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Development of Self Repairable Concrete System

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ABSTRACT:
This study aims to develop self repairable concrete as a new method for crack control and enhanced service life in concrete structure. This concept is one of the maintenance-free methods which, apart from saving direct costs for maintenance and repair, reduce the indirect costs. We are going to develop the self-repairing concrete by adding the materials from inside the concrete to repair. Our technique to develop self-repairing concrete consists of embedding repairing materials in hollow ducts in the repairing zone before it is subjected to damage. Therefore when cracks occurs this repairs materials will get released from inside and it will enter the repairing zone. Where it will penetrate into cracks and rebound to mother material of Structure and it will repair the damage.

KEYWORDS: *Concrete – Serviceability – Cracks - Epoxy resins - Repairs*

I. INTRODUCTION

The serviceabilitylimit of concrete structures by cracking might be overcome by crack control methodologies; the enhanced service life of concrete structures would reduce the demand for crack maintenance and repair. In particular, the utilization of self-repairing technologies has high potential as a new repair method for cracked concrete. The usual approaches for repair of structural concrete are: polymer injection, prestressing,Geomembranes, and polymer wraps.These techniques seek a ductile, less brittle failure. A ll ofthem are based on addition of a repair materialto concrete from the outside in; We add the materials from in side the concrete to repair. Our technique is to develop self-repairing concrete consists of embedding repairing materials in hollow ducts in the repairing zone before it is subjected to damage or crack. Therefore when cracks occurs this repairs materials will released from inside duct and it will enter the repairing zone. Where it will penetrate into cracks and rebound to mother material of structure. The cracking and damages are associated with low tensile strain capacity of concrete, get repaired with our chemical present inside. Thus we repair the problem where it occurs and just in time automatically without material intervention. Hence technique we utilized does precisely that it adds more materials to the concrete repair zone from inside upon demand when it is triggered by events such as cracking. Our approach consists to address the bonding problem of repair material from inside the concrete therefore definitely better technique compared to other methods. It is seen that self-repairing performs better because the resin is flexible itself and keep on releasing the each brittle failure that is cracks. The internal released stiff resins are less brittle, more ductile and stronger in tension as compare to concrete. This type of technique is useful for structural member subjected to bending, shear cracks, etc. This approach of self-repairing is useful for bridges having pre-stressed box girders where dynamics, moving loads cyclic loads are in huge quantity and development of minor to major cracks possibility is more.

II. WORK EXECUTED BY DIFFERENT RESEARCHERS

In literature survey last 20 years different research has develop the self-repairing techniques in different country under different climatic conditions, assumptions, and materials, etc. Out of which Dr. Carolyn Dry from USA has developed the practical technique of Development of self-repairing durable concrete [1]. In his work investigation was made into development of transparent polymer matrix composites that have the ability to self-repair internalcracks due to Mechanical loading. In his work focused on cracking of hollow Repair fibers disposed in a matrix and subsequent release of repair chemicals in order to visually assess the repair and speed of repairs in the impact test the polymer specimen was released in ten seconds. Similarly, Mihashi and Yoshio proposed incorporating glass pipes containing the repairing agent into the concrete for self-healing capabilities to restore strength and for the prevention of water leakage [2]. This concept was also utilized by Li et al. who incorporated hollow glass fibers containing ethyl cyanoacrylate, a thermoplastic monomer, into the mix [3]. This filled hollow-fiber method has been successful in other concrete systems as well as reinforced polymers and epoxies [4-10], but limitations such as a lack of ease in manufacturing have made these products undesirable for commercial use. Sottos et al. have developed a polymer composite system that incorporates a catalyst into the polymer matrix phase with a microencapsulated repair agent [11]. The healing agent is released upon crack propagation through the microcapsule, resulting in as much as an 80% recovery of toughness after a fracture. This method has been successfully demonstrated in various polymer composite systems [12-14].

III. SELECTION OF MATERIAL

In development of self-repairable concrete system main component i.e. resin and hardener were selected such that, it will get mixed together after formation of crack and will get set within crack with addition of sealing it. Some criteria for the selection of resin considered are,

a) The material should be able to repair different types and sizes of damages.
b) It should be economically viable.
c) It should be easily available in market.
d) While using the chemical it should not cause hazardous effects.
e) It should establish good quality assurance and reduce life cycle cost.
f) It should withstand different forces and dynamic loads.
g) It should have satisfactory properties like compressive strength, viscosity and pH.

pH value is such that it will not cause any corrosion to the reinforcement. Viscosity of both the chemical shall be such that it will seal the minor cracks like shrinkage or temperature cracks. Working temperature of both the solution shall be wide. Void former of polyurethane selected so that it can be easily removed from concrete specimen as there is no friction between surfaces. This void former material is elastic and easily available in various diameters.

Fig.1 Polyurethane pipe as void former 6mm outer diameter

Fig.2 Epoxy resin(Dropoxy 7250)

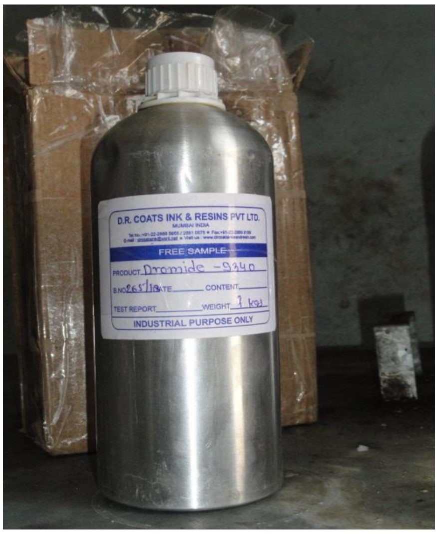


Fig.3 Hardener(Dromide 9340)

IV. TEST METHODOLOGY

The methodology is mainly designed for flexural member and for crack formation within that member due to different loadings. To carry out one point flexural test a concrete specimen of 300mm x 70mm x 1000mm with 6mm dia. mild steel bars is such selected do that it will be a flexural member with sufficient width so that matrix of hollow ducts can be laid along it on the tension side of section. In the initial stage of testing we have provided ducts in two layers along the length and width in cover area of reinforcement of member with the help of polyurethane material of 6mm diameter. This Ducts then alternately filled with epoxy solution and hardener. Idea behind is when crack formation under loading will take place this two solutions will get mixed with each other forming hard compound together which will seal the crack.

Fig.4 Shuttering for test specimen fitted with void formers

After fixing the void formers and reinforcement concreting was done in number of layers and successive vibration.After finishing with concreting specimen was allowed to set for 24 hr. After 24 hr. void former was removed by simple pulling from one end of specimen. Then slab specimen was separated from shuttering.one control specimen was also made same as main specimen but duct system was not provided. Slab specimen were then placed into the water curing tank for 28 days. After 28 days samples were taken out from curing tank and kept in air to dry it properly. This ducts then filled with alternate resin and hardener under gravity flow and it was ensured that no any air pocket will get formed. After filling of ducts with resin both end of specimen were sealed.After sealing ends, the slab specimen then tested with three point flexural loading. Load corresponding to hair crack formation, release of chemical through crack and proper visibility of solution noted along with deflection. After release of chemical from cracks, specimen then unloaded and kept for air curing for 7 days, this was done to allow chemical to get filled into the crack and seal the crack. Control specimen was also tested after 28 days curing,load corresponding to crack formation and also failure load was noted.

Fig.5 Slab specimen placed on one point flexure testing machine

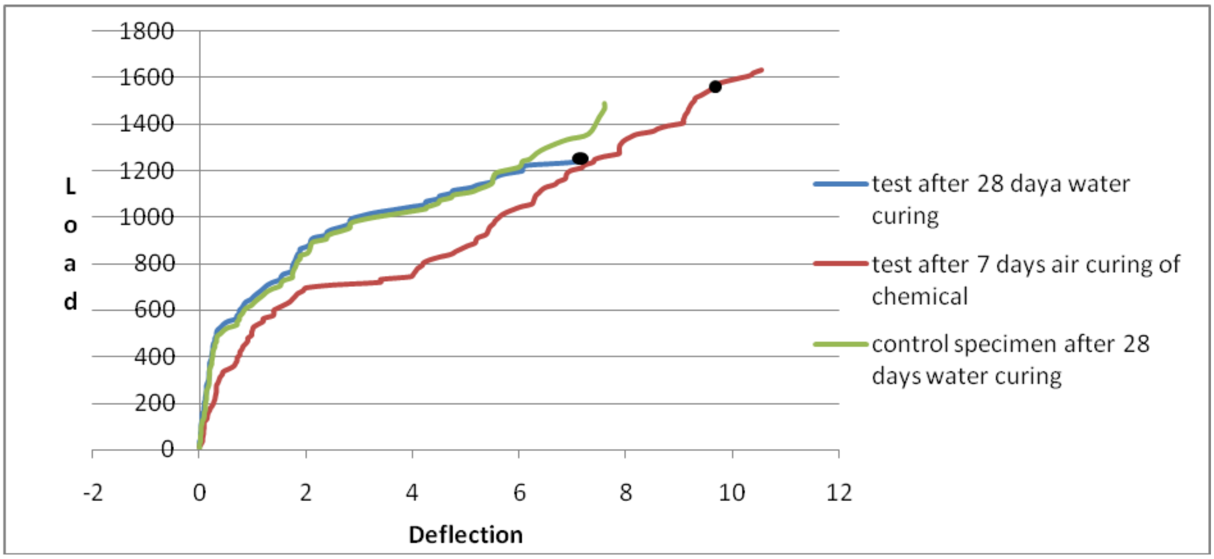
Fig.6 Propagation of crack to soffit of slab

Fig.7 Chemical is released and appeared on surface

Fig.8 Crack sealed with resins and hardener

V. RESULTS AND CONCLUSION:

1. In this research work the load carrying capacity of plain member or control specimen and member with chemical in duct is same. Hence no reduction in strength by providing duct and chemical.
2. After loading and air curing of hardener and resins together, load carrying capacity increased by 15-20 % than control specimen member. Hence strength increases after reaction between hardener and resins by air curing.
3. Three point bending test was carried out on the specimen after 28 days of curing by feeling the resins. Load is gradually added till resin getsreleased through the cracks. Same test was again carried out after 7 days to ensure the curing with resins.
4. Application of research work is for the structures subjected to cyclic loads and dynamic loads. i.e Bridge Girders, etc.
5. Control specimen was also tested after 28 days curing Graph showing load vs. deflection of specimen.



Graphical representation of test data

From this graph of case one of loading some observations are made that are as follows:

- In case of first test chemical visible on surface for load of around 1248 kg and in case of second test chemical getting released for load of around 1548 kg.

- Theoretical value of load for crack formation matches with the experimental value.
- Chemical is getting released through the cracks in desired way.
- Crack getting filled with the solution in proper manner.
- Crack getting sealed properly where there is proper mixing of resin and hardener

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