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Comparative Study of Self Healing Concrete & Traditional Concrete

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Abstract: *Concrete is one of most used building materials. However, it is one of a major producers of carbon dioxide (CO2) which is directly contributing to destroying our environment. Not to mention that enormous costs are being spent each year to maintain concrete constructions. Cracks of various sizes form in all concrete constructions which is need to be sealed manually shortening the life of a particular construction. On the other hand, Self-healing concrete (SHC) is a revolutionary building of material that has the solution to all these problems and is definitely the building material of the near future. Therefore, we need to understand its properties and mechanism and foresee how it impacts the architectural designs of the time to come, which standers are needed to create useful and aesthetic buildings and constructions.*

Keywords: Self-healing concrete, building material, smart material, mechanism, design, architecture.

1. INTRODUCTION

Crack formation in concrete is a phenomenon that can hardly be completely avoided for example shrinkage reaction of the setting concrete and the tensile stress occurring in set structure. While larger cracks can potentially hamper the structure's integrity and therefore require repair action, smaller cracks typically with crack width smaller than 0.2mm are generally considered unproblematic. Although such micro cracks do not affect strength properties of the structure, they do on the other hand contribute to the material porosity and permeability. The actual capacity of micro cracks filling appears primarily related to the composition of the concrete mixture. Particularly mixture based on the high binder content show the remarkable crack healing properties. What is due to delayed (secondary) hydration of the matrix embedded non hydrated cement and the binders particles upon reaction with crack ingress water.

2. RELATED WORK

To achieve the extended service life of the concrete material, expansive chemicals and microbial induced calcium carbonate precipitation are used, which induced autonomous healing of cracks in concrete. Various approaches are adopted to the develop self-healing cement based materials, where experiments are conducted to establish a new method of self-healing. However, comprehensive evaluations of the self-healing efficiency are not performed at the level of macro-, micro- and nano scale. Existing approaches evaluated of the self-healing efficiency at the macrostructure level. These are based on the durability criterion of the water absorption of chloride and acid

resistance. Tests at microstructure level are of the commonly performed to maximize the reliability of the results. Only few tests are the conducted at of nanostructure level. It is worth to review all of the available tests and methods on self-healing efficiency assessment of cement based materials to develop innovative experimental strategy.

3. METHODOLOGY

Problem Statement

- Weak structural nature of old concrete buildings leads to cracks micro as well as macro.
- Due to extensive traffic on concrete roads, live load gets generated leading to wear and tear of the roads. Water percolates through the cracks reaching the sub surface layer thus disturbing the structural integrity. This affects the durability of roads and can have hazardous impacts on the traffic.
- Due to their ancient nature of construction, fort has excellent durability yet due to the seasonal variation and weathering of rocks, their condition is started to deteriorate.
- Temperature variation leads to disturbance in the homogenous nature in the concrete structures leading to gradual formation of cracks.
- Conventional methods of production of bricks lead to environmental pollution and also wastage of the bricks.

Fig. 1

Case Study

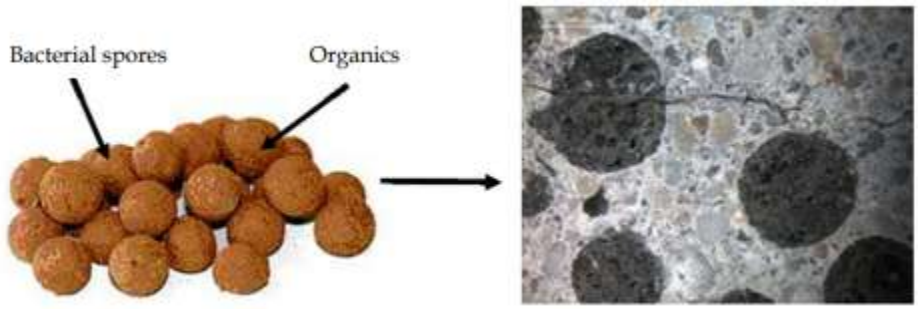

Fig. 2

Concrete test specimens were prepared in which the part of a aggregate material, i.e. the 2-4 mm size class, was replaced by the similarly sized expanded clay particles loaded with the biochemical self-healing agent (bacterial spores 1.7x105 g-1 expanded clay particles, corresponding to 5x107 spores dm-3 concrete, plus 5% w/w fraction calcium lactate, corresponding to 15g dm-3 concrete). Before application, loaded expanded clay particles were oven-dried until no further weight loss due to water evaporation was observed (one week at 40ºC). Control specimens had a similar aggregate of the composition but these expanded clay particles were not loaded with the bio-chemical agent. Both the types of expanded clay particles (empty for the control specimens and loaded for the bacterial specimens) The amount of light weight aggregate applied in this case represents 50% of the total aggregate volume. Replacement of the such a high fraction of the sand and gravel for expanded clay has consequences for strength characteristics of the derived concrete. In this specific case of a 50% decrease in compressive strength was observed after 28 days curing when compared to specimens of similar aggregate composition without replacement of sand and gravel fractions for expanded clay particles.

This case study portrays the advantages of the cement treated with the self healing agents in the form of comparison between amount incurred in construction of cement road with conventional cement mix vs. the cement treated with self healing agents. For the purpose, a cement road of 2km from Kolhapur toll to Shivaji University.

This cement road is a two lane road prepared using conventional methods.

- Length of road = 2 km

- Breadth (2 lanes)= 24 m
- Depth = 0.38 m
- Volume = 18,240 m

4. RESULT & DISCUSSION

- There is still an ongoing of the research regarding SHC; many scientists are trying different approaches that ensure the same outcome which is closing cracks with minimum intervention while keeping cost at reasonable rates. SHC is much more effective than concrete; A brief comparison of some aspects is tackled below.

- **SAFETY**

  Since cracks in SHC are easy to close with no extra costs being added, the general safety of a particular construction is increased. However, that the leaves a question regarding of the resistant ability of concrete and whether crack closing would affect its strength. All of the research conducted so far show that the concrete gains about 25% of its original strength in the healed spot which more than the 15% gained back when the crack is sealed by current methods.

- **COST**

  It is obvious that the initial cost of the construction of using SHC is higher, however, on the long-term, durable concrete is much more cost-efficient due to the low cost of maintenance, durability and the long life-span of the construction.

- **DURABILITY**

  According to research and experimentation of the bacteria-based SHC is denser and more durable than concrete.

- **AVAILABILITY**

  As it is a still under development & this kind of concrete is used on a limited scale and still not a commercially wide-spread. Some main obstacles are cost and production.

- **EFFECTS ON ARCHITECTURE & DESIGN**

  By increasing the life-span of a construction, architects need to re-consider design standers. A long life-span impacts the design of any construction, as architects must take into consideration future prognosis of two main aspects.

5. CONCLUSION

- In this study it is concluded that over a long lifespan of the mega structures, use of SHC is economical as compared to traditional concrete.
- Suitability of SHC is more in the parts of the structure where maintenance cannot be done easily.
- Minimal chances of the corrosion of reinforcement due to the leakage proofing reducing the cost of epoxy coating.
- Durability of the structure is increased.
- Metabolic activities of some specific microorganisms in concrete are responsible to improve the performance of concrete. It has been hypothesized that of almost all the bacteria are capable of CaCO3 production because precipitation occurs as a byproduct of common metabolic processes such as photosynthesis, ammonification, denitrification, sulfate reduction and anaerobic sulphide oxidation. Even the effect of bacteria on the various parameters in the concrete proves to be beneficial development. Based on the studied properties like compressive strength, permeability, water absorption, chloride ingression, the microbial mineral precipitation appears to be a promising technique at this state of development.

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