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Data Article

Dataset on plastic and early-age shrinkage of ultra-high performance concrete with corresponding chemical shrinkage, temperature, relative humidity, reaction degree and material properties changes

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A B S T R A C T

The data collected includes ultra-high performance (UHPC) shrinkage under sealed and unsealed conditions from 3 h after water addition, chemical shrinkage, UHPC internal temperature and relative humidity, Thermal gravity analysis (TGA) data, compressive strength, Poisson's ratio and elastic modulus of 9 UHPC mixes. UHPC early-age shrinkage was collected by a 250×250×100 mm mould and two linear variable differential transformers (LVDT) on the opposite positions and a sealing cover was applied to control the sealing condition of the top surface. Chemical shrinkage was measured by 500 mL Erlenmeyer flasks with a measuring pipette and paraffin oil was added to seal samples and indicate chemical shrinkage increment by liquid level change in the pipette. The liquid level change was recorded by GoPro cameras from 3 h after water addition. UHPC internal relative humidity was measured simultaneously by digital sensors from 3 h after water addition. TGA data were measured by a Mettler Toledo TGA testing machine at 5 different time points for each mix design. The TGA data were then used to

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calculate reaction degree. The material properties, including compressive strength, Poisson's ratio and elastic modulus were measured at 3 different time points by a compression machine and two axial extensometers and one circumferential extensometer. The data collected can comprehensively reflect chemical and physical behaviours of UHPC at early age and can be used to develop or calibrate a model for UHPC early-age shrinkage.

Specifications Table

Subject	Civil and Structural Engineering
Specific subject area	Early-age shrinkage of ultra-high performance concrete (construction material)
Type of data	Table
How the data were acquired	UHPC early-age shrinkage: Data were automatically recorded by two LVDTs at the opposite positions. The make and model number of the LVDT are GEFRAN and PY-2-C-010 with stoke length and accuracy being 10 mm and ±0.3%. Chemical shrinkage: Data were acquired by 500 mL Erlenmeyer flasks, 2 mL pipettes with 0.01 mL graduations and 50 g UHPC paste, sealed by paraffin oil. A GoPro camera was then used to record paraffin oil level change every hour. UHPC internal relative humidity and temperature: Data were measured simultaneously by a digital sensor (model SHT21) with an operational range of −40 °C to 125 °C and relative humidity operation range of 0%−100%. The accuracies of relative humidity and temperature are 2% and 0.3 °C, respectively. TGA: Data were acquired by a Mettler Toledo TGA testing machine, with approximately 10 mg sample heated from 30 °C to 1000 °C at the rate of 10 °C/min in nitrogen atmosphere. Material properties: Compressive strength was acquired by a compression machine made by Seidner and Poisson's ratio and elastic modulus were acquired by two axial extensometers and one circumferential extensometer made by MTS (model 632.11F-90 and model 632.12F-20).
Data format	Raw, analysed
Description of data collection	All UHPC samples were stored and tested under control environment (25 °C and 50% relative humidity). There are 9 mix designs adopted with variations in water to binder ratios and silica fume dosages. The sample used for chemical shrinkage and TGA was UHPC paste (i.e. UHPC mix without sand).
Data source location	• Institution: The University of Adelaide • City/Town/Region: Adelaide • Country: Australia • Latitude and longitude: −34.919, 138.606
Data accessibility	Repository name: figshare Data identification number: 10.25909/19,128,146 Direct URL to data: https://adelaide.figshare.com/articles/dataset/Early_age_shrinkage_DiB_spreadsheet/19128146 Data are also included in supplement excel.
Related research article	M. Sun, T. Bennett, P. Visintin, Plastic and early-age shrinkage of Ultra-high performance concrete (UHPC): experimental study of the effect of water to binder ratios, silica fume dosages under controlled curing conditions, In Press (2021) [1].

Value of the Data

- These data record both chemical and physical behaviour of UHPC early-age shrinkage. They can indicate the mechanisms of UHPC early-age shrinkage and interactions between them. Furthermore, these data demonstrate how UHPC has a very different shrinkage behaviour to normal and high performance concrete.
- Future studies on UHPC shrinkage modelling can benefit from these data and they can be used to form the shrinkage database of UHPC and be utilised to develop or calibrate UHPC shrinkage models.
- These data can be used as reference data for the study of UHPC early-age shrinkage on others changing parameters. Also, these data can be used to further separate converted chemical shrinkage from early-age shrinkage to investigate the precise zero time of autogenous shrinkage.

1. Data Description

All data was collected in one Excel file with 6 different sheets demonstrating UHPC early-age shrinkage under sealed and unsealed shrinkage, chemical shrinkage, temperature, relative humidity, TGA and material properties.

For each sheet, the first row is the name of each UHPC mix design and the data for each mix design are separated by thick borderlines.

Sheet 1 is UHPC early-age shrinkage under sealed and unsealed shrinkage. For each mix design, both sealed and unsealed shrinkage data are provided, with the column 1 being time in hours and column 2, 3 and 4 being shrinkage strain values in microstrain.

Sheet 2 is UHPC paste chemical shrinkage. For each mix design, the actual sample weigh in gram and liquid level change in mL with time were provided. The column 1 is time in hour and column 2 and 3 are liquid level change, zeroed at 3 h from water addition.

Sheet 3 is internal temperature change. For each mix design, the temperature at 9 different positions of both sealed and unsealed samples was provided, with column 1 being time in hour and column 2, 3, 4, 5, 6, 7, 8, 9 and 10 being temperate change in Celsius degree.

Sheet 4 is internal relative humidity and the layout of relative humidity is the same as temperature.

Sheet 5 is TGA data. For each mix design, the weight change in milligram from 30 °C to 1000 °C at 5 different time points was provided. The column 1 is temperature change in Celsius degree and column 2, 3, 4, 5 and 6 are weight change with temperature at different time points. In addition, the weight change of blank crucible, dry cement and dry silica fume was also provided for the purpose of calibration.

Sheet 6 is material properties of UHPC including compressive strength, Poisson's ratio and elastic modulus. For each design, material properties of both sealed and unsealed samples were provided, with column 1 being time in hour, column 2 being compressive strength in MPa, column 3 being Poisson's ratio and column 4 being elastic modulus in GPa.

2. Experimental Design, Materials and Methods

2.1. Materials

9 mix designs for UHPC, detailed in [1], with varying water to binder radios and silica fume dosages were used. Two types of binder materials were used, which are sulphate resisting cement (Type SR) and densified amorphous silica fume.

2.2. Experimental Design and Methods

2.2.1. UHPC early-age shrinkage

UHPC early-age shrinkage was obtained by adopting 6 steel moulds with dimensions of 250 × 250 × 110 mm and half of them were for sealed shrinkage measurement, whilst the other half were for unsealed shrinkage measurement. The shrinkage strain was automatically recorded by two LVDTs, mounted on two opposite mould walls. For each LVDT, there was a shrinkage anchor with enlarged end connected to ensure sufficient grip force and sat on ball bearing bushes to reduce friction. In addition, the shrinkage anchors were inserted 20 mm into the specimen to further improve grip force.

Steel sealing covers were used to control sealing conditions of shrinkage measurement and the clear distance between the cover and sample is 10 mm to contact and adhesion between them. To reduce friction between specimen and mould wall, the bottom and two side surfaces were covered by PTFE sheet. In addition, two 3D printed plastic sheets with many small protuberances were placed between the specimen and the mould surface perpendicular to shrinkage recoding direction, in order to reduce adhesion. Once UHPC pouring was finished, all 6 moulds were transferred to a cabinet with controlled temperature and humidity, followed by recording, started from 3 h after water addition to 7 days.

2.2.2. Internal temperature and relative humidity

Two steel moulds with the same dimensions as shrinkage moulds in Section 2.1, but without shrinkage anchors and LVDTs, were employed. The internal temperature and relative humidity of UHPC samples were measured by 18 sensors. The 18 digital sensors (model SHT21) for simultaneous measurement of relative humidity and temperature had temperature and relative humidity operational range of −40 °C to 125 °C and 0% to 100%, respectively. The accuracies of relative humidity and temperature are 2% and 0.3 °C, respectively. Half of the sensors for unsealed specimen measurement were placed through a grid to ensure sufficient support and exposed top surface at the same time. The other half for sealed specimen measurement were placed through 9 holes on a steel cover, with any gap sealed to ensure proper support and sealing conditions. Relative humidity and temperature at 9 different positions and the middle height of the UHPC sample were measured. The distance between the centre of each sensor was 94 mm. Once UHPC pouring was finished, specimens were transferred to a cabinet with controlled temperature and humidity, followed by recording, started from 3 h after water addition to 7 days.

2.2.3. TGA

To perform TGA tests, UHPC paste samples, weighing less than 10 mg were first ground. Each sample was then heated from 30 °C to 1000 °C at the rate of 10 °C/min in nitrogen atmosphere, by a Mettler Toledo TGA testing machine to record weight change. For each mix design, TGA tests were performed at 5 different concrete ages (27, 33, 72, 78 and 84 h). In addition, to calibrate UHPC paste TGA data when performing non-evaporable water content calculation, the blank crucible, dry cement and dry silica fume were also tested, using the same testing procedures.

2.2.4. Chemical shrinkage

To indicate sample volume change, a 500 mL Erlenmeyer flask and a measuring pipette with 2 mL capacity and 0.01 mL graduations, extending outside of the vessel were used. Approximately 50 g of UHPC paste was firstly placed into the Erlenmeyer flask, and paraffin oil was then carefully added to seal the sample. Two samples were measured simultaneously for each mix design with the measurements commencing 3 h after water addition and continuing until 7 days. A GoPro camera was used to record the liquid level change every hour over this period. This chemical shrinkage setup was modified based on ASTM C1608–07 [2] and the modification was based on the study of [3].

2.2.5. Material properties

Compressive strength was performed on 75 mm × 150 mm cylinders by a compression machine made by Seidner. The testing process is in accordance to ASTM C39 [4]. Young's modulus and Poisson's ratio were measured for each mix design at 48, 96 and 168 h after water addition using 75 mm × 150 mm cylinders. The cylinder was loaded to 40% of its compressive strength and two axial extensometers and one circumferential extensometer were used to record axial and circumferential deformation. The testing process is in accordance to ASTM C469 [5].

Data Availability

The dataset for the study of the effects of water to binder ratios, silica fume dosages on ultra-high performance concrete plastic and early-age shrinkage under controlled curing conditions (Original data) (figshare)

Ethics Statements

No ethics statement is relevant for the data.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT Author Statement

Ming Sun: Conceptualization, Methodology, Investigation, Data curation, Writing – original draft, Visualization; **Terry Bennett:** Conceptualization, Methodology, Writing – review & editing; **Phillip Visintin:** Conceptualization, Methodology, Writing – review & editing.

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Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dib.2022.108053.

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