EVALUATION OF THERMAL CRACKING SENSITIVITY OF BLENDED PORTLAND CEMNET CONCRETES

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1. Introduction

Cracking of concrete is a popular problem for engineering field. Occurrence of cracks let aggressive agents easier to enter into concrete and thus accelerate deterioration process such as carbonation and reinforcing bar corrosion. It is well known that thermal cracks in early age can appear due to hindrance of temperature induced movement generating restrained stress that exceeds the tensile strength of concrete.

Fly ash and blast furnace slag is industrial by-products, which bring advantages in concrete production for cost reduction, durability and environmental preservation. These mineral admixtures have been utilized in mass concrete to possibly mitigate the risk of thermal cracking by low heat generation during the hydration.

This paper is to present evaluation of early age thermal cracking sensitivity of the concrete containing fly ash and slag as partial replacement by Portland cement. The temperature history and stress of specimen under restrained degree of 100% were measured by a temperature stress testing machine (TSTM). The test results were discussed and thermal cracking sensitivity was evaluated.

2. Experimental program

2.1 Equipment

A TSTM in laboratory used to measure uniaxial restrained stress of a 120x120x1200-mm specimen was shown in figure 1. The whole of measuring system was automatically managed by a computer program. The temperature inside specimen was recorded by two temperature sensor. The deformation was measured by two displacement measuring systems. Before 24 hours, measurement was recorded by two linear variable displacement transducers (LVDT) between the two cross-heads and after 24 hours, a new one system with two other LVDT was applied to measure deformation of specimen through two anchors inserted into concrete while casting in position of both cross-heads (figure 2).

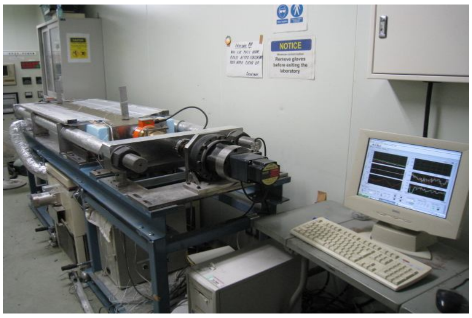

Figure 1 Thermal stress testing machine (TSTM)

Figure 2 Installation of displacement transducers after 24 hours

2.2 Test conditions

A full restraint condition was achieved by the computer program that controlled the step motor to apply a confining force on the adjustable cross-head to drives it return to original position whenever deformation of specimen exceeded a threshold value of $0.5x10^{-6}$ m. Thus, full restrained stress could be measured.

To simulate a temperature condition which is similar to the in-site situation of mass concrete, a semi-adiabatic condition was adopted by using a temperature controlled chamber the air temperature surrounding specimen was kept 0.1^{0}C lower than that of specimen center.

2.3 Material and test procedures

Materials used to make concretes were ordinary Portland cement, crushed lime stone, and natural sand, 78S type water reducer. Fly ash and slag used were two

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common types in Japan.

The mix proportions are listed in table 1. Three concrete mixtures as CT, FA, SG is respectively denoted as normal, fly ash and slag concrete. The replacement ratio of fly ash and slag with Portland cement were 30% and 45%, respectively. Water to binder ratio (45%), dosage of 78S (2Kg/m^3), amount of binder (400Kg/m^3) and sand to aggregate volume ratio (48%) were the same for all mixture.

Table 1 Concrete mix proportions

Mix no.	C	FA	SG	S	G	Water	78S
	Kg/m^3						
CT	400			844	942	180	2
FA	280	120		823	919	180	2
SG	220		180	838	936	180	2

C: Ordinary Portland cement, FA: Fly ash, SG: Blast furnace slag, S: Sand, G: Coarse aggregate, 78S: water reducer

After mixing, fresh concrete was placed in mold of TSTM and right after the two anchors were embedded into concrete in positions of both cross-heads. Two hours afterward, the surface of the specimen was covered with a slightly wet cloth and wrapped with two layers of plastic sheet to prevent the moisture loss due to both drying and water absorption of the specimen from cloth. Twenty fours hours later, the lateral and bottom molds were separated from the beam allowing it to deform freely over three-roller supports without friction disturbance, subsequently the new displacement measuring system was installed to measure deformation of specimen. The measuring processes lasted until the specimen temperature returned to indoor temperature and it was afterward cooled artificially till cracked, or the specimen cracked.

3. Test results and discussion

Test results of tensile strength at 7-day age and temperature history, restrained stress of various concrete are shown in figure 3 and 4, respectively.

It can be seen under full restraint condition that the normal concrete CT cracked before its temperature returned to indoor temperature whereas fly ash concrete FA could overcome from cracking after its temperature had returned to room temperature. It was cracked after its temperature was dropped 1^{0}C by cooling artificially at 140-hour age and the tensile stress was suddenly increased 0.2Mpa. Therefore, it is obvious that the thermal cracking sensitivity of fly ash concrete is lower than that of normal concrete.

In the case of slag concrete SG, experimental result expressed that its thermal cracking sensitivity is highest. It cracked at temperature of 33^{0}C that is higher than cracking temperature of CT, 28^{0}C. Due to a lower tensile strength and a higher development rate of tensile stress, SG cracked sooner regardless its lower evolution of temperature rise than that of CT.

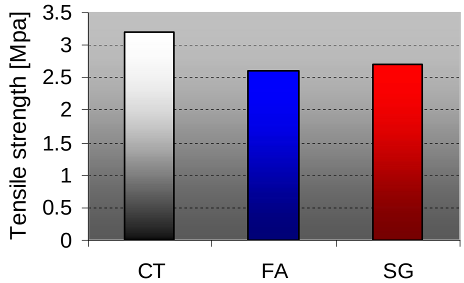

Figure 3 Tensile strength at 7-day age

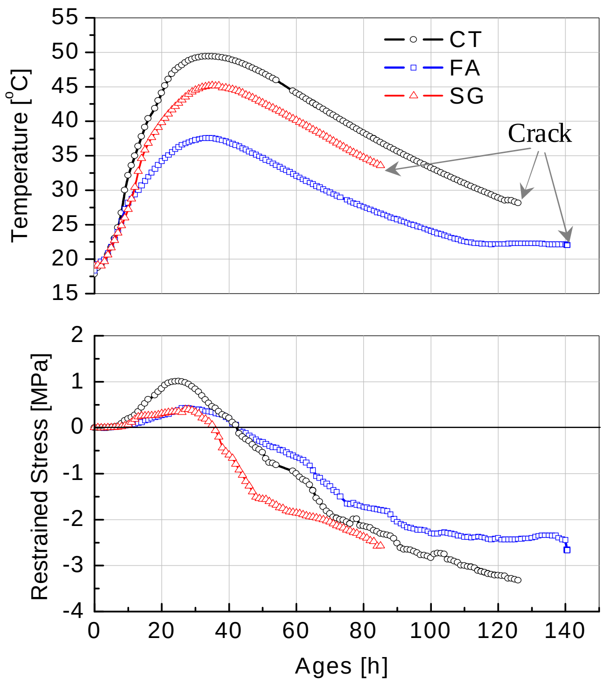

Figure 4 Temperature history and restrained stress

4. Conclusions

(1) Under a same restraint condition of 100%, the thermal cracking sensitivity of normal concrete is higher than that of fly ash concrete.

(2) The thermal cracking sensitivity of slag concrete is higher that that of normal concrete.

Reference

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