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ENHANCEMENT OF SELF-HEALING IN CEMENTITIOUS MATERIALS

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ABSTRACT

This paper presents an experimental study on autogenous healing in a recently developed shrinkable polymer cementitious material system. The basic concept of the material system tested is illustrated in figure 1. Small scale hollow prismatic mortar beams with un-bonded shrinkable polymer tendons were loaded under three-point bending until a crack of predefined width had formed. The specimens were then subjected to a range of combined heating/curing regimes to activate the shrinkable polymer to provide crack closure and to promote autogenous healing of the cementitious material prior to reloading to failure.

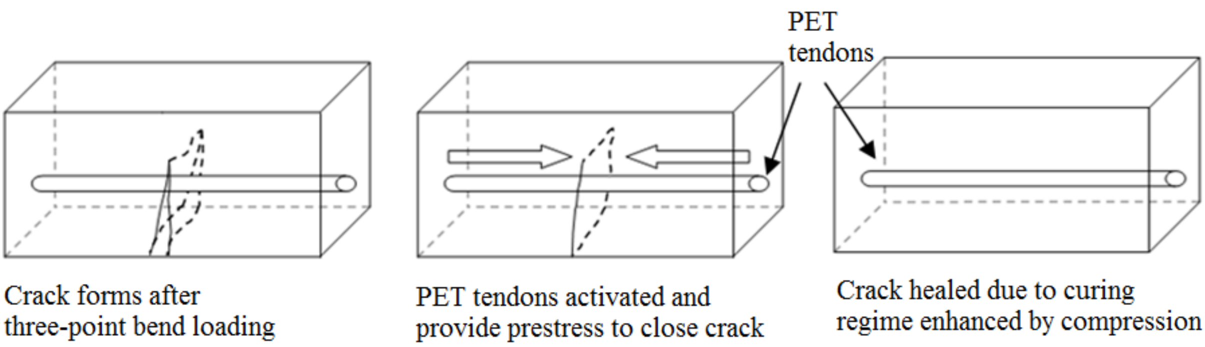

Figure 1: Concept of developed material system

The experimental procedure adopted in the proof of concept tests described by Jefferson et al. [1] was also used for this experimental investigation. This comprised small scale hollow prismatic mortar beams that were tested in a series of three-point bend experiments. The shrinkable polymer tendons comprised 75 individual Polyethylene Terephthalate (PET) strips, each measuring 6 mm x 0.046 mm. The PET tendons have been subject to a parametric investigation described by Dunn et al. [2].

The experimental procedure was divided into 3 stages. Stage 1 consisted of casting the specimens (day 1), curing the specimens in sealed conditions (days 1–4), and loading the specimens to a predetermined crack width (day 4) under three-point bending. During stage 2 the specimens were subject to heating (starting on day 4 for 18 hours) in order to activate the PET tendons and were then subject to a healing regime (48 hours) in order to promote autogenous healing. The specimens were loaded to failure in stage 3 (day 8) in order to identify whether the tendons had effectively closed the pre-formed crack and whether any autogenous healing had taken place. It is noted that henceforth the heat activation and healing regime conducted during stage 2 will be referred to as the AH regime. Three AH regimes were investigated for stage 2 as shown in table 1.

Twelve 145 mm x 25 mm x 25 mm specimens were cast for each of the AH regimes and the twelve specimens were divided into four groups of three beams. Three of the beams had the polymer tendon left inside the beam for all stages (PET specimens); three of the beams had the tendon left in place for stages 1 and 2, but removed before stage 3, (PETr specimens) and six control beams were tested to failure with no tendons, stage 3 (Ctrl2 specimens). Material tests were also carried out using six small scale 25 mm x 25 mm x 25 mm cubes to determine the compressive strength and six 160 mm x 40 mm x 40 mm prismatic mortar beams, three of which were used for fracture energy tests and three for elastic modulus tests.

Table 1: Heat activation and healing (AH) regimes

AH regime	Heat activation method			Healing regime	
	Description	Temp. (°C)	Time (Hrs)	Description	Time (Hrs)
1	Dry heat activation	90	18	Cured in water at ambient temperature	48
2	Steam heat activation	90[a]	18	Specimens left in the steam chamber with the steam production turned off and the chamber allowed to return to ambient conditions	48
3	Water heat activation	90	18	Specimens left in the water tank with the temperature allowed to return to ambient conditions	48

three of which were tested at stage 1 (Ctrl1 specimens) and three tested at
Note: [a]the atmospheric temperature was measured at 90 ^{o}C and the water in the tank was heated to 100 ^{o}C in order to produce steam conditions.

The experimental investigation demonstrated that crack closure and autogenous healing can be achieved on small scale hollow prismatic mortar beams post tensioned with shrinkable polymer tendons. Crack closure was achieved as a result of the shrinkage stress developed by the activated tendons. Two of the regimes adopted for activating and healing the specimens also demonstrated effective autogenous healing, namely, dry heat activation and water based healing (AH1), and steam activation and healing (AH2). In the former case, the initial mechanical stiffness was recovered and strength recoveries of approximately 80 % (PETr) and 125 % (PET) were achieved and, in the latter case, the initial mechanical stiffness was again recovered and load recoveries of approximately 80 % (PETr) and 200 % (PET) were achieved. It is concluded that both dry heat activation followed by water curing, and steam activation and curing are both effective heating/healing regimes, with the latter providing the highest prestress force.

Only 16% of the initial strength was recovered in specimens activated and healed in water at 90 °C (AH3) although the regime did activate the tendons and produce sufficient prestress to achieve crack closure. It is believed that the reason for the reduced level of self-healing in this case was related to the formation of bubbles in the crack which may have impeded the healing process.

REFERENCES

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