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SELF-HEALING CONCRETE STRUCTURAL ELEMENTS

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ABSTRACT

Introduction

Self healing agents are introduced in host materials to create systems that have the ability to sense and repair the defects automatically and thereby reduce or delay subsequent damage. The idea of creating self-healing function in concrete has stopped short at the conceptual phase of small scale mortar beams, partly due to the difficulties arising in the casting such as the impact of aggregates. This current research is an extension of the study by Tran et al. [1] where self-healing units (SHU), comprising of adhesive POR-15 enclosed in hollow glass tubes with inner and outer diameters of 5mm and 7mm respectively, are introduced in three key structural elements, namely beam, column and slab. The glass tubes are coiled with spiral wire followed by a 3.5mm thick mortar layer to protect the SHUs from premature damages during casting. The efficiency of self healing is qualified by the recovery of member stiffness in the structural elements after each loading-recovery cycle.

Self-Healing Beam

Fig. 1 shows the configuration of the self-healing beams. The beams were loaded with displacement-control under 4-point bend and were unloaded when leakage of healing agent was detected. They were unloaded and rested for 7 days to allow healing before they were re-loaded until fresh leakage of healing agent was detected. This unloading-reloading cycle was repeated twice and each time, new cracks were formed while the old cracks remained sealed as shown in Fig. 3(a) & (d), clearly demonstrating that the healing strategy is effective and the beam possessed multiple self-healing abilities. Results showed that the self-healing beams were able to recover 84% of its virgin stiffness after healing.

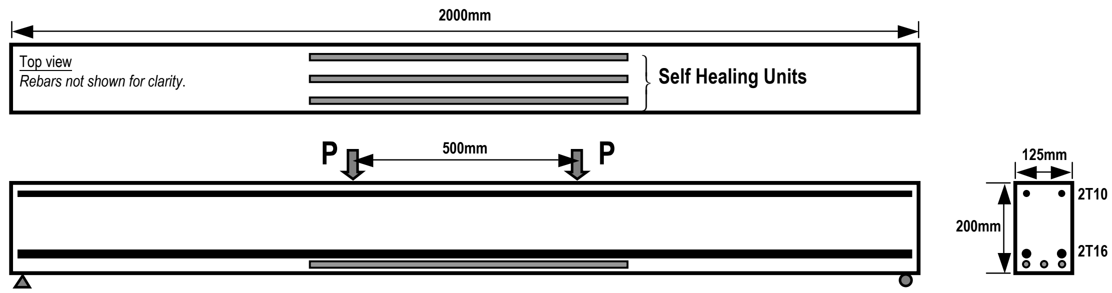

Fig. 1: Configurations of Self-Healing Beam

Self-Healing Column

The SHUs are embedded in column to investigate the effect of healing when the flow of the healing agent is not assisted by gravity. Fig. 2(a) shows the set-up of a cantilevered column which has SHUs tied to the longitudinal reinforcement bars. Short self-healing units were used and acted as compartments to prevent all healing agent from flowing into one single crack, and hence, allowing multiple healing. Analogous to the observations in self-healing beam tests, the presence of newly formed cracks and absence of crack re-opening shown in Figure 3(b) & (e) demonstrate that the self-healing column was able to perform multiple autonomic healing. The efficiency in healing is compared with a control column without SHU whereby the self healing column recovers up to 70% of its initial stiffness while the control beams suffers from continuous stiffness degradation.

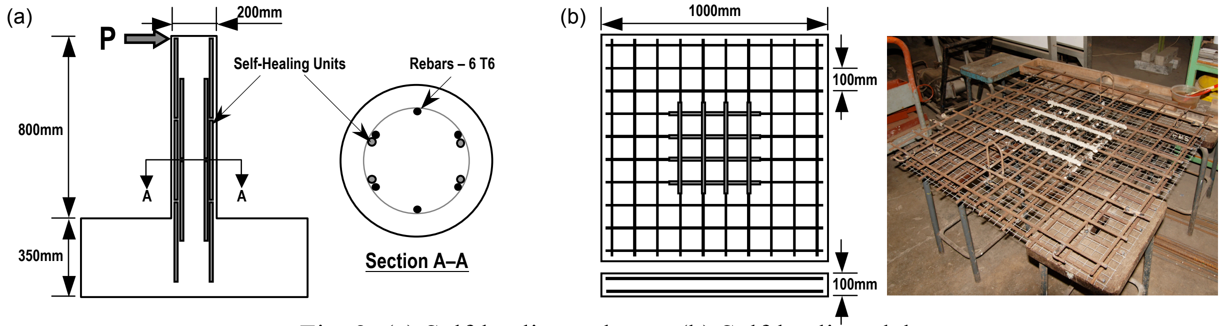

Fig. 2: (a) Self-healing column; (b) Self-healing slab

Self-Healing Slab

Fig. 2(b) shows the rebar and SHU arrangement for the slab element which was evaluated for its self-healing efficiency when subjected to repeated impacts by a 20kg weight dropped from a constant 2-m height. The slabs were pinned at 2 opposite edges. The self-healing slab was subjected to repeatedly impacts until the release of healing agent was spotted and it was subsequently left to cure for 7 days before being tested again. The tests on the control slab followed the same procedure as the self-healing slab. To quantify the effect of self-healing, the static stiffness before and after impact were compared. The results of the test showed that the control slab suffered from a continuous loss in stiffness after each impact and failed after 3 test sequences. In contrast, the self-healing slab exhibited a strong recovery with up to 99% of the stiffness being recovered. Similar to the self-healing beams, crack reopening was not observed after healing.

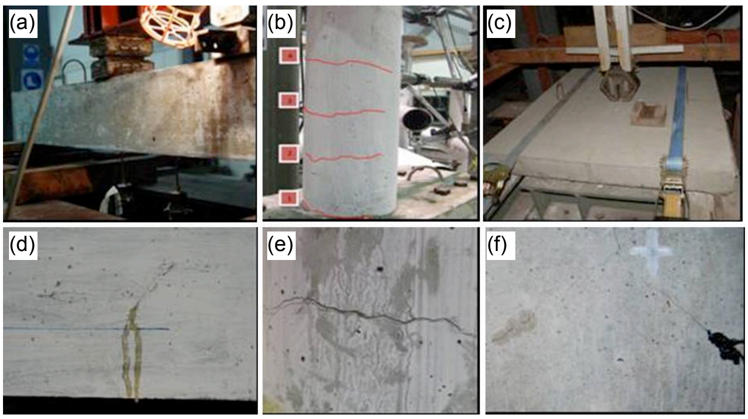

Fig. 3: Testing of self-healing concept in concrete elements. (a) beam; (b) column; (c) slab. Self-healed cracks in (d) beams; (e) columns; (f) slabs.

Conclusion

This paper addresses the implementation of self-healing function in three key structural members namely, beam, column and slab. The self-healing beam exhibited multiple crack healing capabilities with 84% of the initial flexural stiffness being recovered. Self-healing function was also introduced in column element where a stiffness recovery of up to 70% was reported despite the crack planes being normal to the direction of the gravity flow. The self-healing slab was assessed for its healing capability when subjected to multiple drop weight impacts. Again, multiple crack healings were observed with the maximum healing efficiency, in terms of stiffness recovery, found to be 99%.

REFERENCES

[1] Tran DPT, Tay JSJ, Quek ST and Pang SD, Implementation of self-healing in concrete – Proof of concept, *The IES Journal Part A,* **2**, 2008, pp. 116-125.