RP1020

REDUCING BARRIERS FOR COMMERCIAL ADAPTATION OF CONSTRUCTION MATERIALS WITH LOW-EMBODIED-CARBON

Research Question

Geopolymer concrete (GPC) is expected to reduce 80% carbon dioxide emission compared to conventional ordinary Portland concrete (OPC). Carbonation process of GPC is yet to be investigated in fully understanding the corrosion mechanism of the green concrete material. The changes of pH value in concrete have been considered as a key indicator of carbonation process. Current method measures concrete pH value through core drilling and powder sampling, which is destructive and fails to monitor in-situ pH value continuously.

Methodology

This research aims to measure real-time pH value within GPC through embedding electrode sensors in concrete. The pH electrode sensor from Emerson Electric Co. was deployed in the experimental study, as shown in Figure 1.

Figure 1: pH electrode sensor system (Model: Emerson General Purpose 3900)

Two sensors are embedded into GPC cylinders with 100 mm and 20 mm depths from the bottom of the specimens respectively (See Figure 2). After 7-day curing process, one specimen was placed in a carbonation chamber with 1% carbon dioxide for 6 weeks. The concrete grinding test was also carried out at the same time to provide referenced readings of pH value.

Figure 1: pH sensors embedded in GPC cylinders

Results

The pH values of the two GPC specimens have been successfully collected and continuously recorded since June 2015. Figure 3 shows the pH values within the two specimens during the curing process for 7 days.

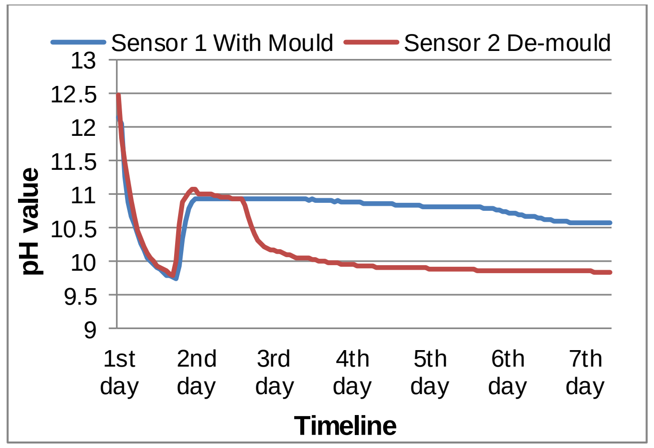

Figure 2: pH value during curing process

The original pH values for the two specimens were 12.2 and 12.4 respectively. They decreased to 9.7 when the concrete specimens were heated in the oven and then recovered to around 11 in the ambient temperature. The drop of pH value for the sensor 2 (De-mould) was observed from 3rd day. This is mainly due to the humidity loss around the sensor tip.

Saturation tests were conducted to verify the effects of moisture to the pH readings. Figure 4 shows the results after saturating the two specimens in water for six hours. It is found the pH results increased gradually and then stabilised after several days. The difference of pH value between the two specimens was confirmed to be 0.4 after saturation. This is considered as carbonation effect as the specimen 2 has been exposed to the carbonation environment for six weeks.

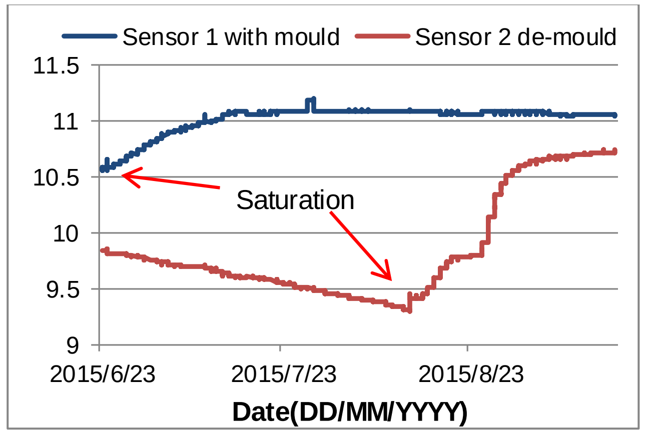

Figure 3: pH value after saturation tests

Table 1 compares the pH results from sensor measurement and grinding test. The absolute values of sensor measurement are slightly lower than grinding test results due to the humidity loss in concrete. The pH change of 0.4 after carbonation is consistent for both methods.

Table 1: pH value after carbonation measured by two methods

Phase	Sensor Measurement	Grinding Test
Initial	11.05	11.45
Carbonation	10.68	11.02

Conclusions

An innovative approach to monitor in-situ concrete pH value has been developed in this research project to study the carbonation process of GPC. The laboratory testing results verify the new sensing system can effectively measure the changes of pH value for GPC due to carbonation. It is also found the pH readings are affected by humidity and temperature. In future research, the humidity and thermal effects will be investigated to calibrate the outputs from the electrode pH sensors.

Anticipated impacts

This is the first attempt to continuously monitor the pH value within the GPC, which is very helpful to understand carbonation process and corrosion mechanism of GPC.

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