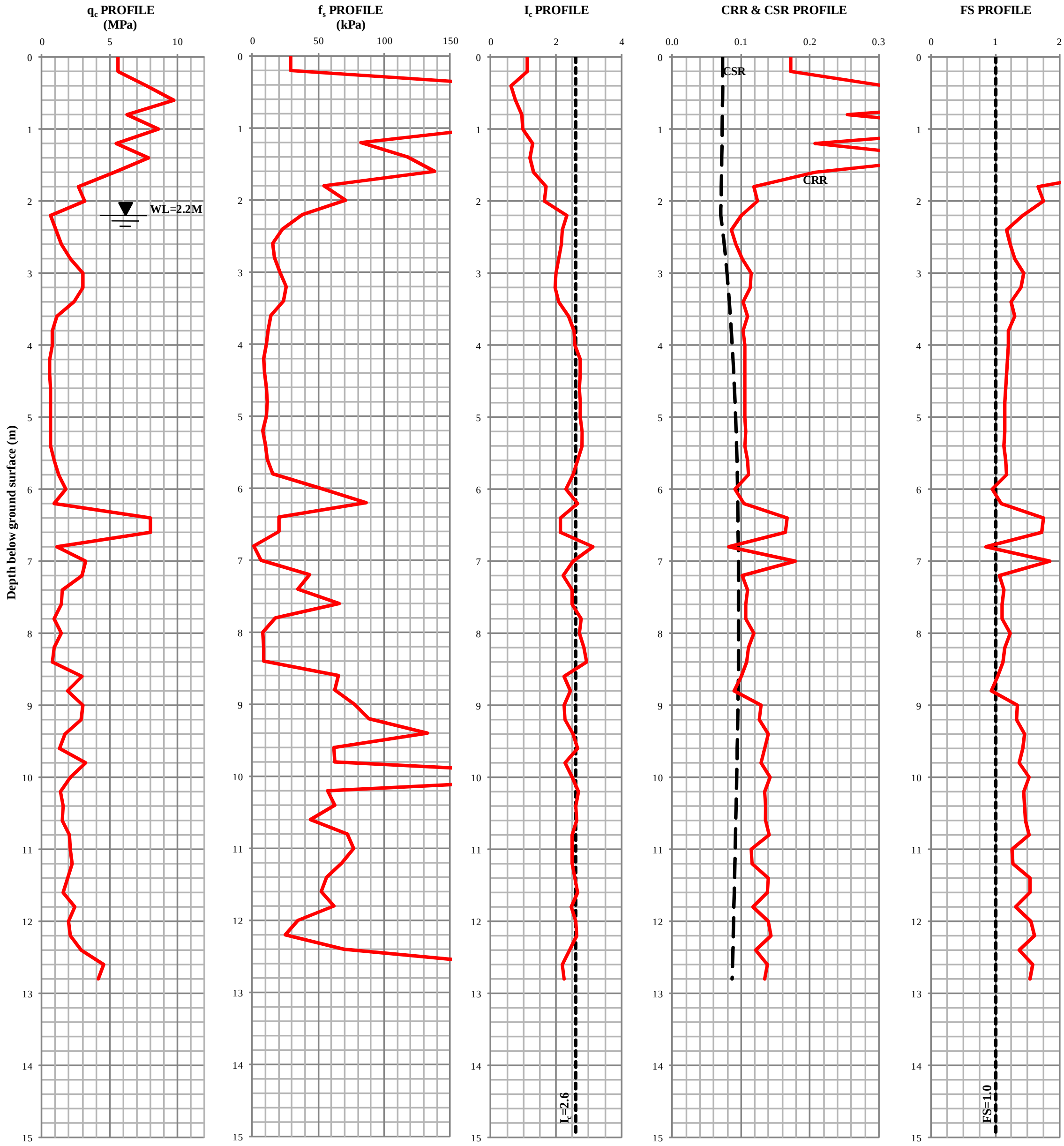
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 1 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

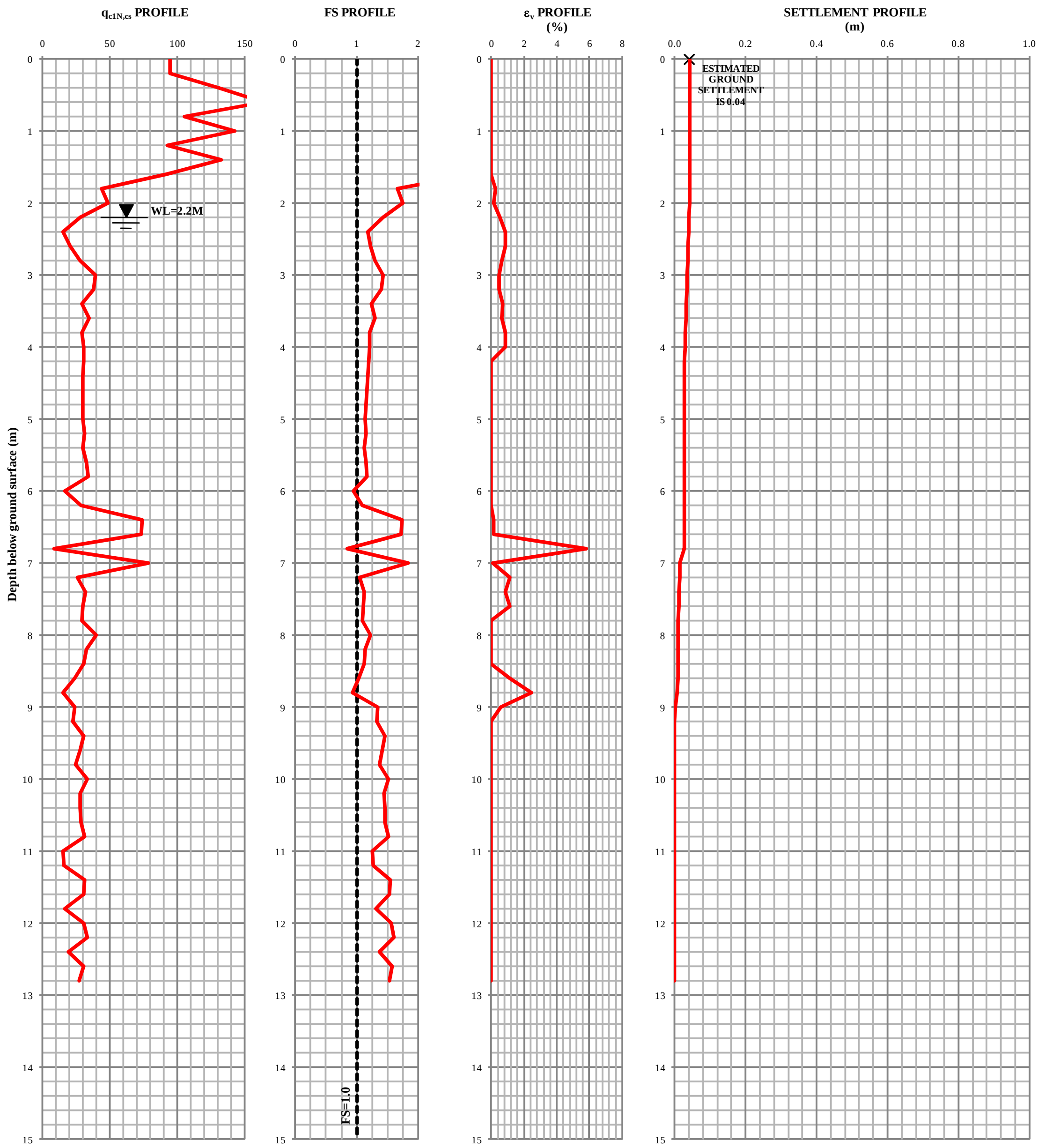
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 2 OF 12

RESULT OF THE ESTIMATION FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

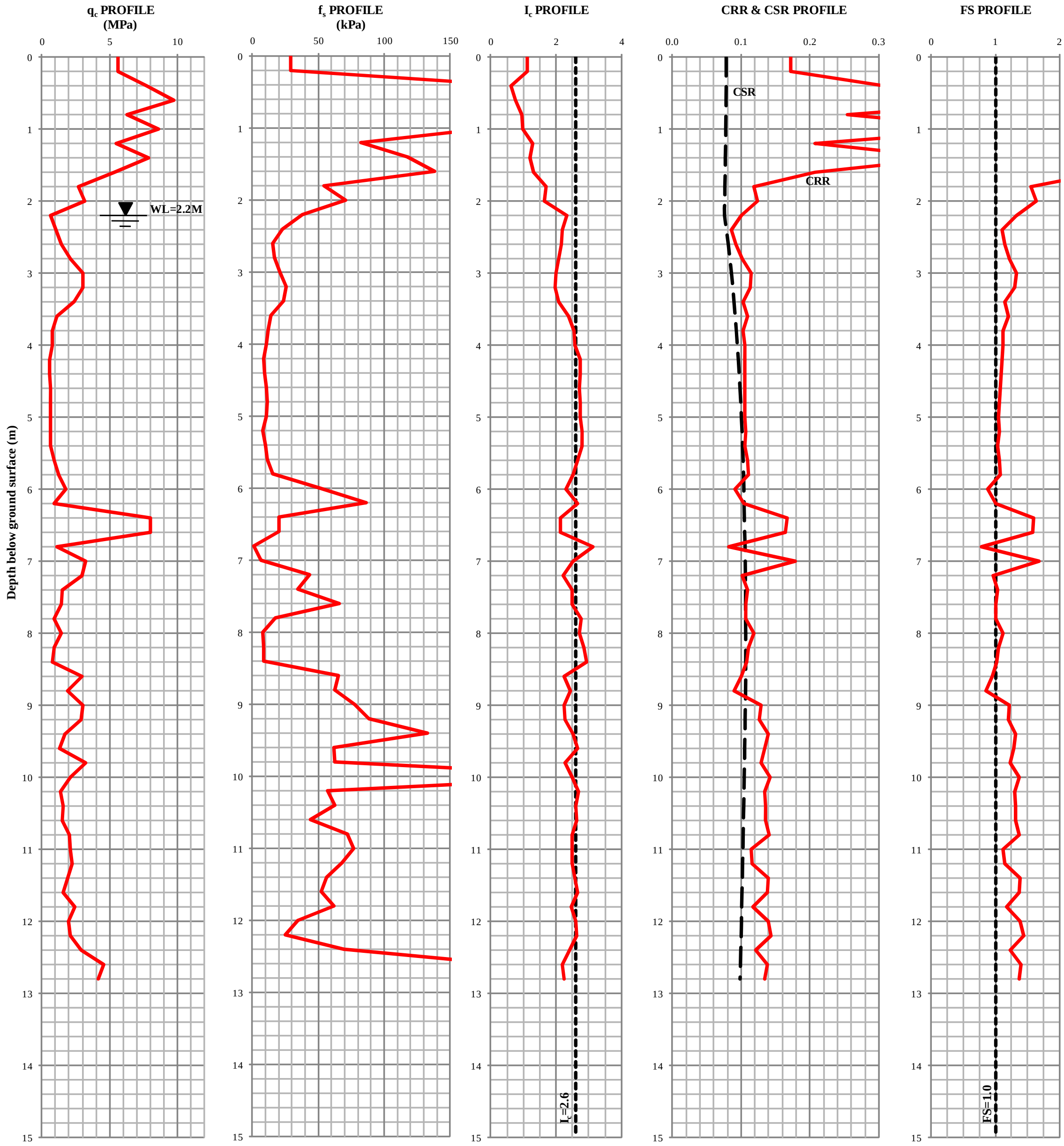
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 3 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

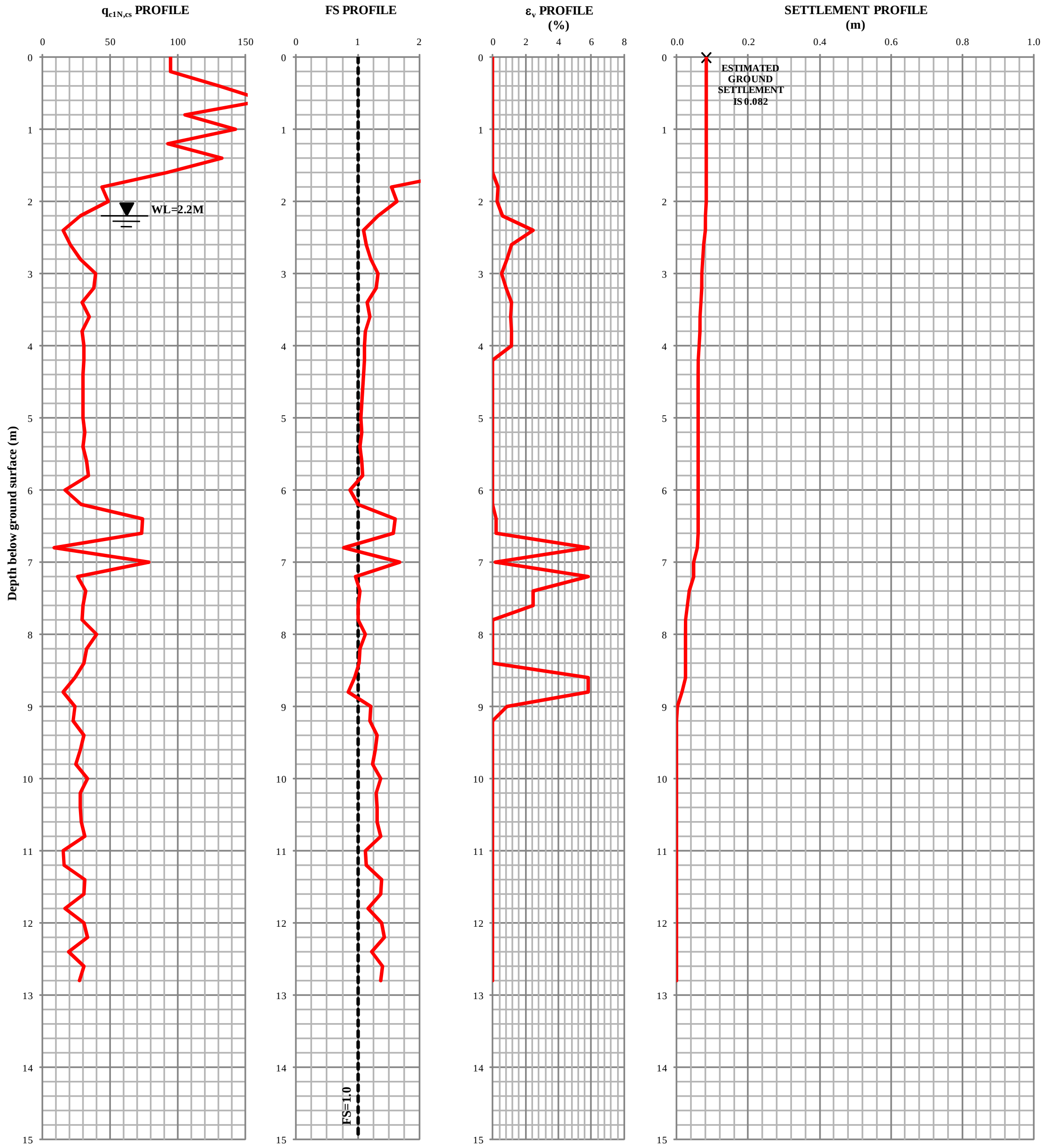
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 4 OF 12

RESULT OF THE ESTIMATION FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

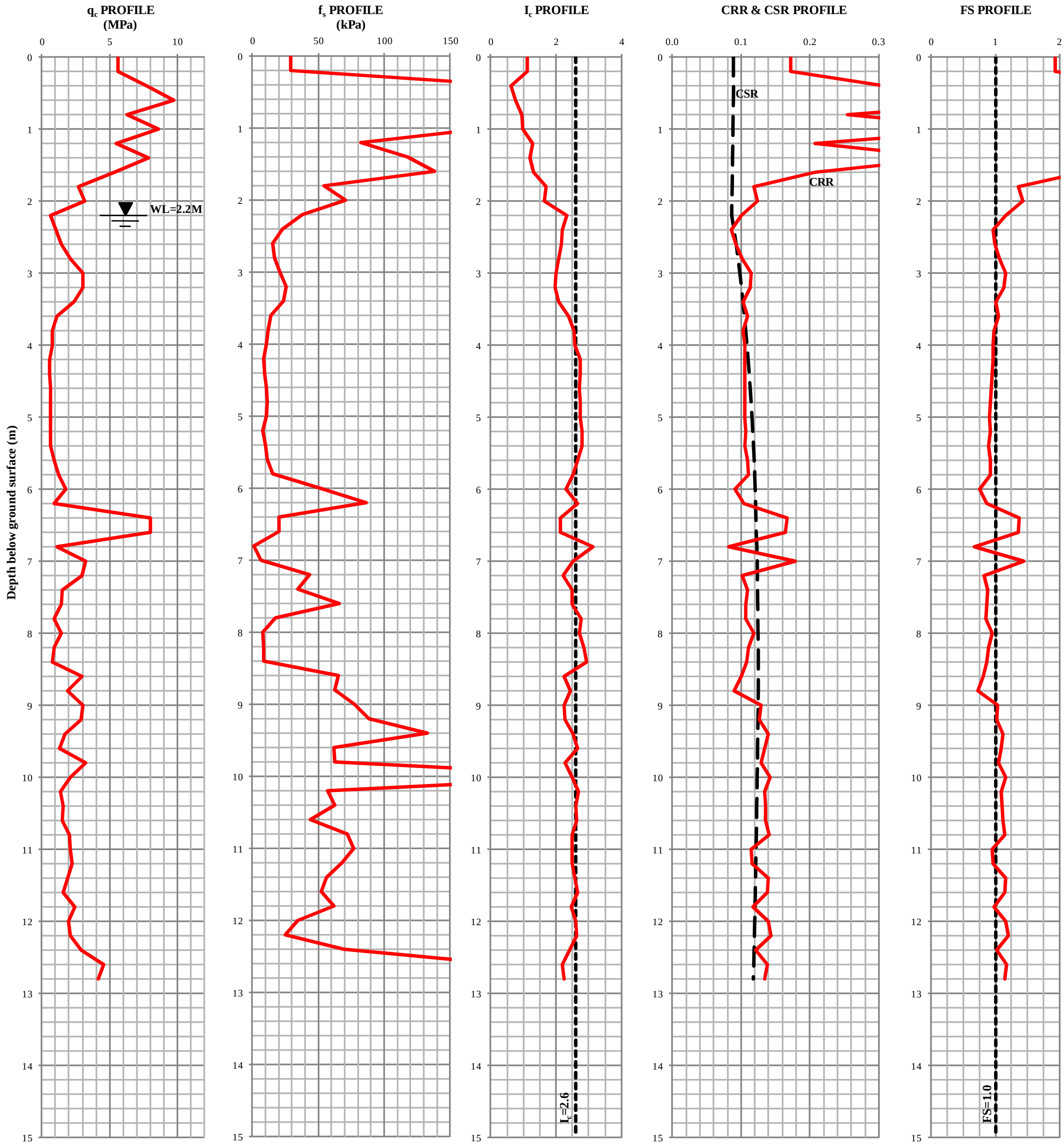
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 5 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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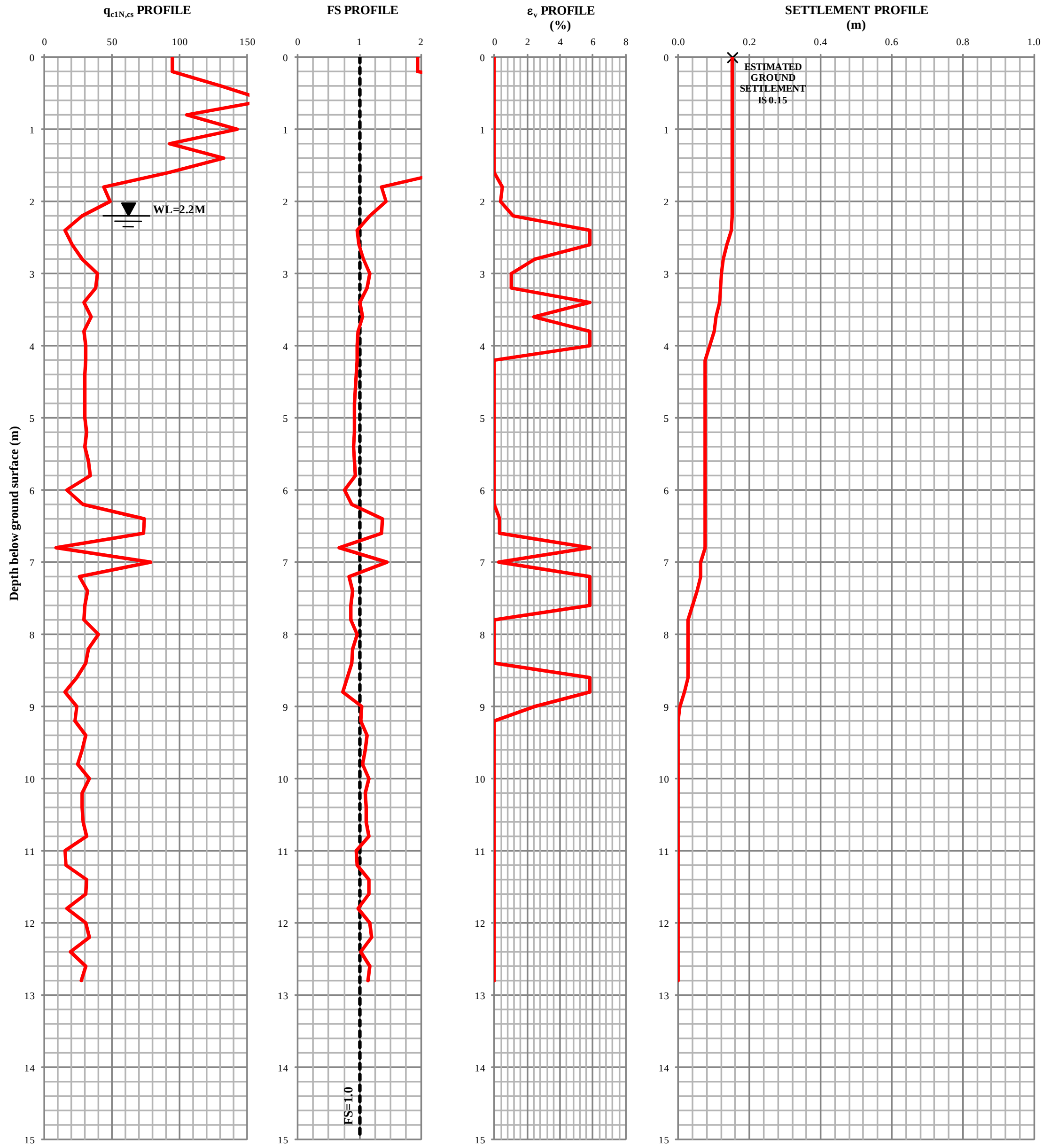
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 6 OF 12

RESULT OF THE ESTIMATION FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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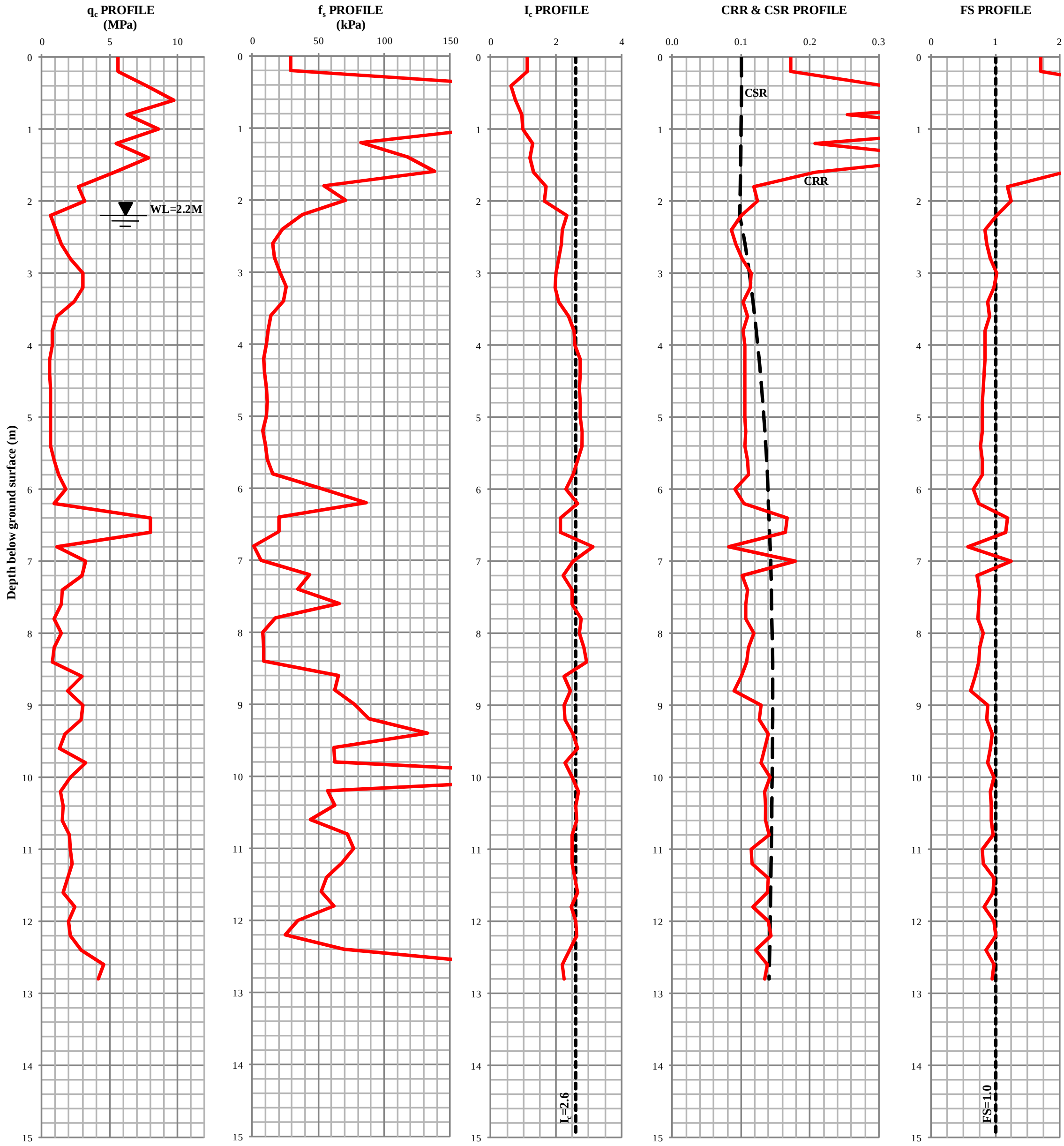
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 7 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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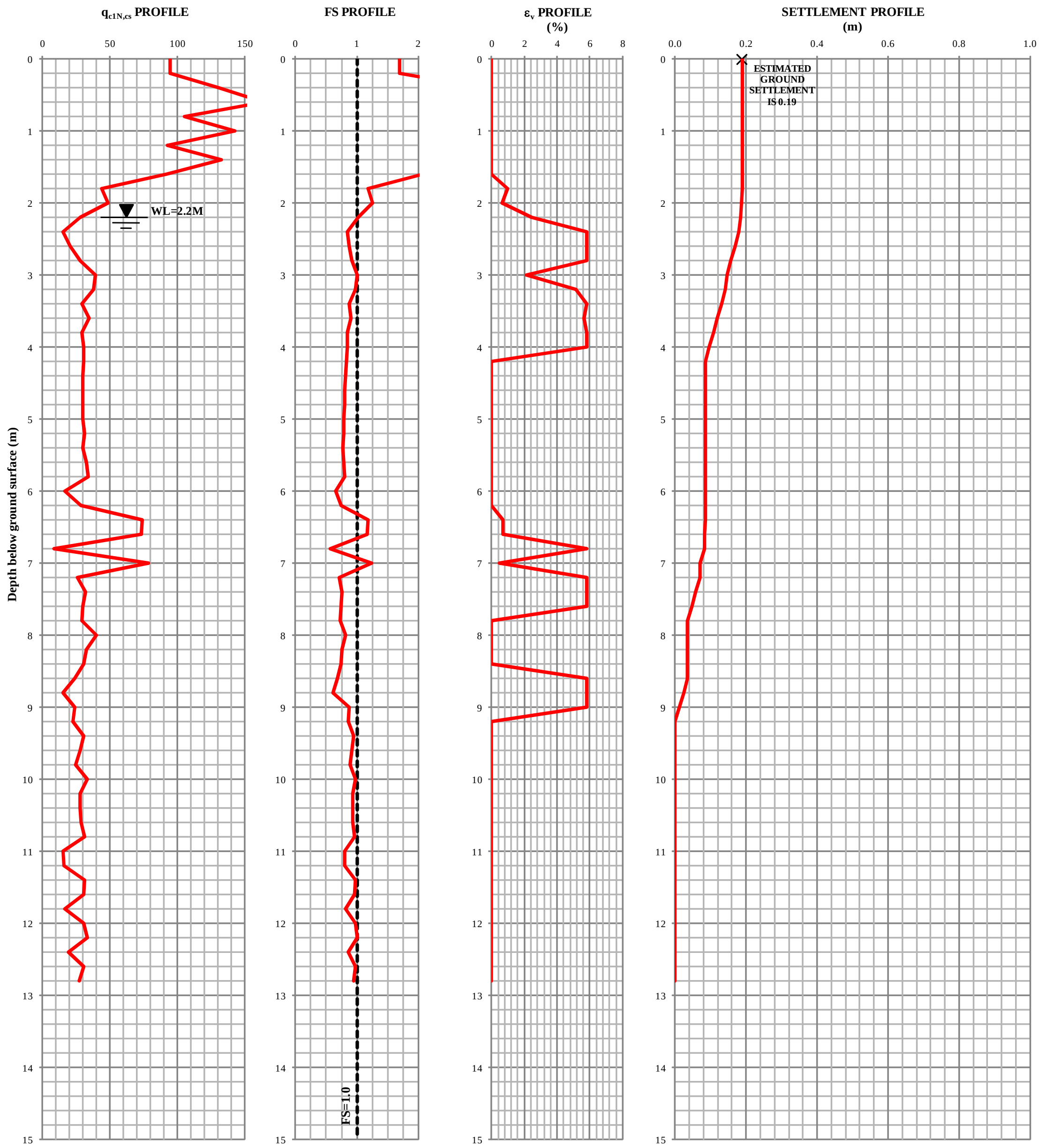
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 8 OF 12

RESULT OF THE ESTIMATION FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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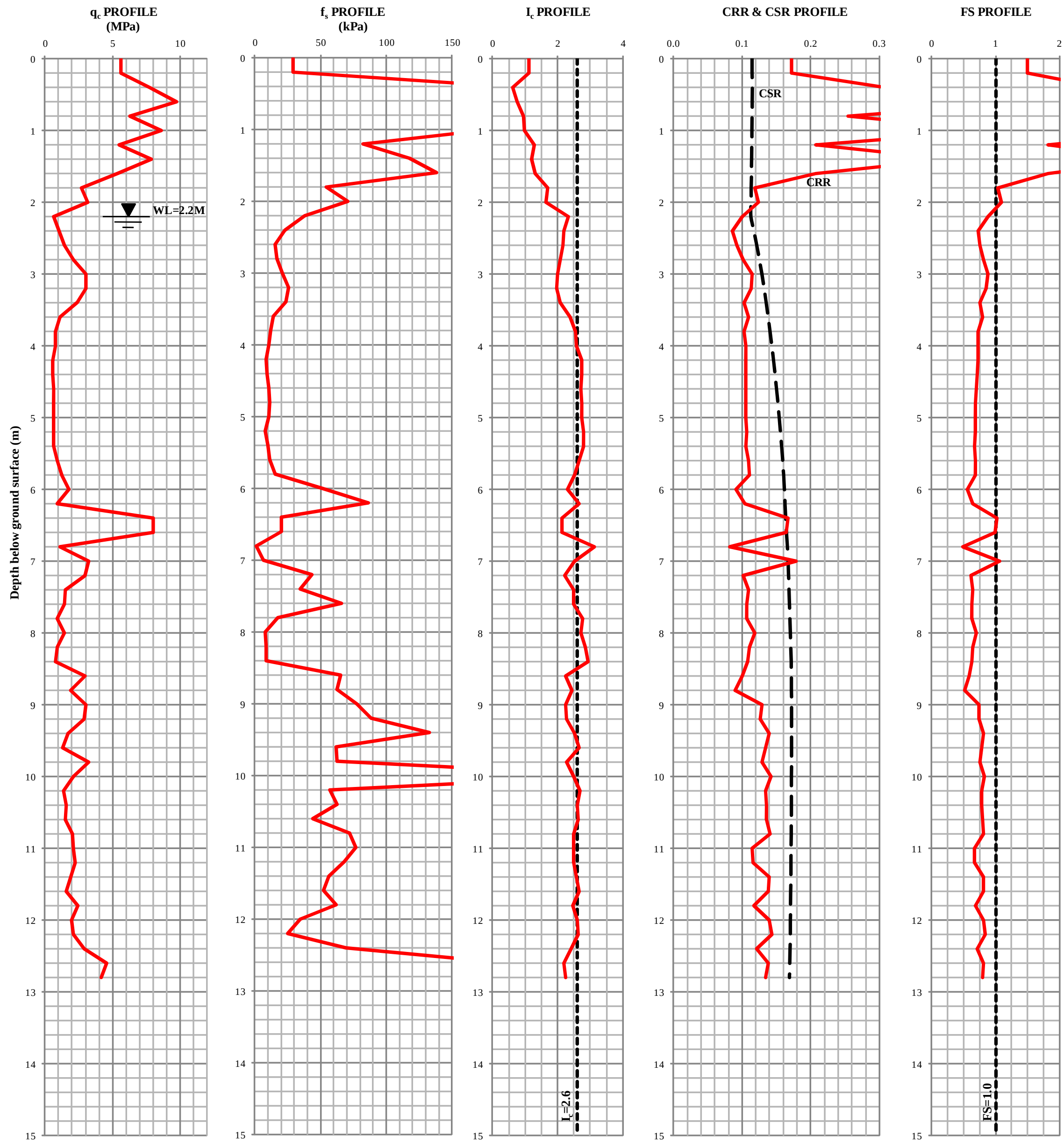
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 9 OF 12

PLOTS OF q_C, f_S, I_C, CRR & CSR AND FS FOR M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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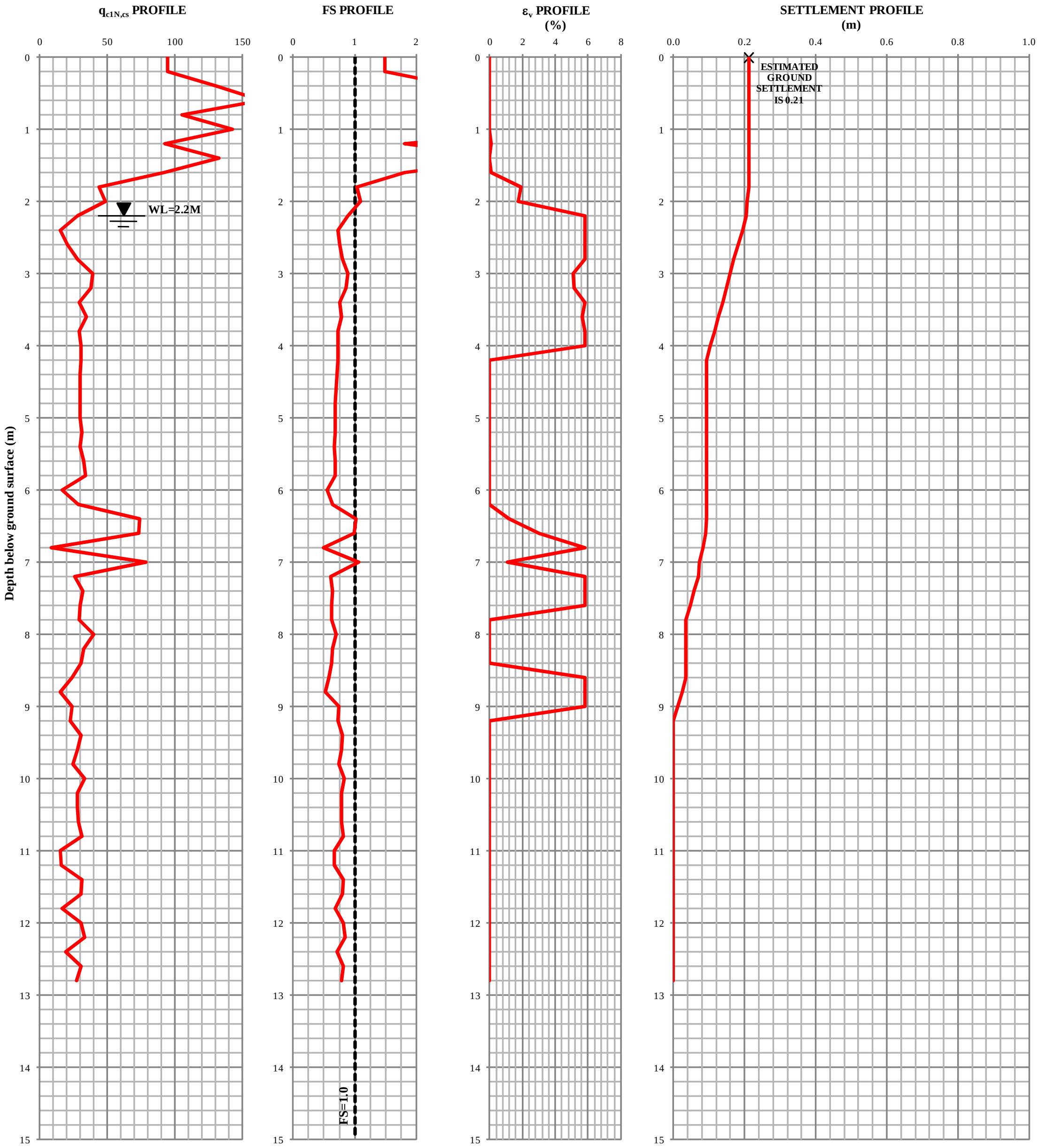
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 10 OF 12

RESULT OF THE ESTIMATION FOR M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date : 20 August 2011

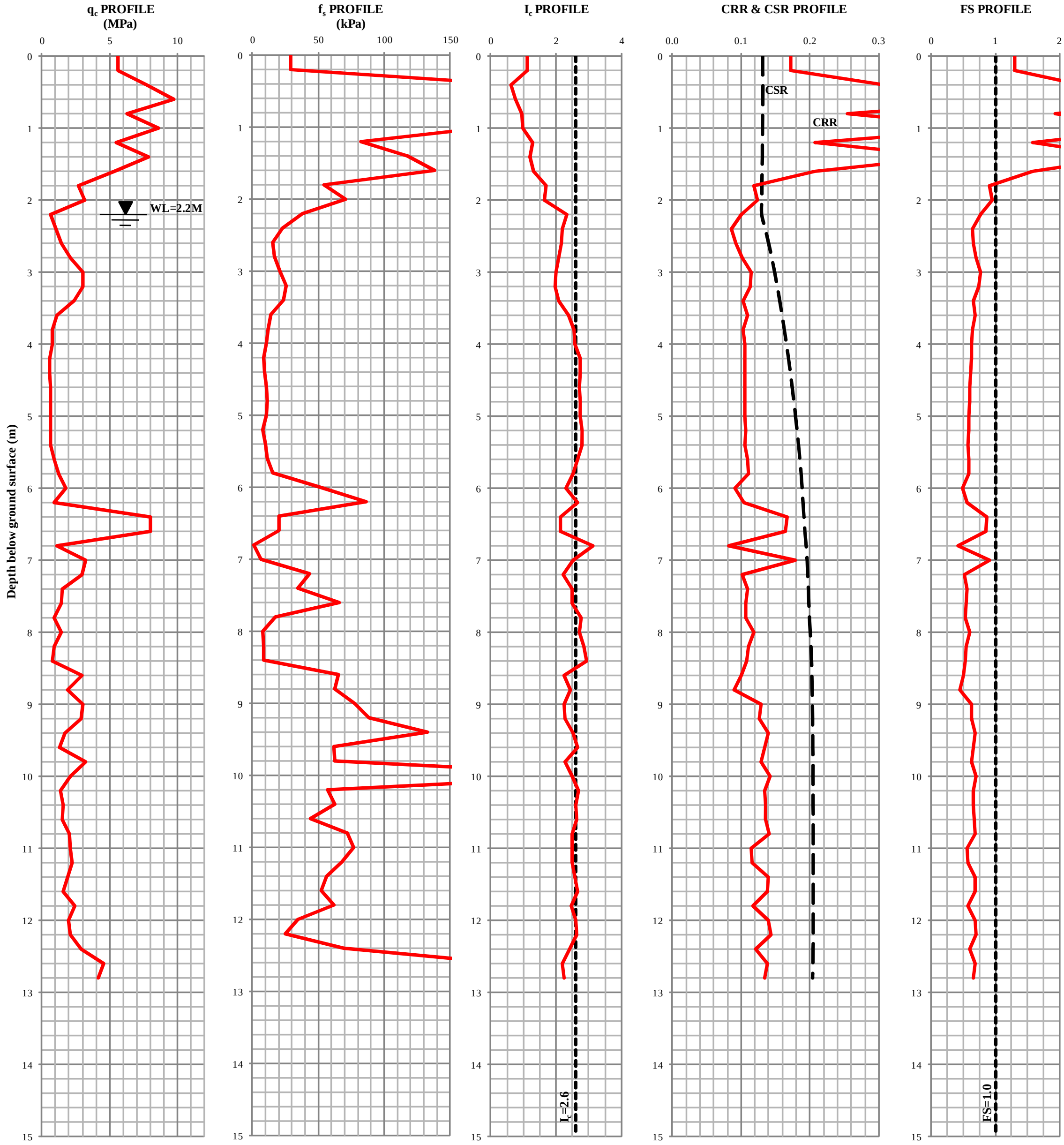
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 11 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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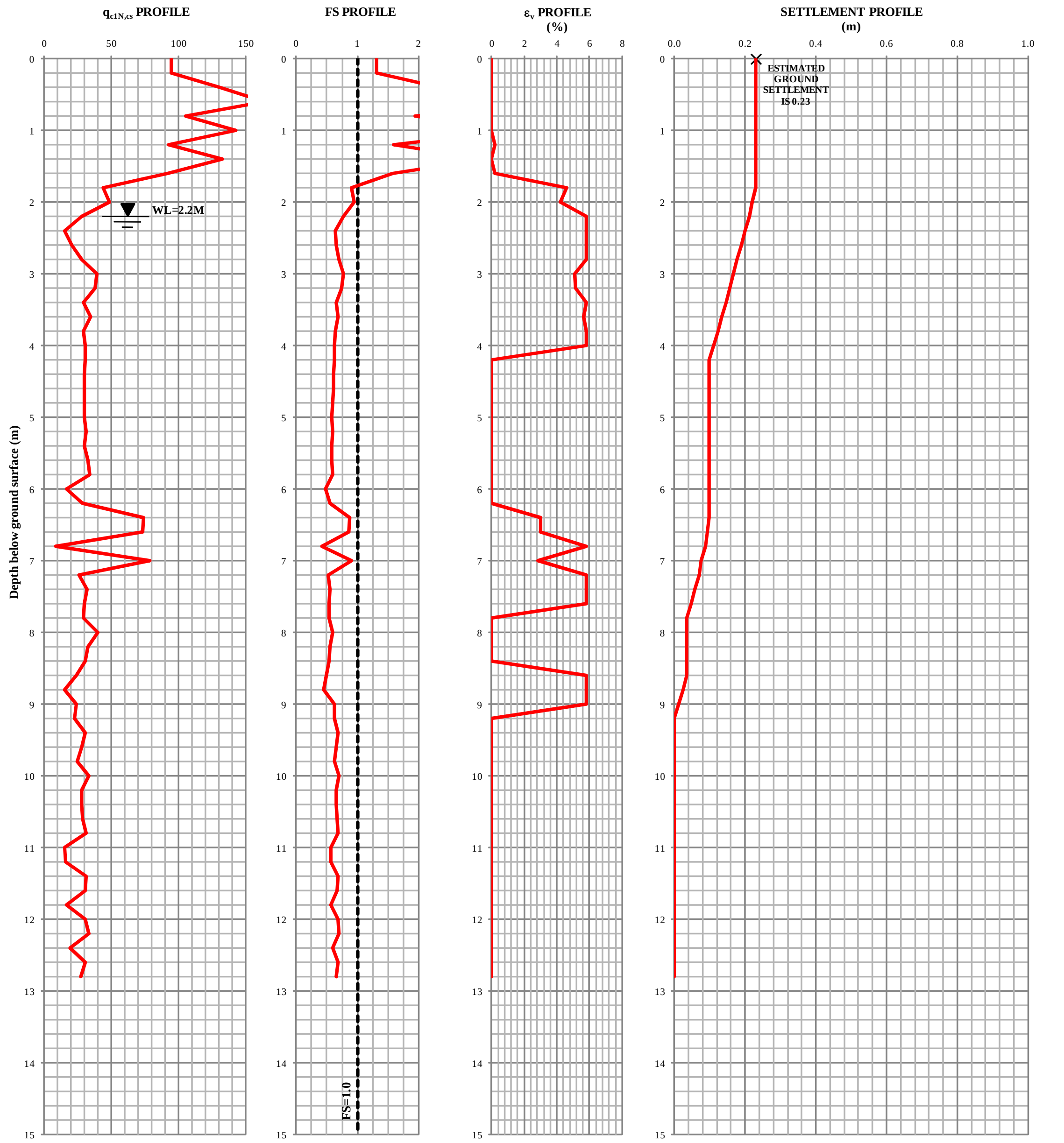
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#2

SHEET : 12 OF 12

RESULT OF THE ESTIMATION FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 12.8 m	**REDUCE LEVEL**	: - m	
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan	
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan	
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa	



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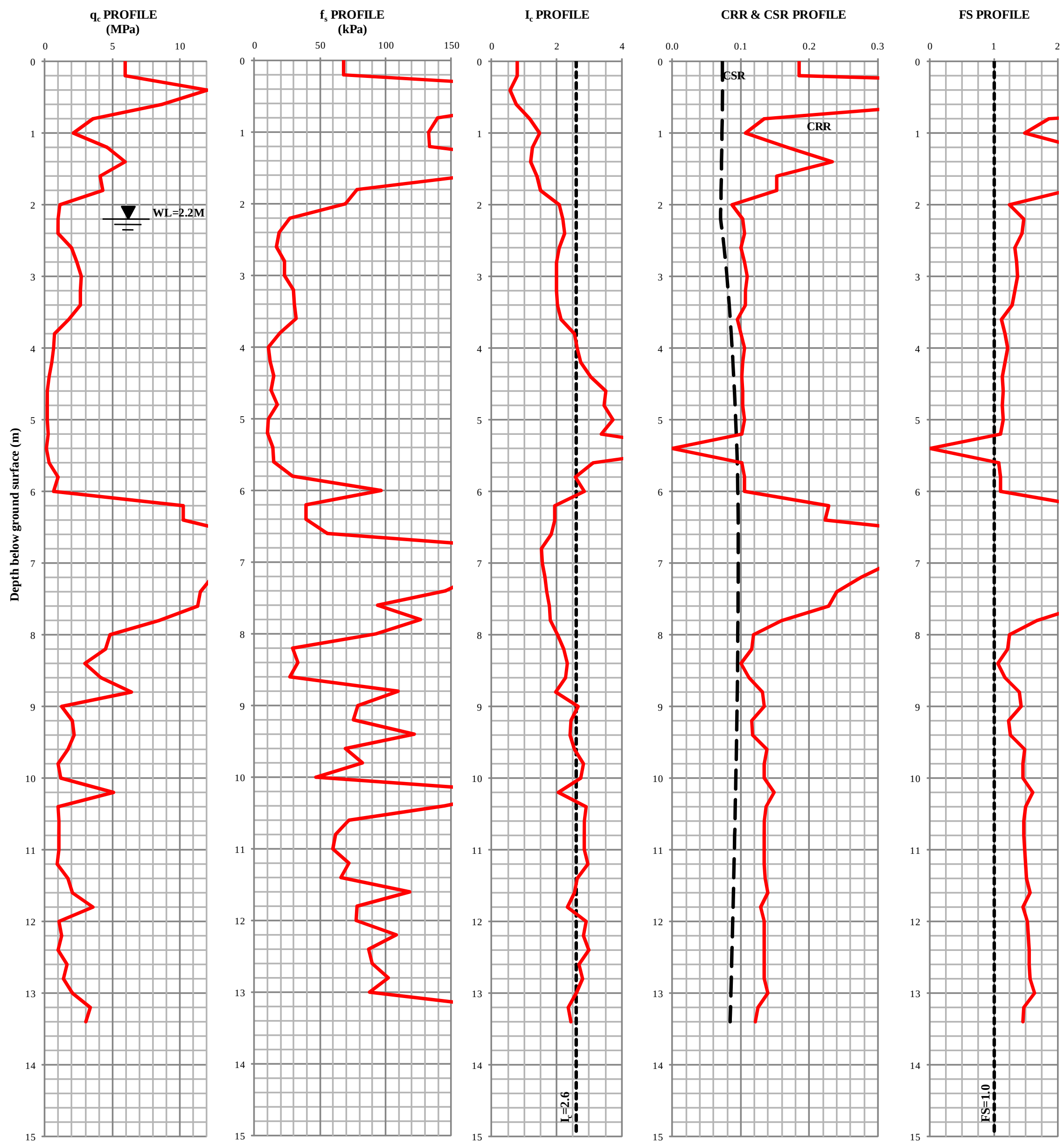
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 1 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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	Date : 20 August 2011

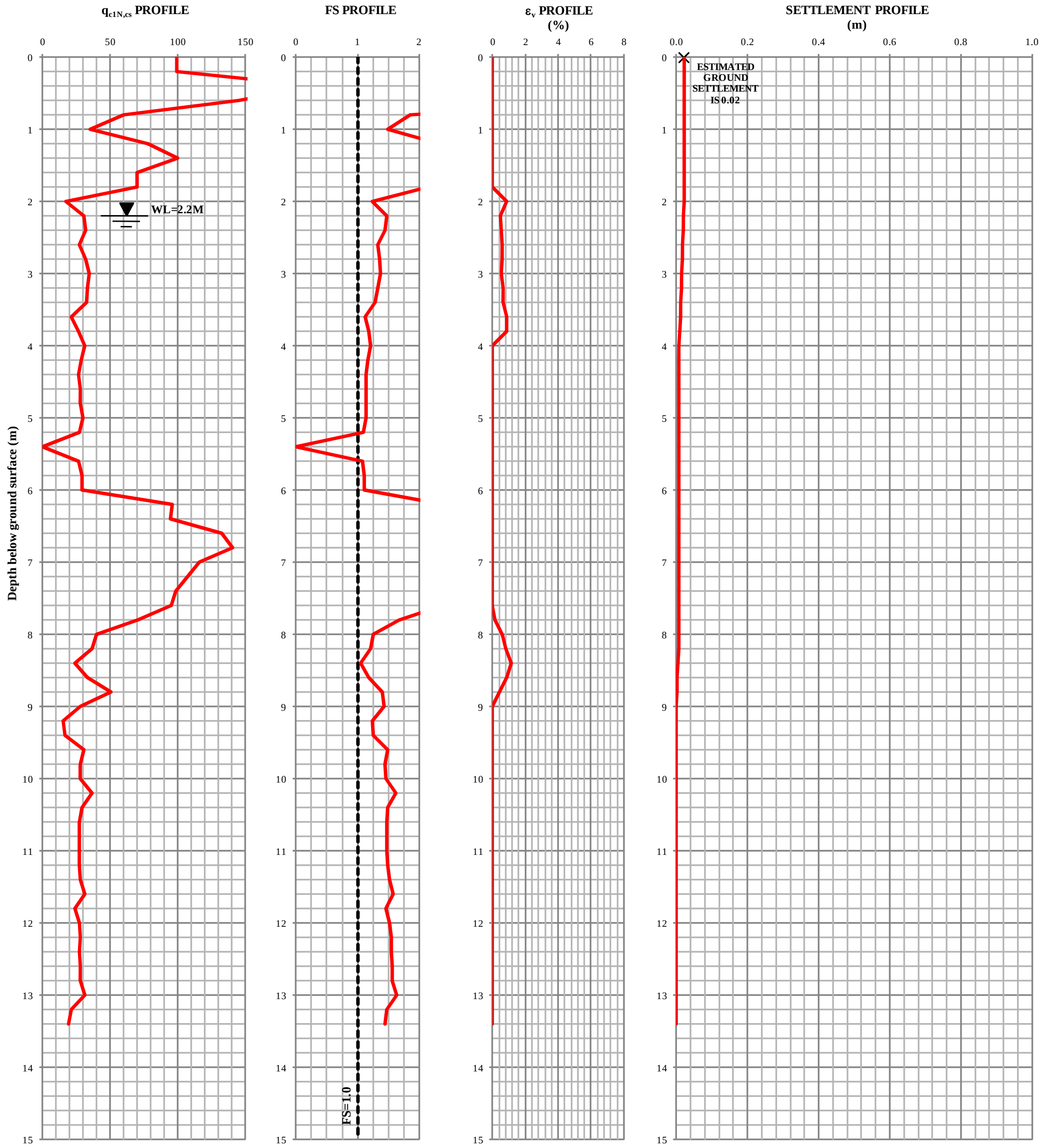
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 2 OF 12

RESULT OF THE ESTIMATION FOR M=5.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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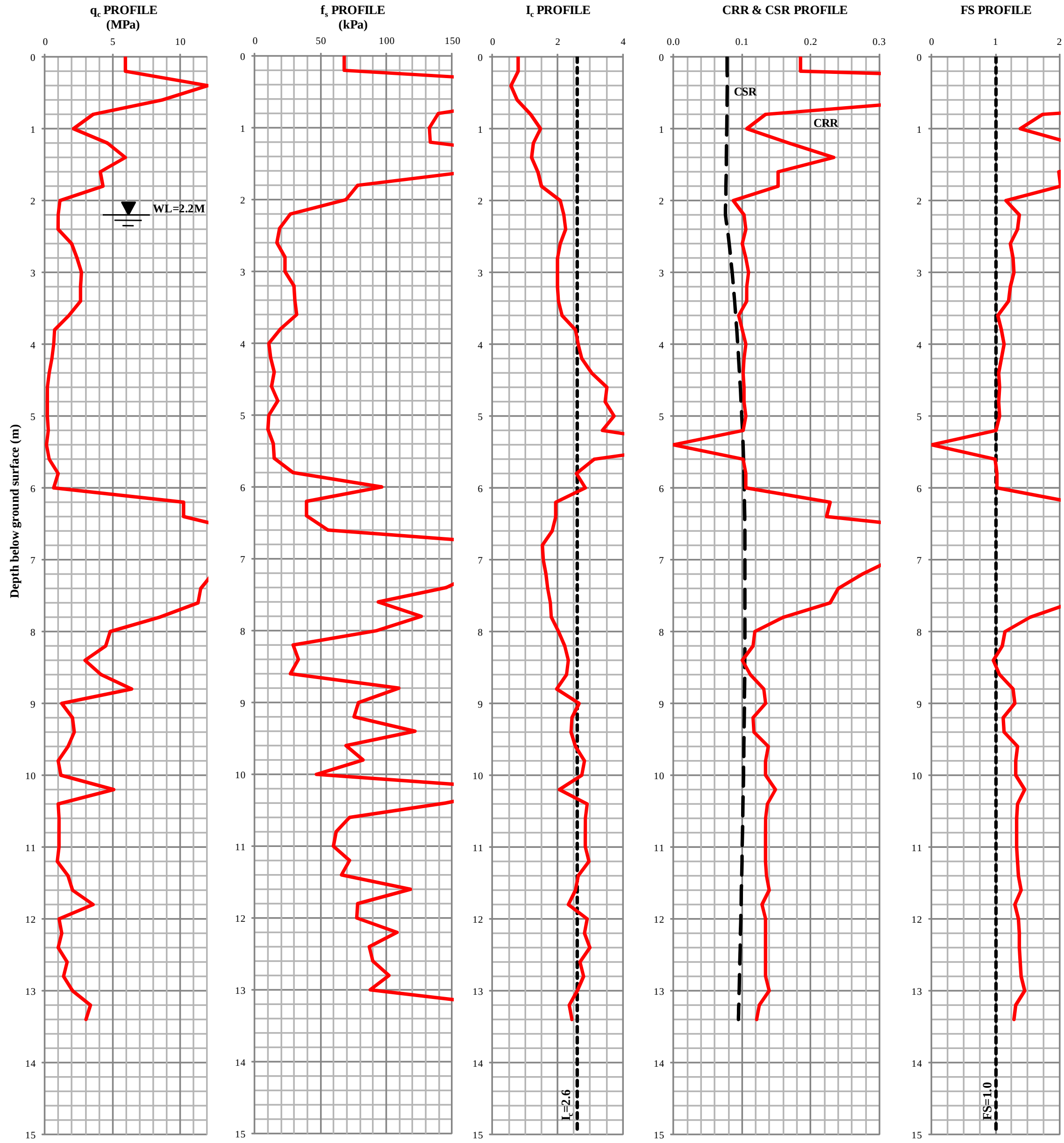
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 3 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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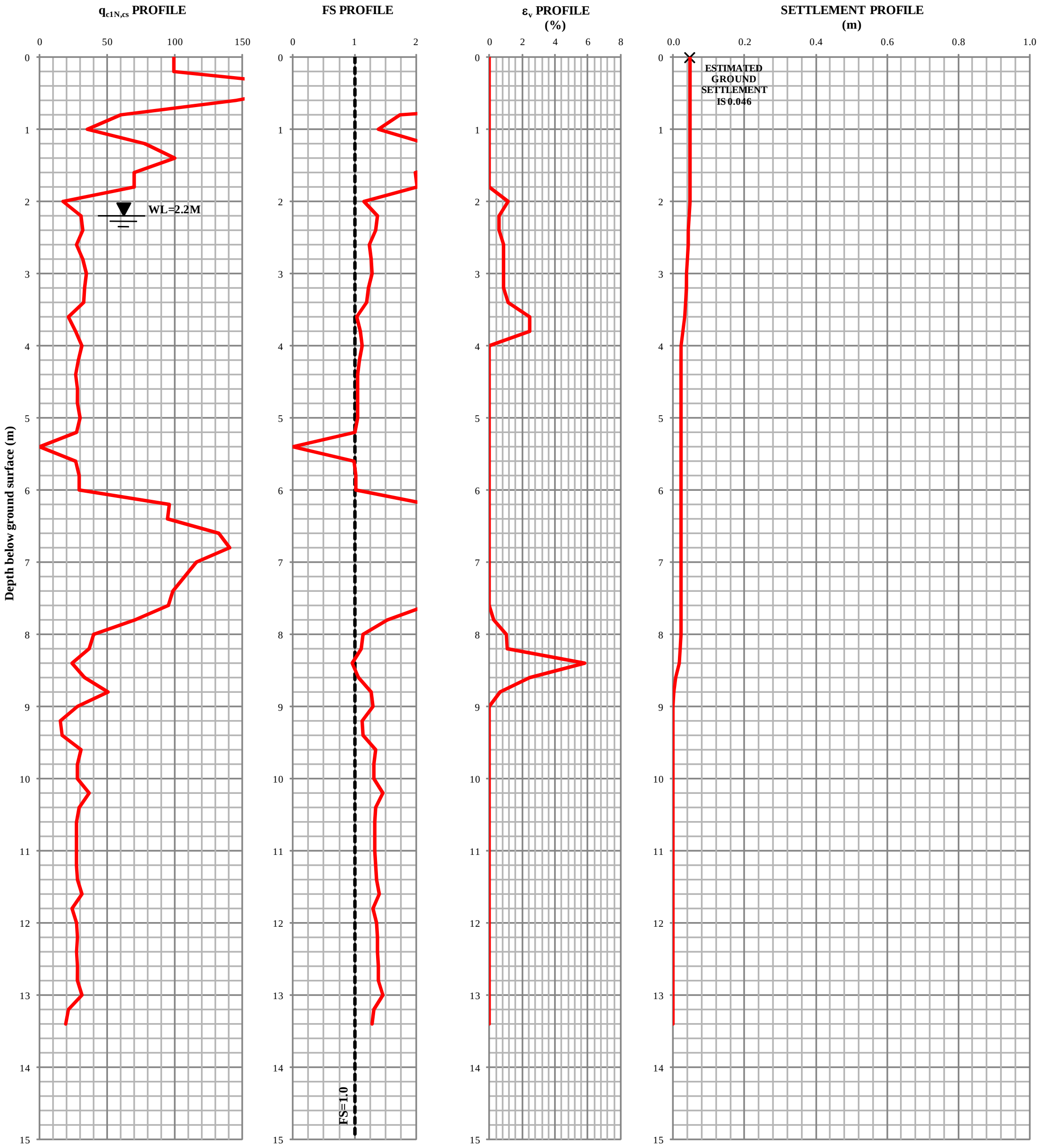
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 4 OF 12

RESULT OF THE ESTIMATION FOR M=5.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING		**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA		**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : -	Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010	TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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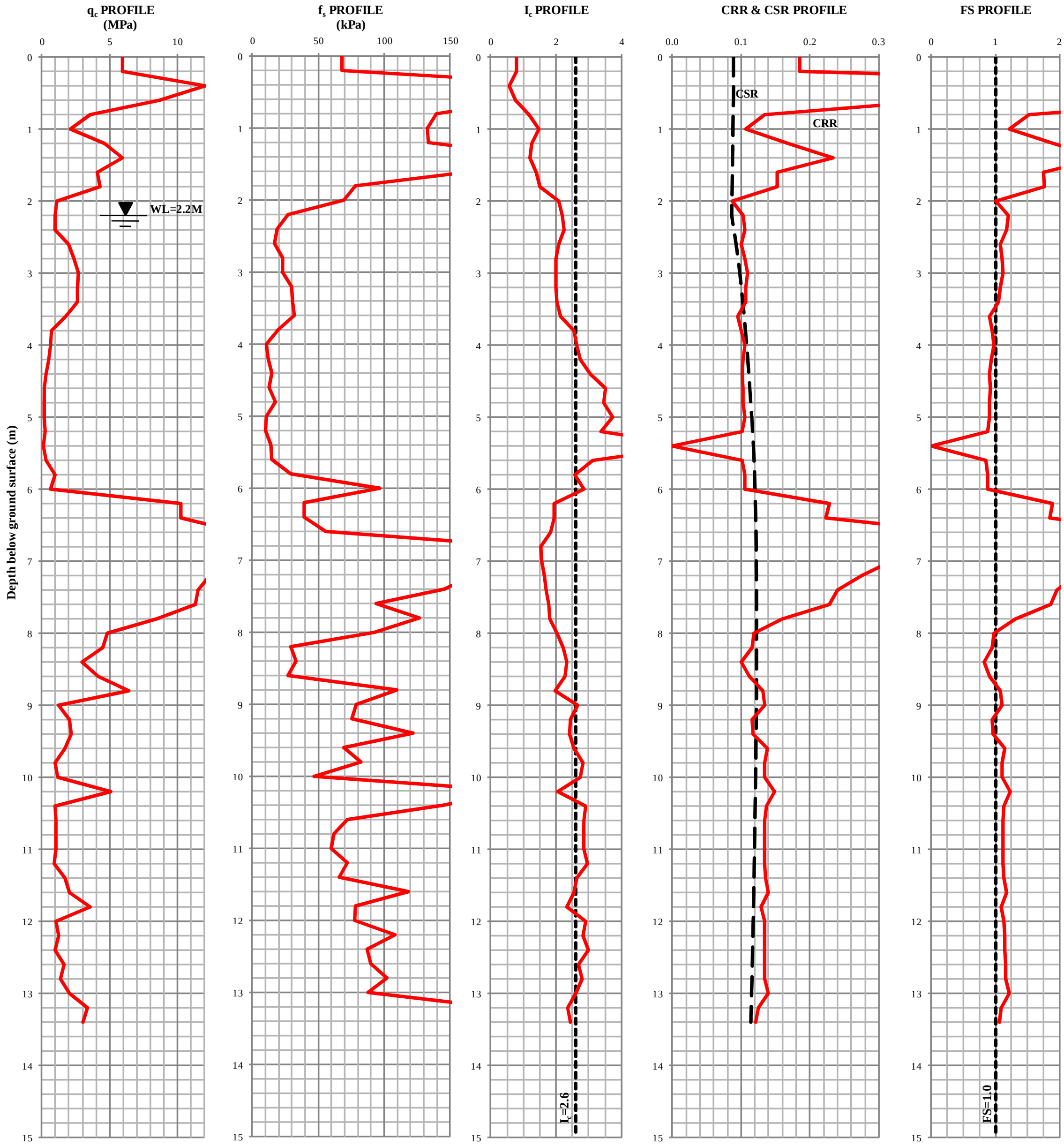
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 5 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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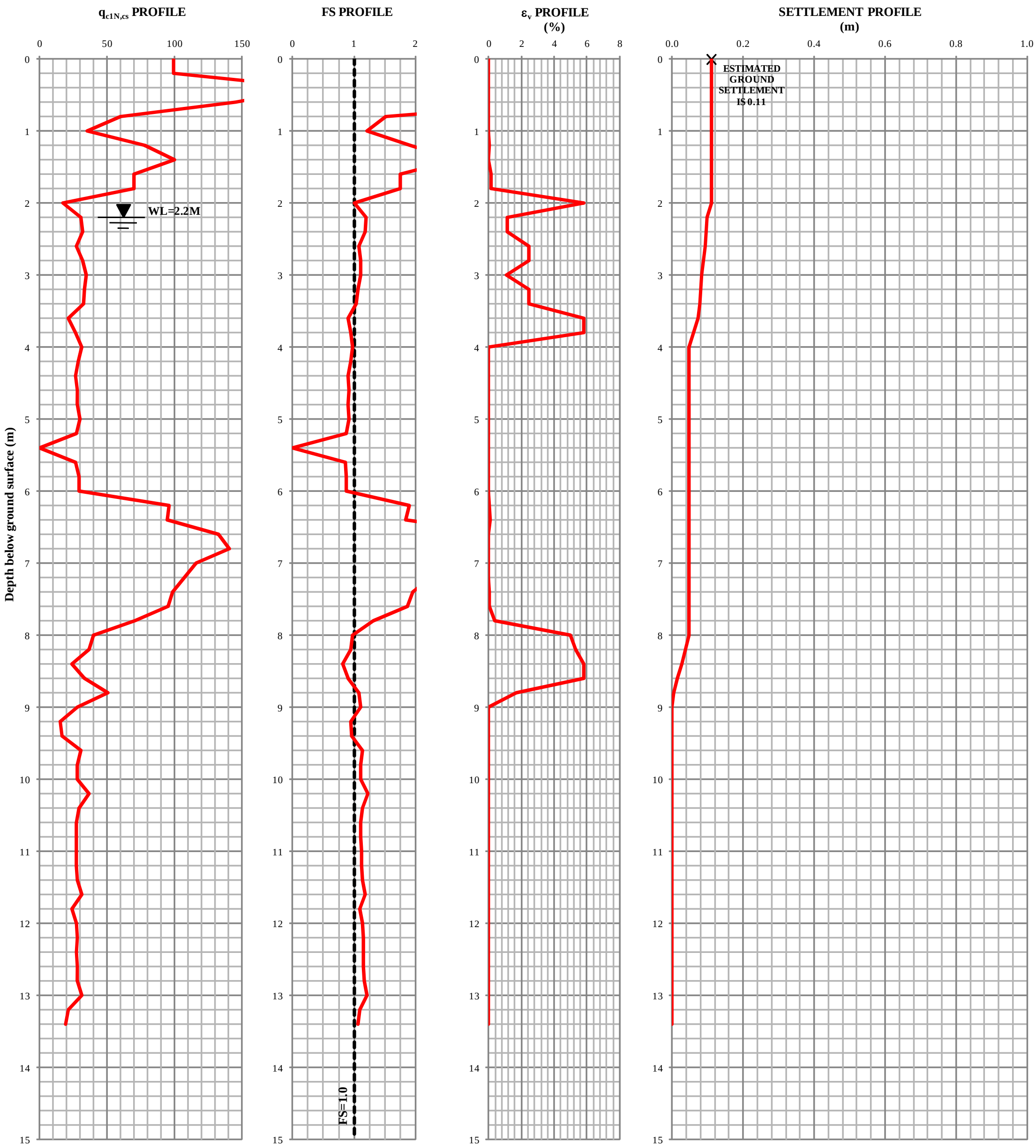
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 6 OF 12

RESULT OF THE ESTIMATION FOR M=6.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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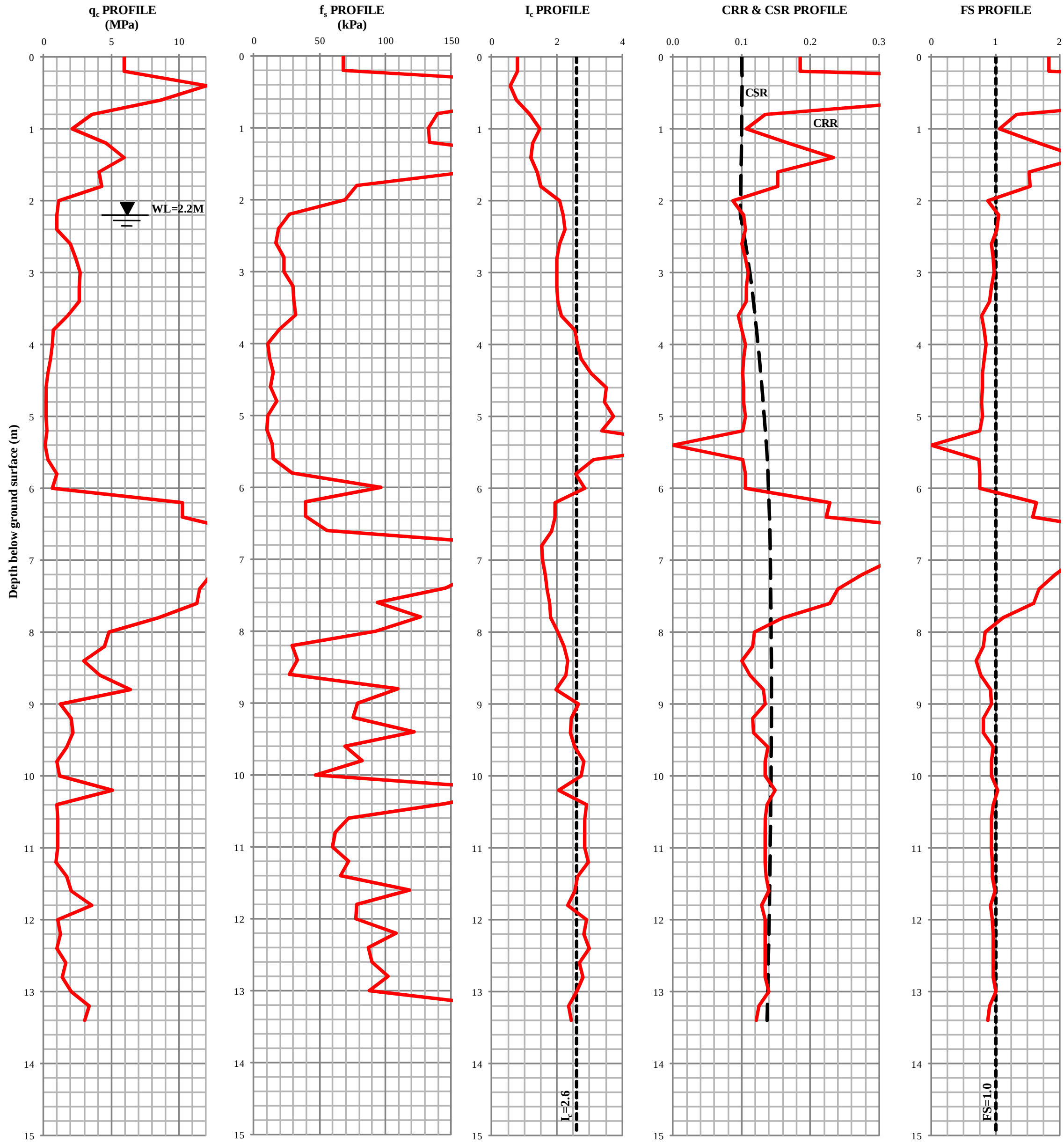
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 7 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	DEPTH	: 0 - 13.4 m	REDUCE LEVEL	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	INCLINATION	: Vertical	OPERATOR	: Andrew/Brendan
COORDINATE	X : - Y : -	PUSHING SYSTEM	: ISUZU EZY PROBE	SUPERVISED BY	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			CHECKED BY	: A/Prof. Mark Jaksa



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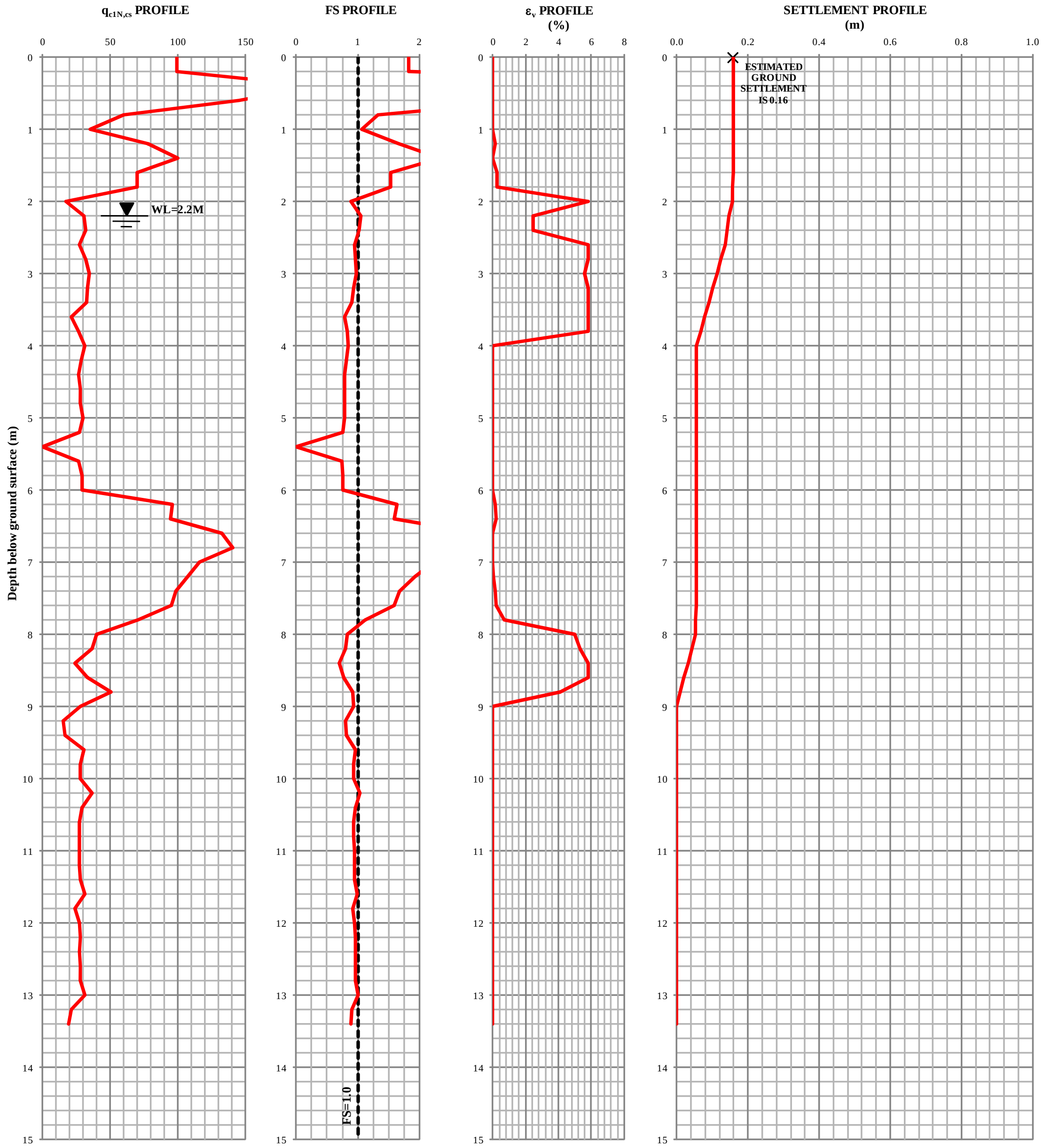
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 8 OF 12

RESULT OF THE ESTIMATION FOR M=6.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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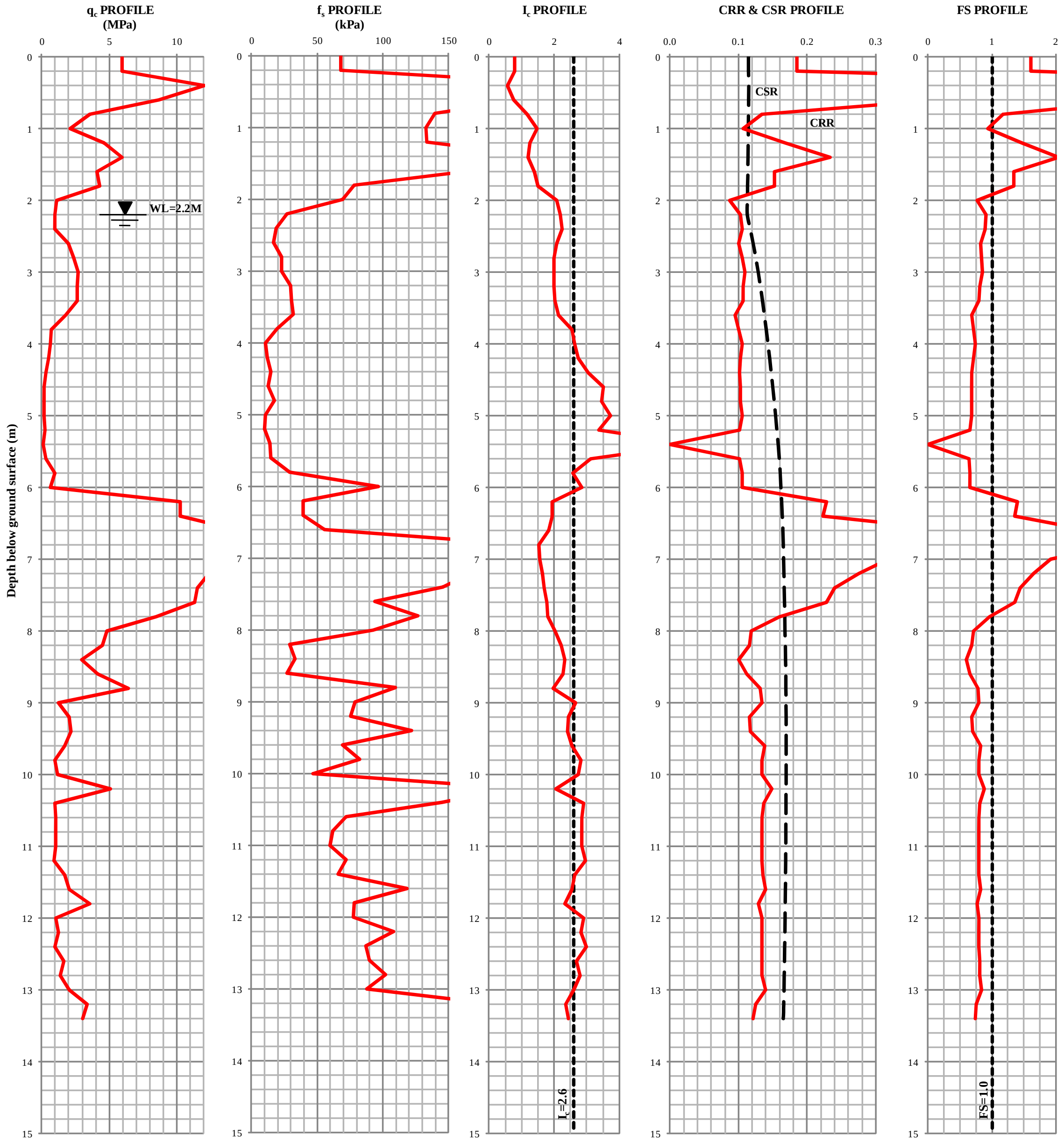
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 9 OF 12

PLOTS OF q_C, f_S, I_C, CRR & CSR AND FS FOR M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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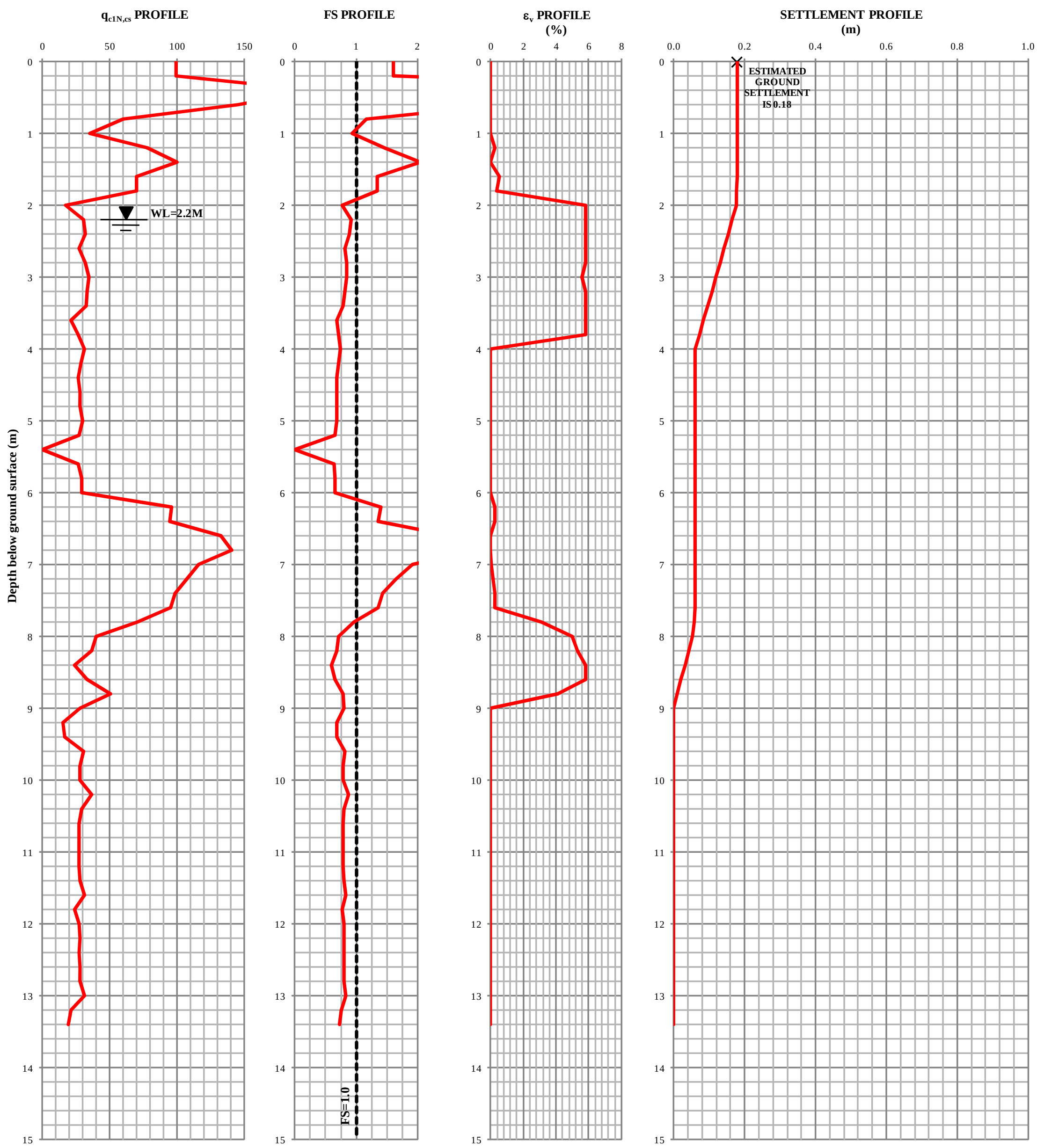
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 10 OF 12

RESULT OF THE ESTIMATION FOR M=7.0

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date	: 20 August 2011

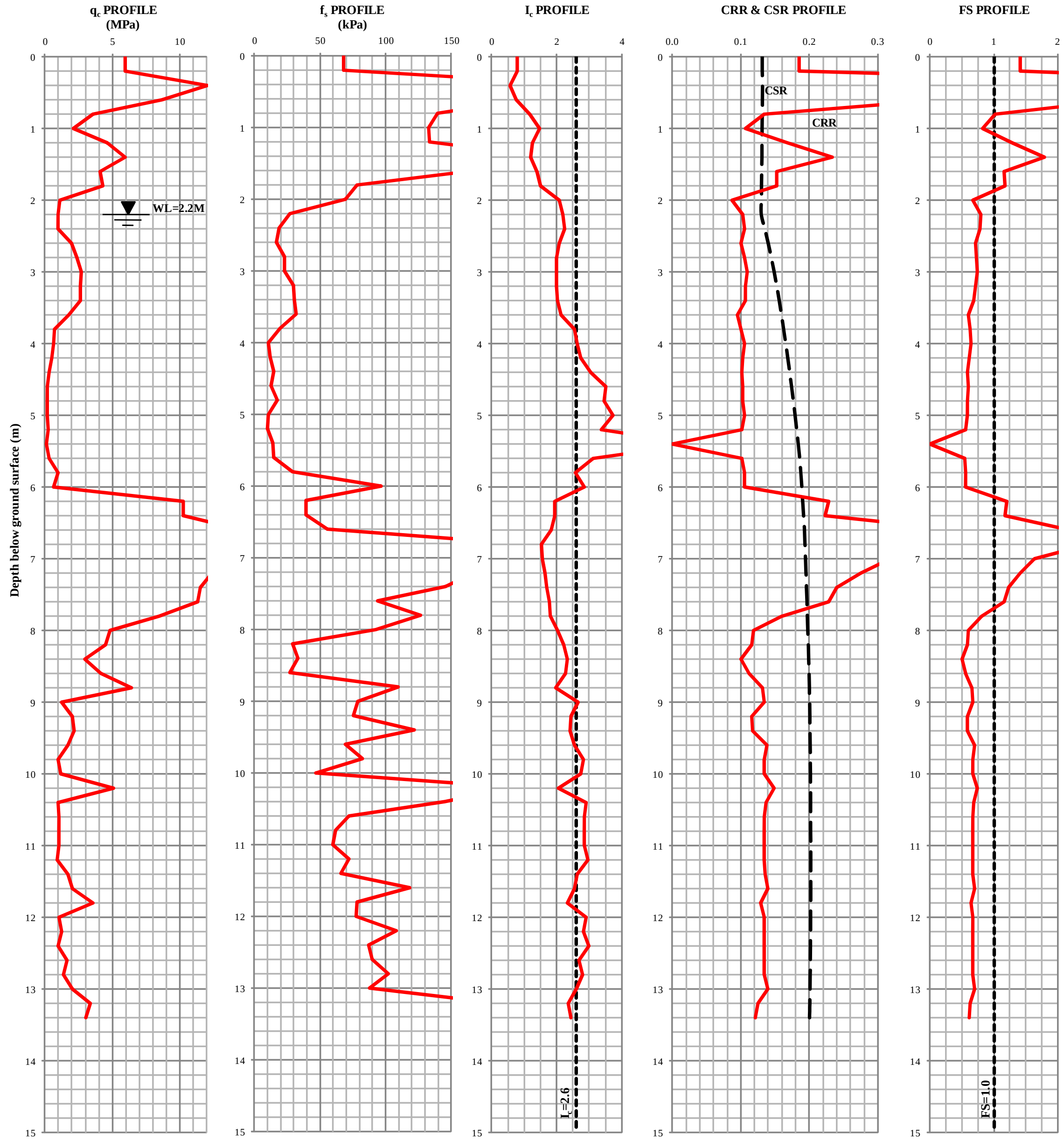
CONE PENETRATION TESTING (CPT)
GROUND SETTLEMENT ESTIMATION

CPT#3

SHEET : 11 OF 12

PLOTS OF q_c, f_s, I_C, CRR & CSR AND FS FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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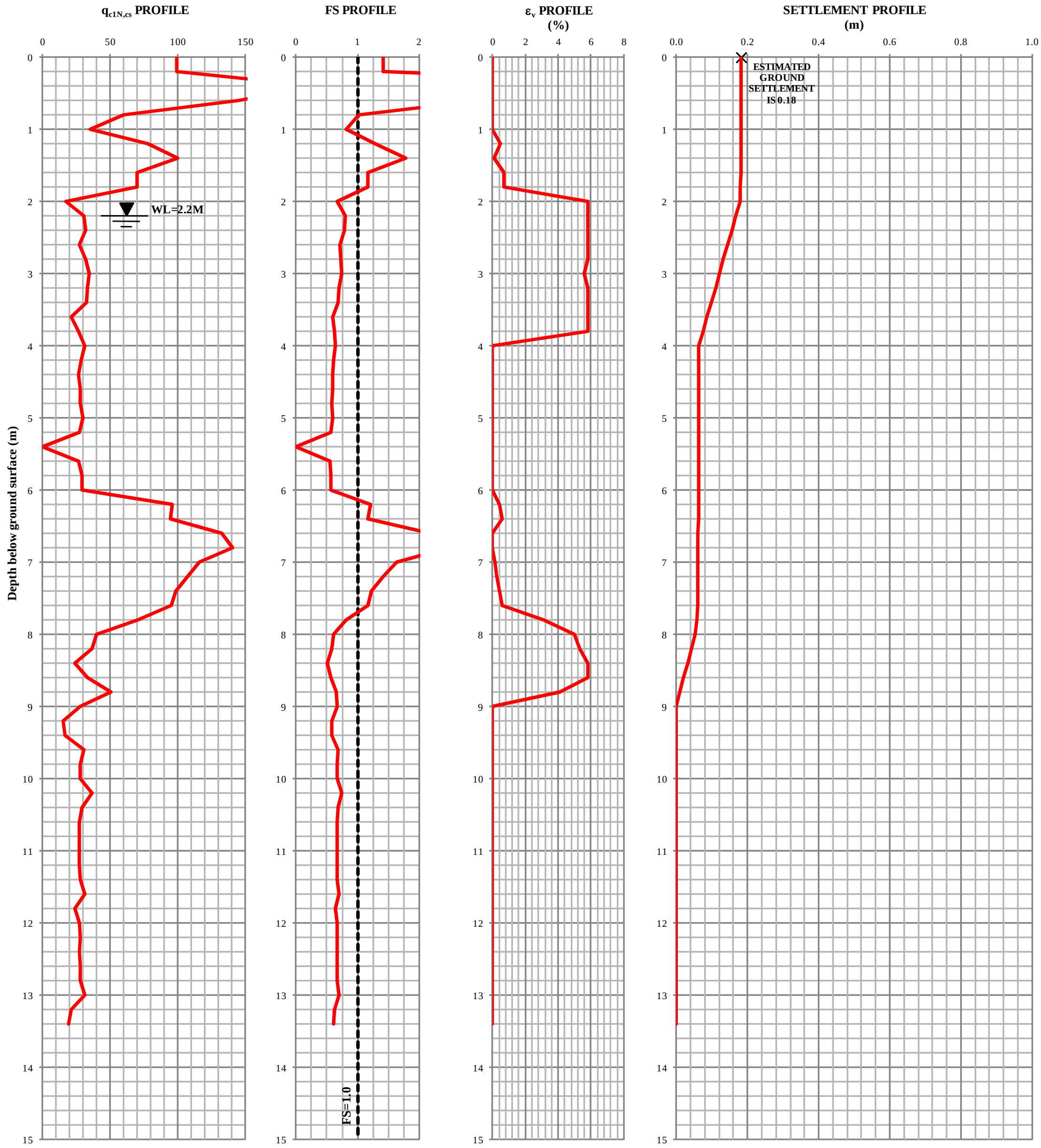
CONE PENETRATION TESTING (CPT) ***GROUND SETTLEMENT ESTIMATION***	**CPT#3**	**SHEET : 12 OF 12** RESULT OF THE ESTIMATION FOR M=7.5

PROJECT	: ASSESSING LIQUEFACTION POTENTIAL OF SOILS UTILISING IN-SITU TESTING	**DEPTH**	: 0 - 13.4 m	**REDUCE LEVEL**	: - m
LOCATION	: GILLMAN, SOUTH AUSTRALIA	**INCLINATION**	: Vertical	**OPERATOR**	: Andrew/Brendan
COORDINATE	X : - Y : -	**PUSHING SYSTEM**	: ISUZU EZY PROBE	**SUPERVISED BY**	: B. Setiawan
DATE	: 11 JUNE 2010 TO 11 JUNE 2010			**CHECKED BY**	: A/Prof. Mark Jaksa



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Date	:	20 August 2011