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Experimental study on self healing concrete by using bacteria(Escherichia coli)

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Abstract— The extent of deterioration to concrete structures globally is occurring at an alarming rate, which challenges engineers throughout the world on a daily basis. This includes damage to bridges, buildings, parking structures, environmental facilities, as well as other structures. Unfortunately, repair costs can be staggering. The micro-cracks and porosity of concrete structures are very common problems due to the fact that this material has a high permeability which allows water and other aggressive media to enter thus leading to deterioration. Recent investigations in the field of biotechnology show the potential of bio-inspired materials in the development of low toxic solutions. Calcium carbonate is one of the most well known mineral that bacteria deposit by the phenomenon called bio-cementation or microbiologically induced calcite precipitation (MICP). An alkalophilic aerobic soil bacterium Escherichia coli was incorporated into concrete at different cell concentrations with the mixing water.

Index Terms—Calcium carbonate, Escherichia coli, cement, fine aggregate, coarse aggregate, water, self healing.

1 INTRODUCTION

1.1 Objective of project

Cracks in concrete are a common phenomenon due to the relatively low tensile strength. Durability of concrete is impaired by these cracks since they provide an easy path for the transportation of liquids and gasses that potentially contain harmful substances. If micro-cracks grow and reach the reinforcement, not only the concrete itself may be attacked, but also the reinforcement will be corroded. Therefore, it is important to control the crack width and to heal the cracks as soon as possible. Since the costs involved for maintenance and repair of concrete structures are usually high, this research focuses on the development of self-healing concrete. Self-healing of cracks in concrete would contribute to a longer service life of concrete structures and would make the material not only more durable but also more sustainable.

1.2 Scope of project

Concrete is one of the most used building materials. However, it is one of the major producers of carbon dioxide (CO2) which is directly contributing to destroying our environment. Cracks of various sizes form in all concrete constructions which need to be sealed

1.3 Introduction of bacterial concrete

As revolutionary as it was and still is, modern concrete (Lime-based) has a short lifespan caused by the formation of cracks shortening the longevity of a particular construction. Many researchers have been attempting to improve concrete in order to get a better longevity among many other things.

1.4 Definition of Self-healing

A self-healing material is described as a material that is capable of repairing itself back to the original state. The concept of self-healing concrete (SHC) that happens over time (autogenic) has been noticed for over 20 years.

2. MATERIALS AND METHODS

2.1 Materials

Ordinary Portland Cement (53 Grade)
Graded fine aggregates.
Graded coarse aggregates.
Water.
Bacteria = Escherichia coli
Calcium carbonate

2.2 Methods

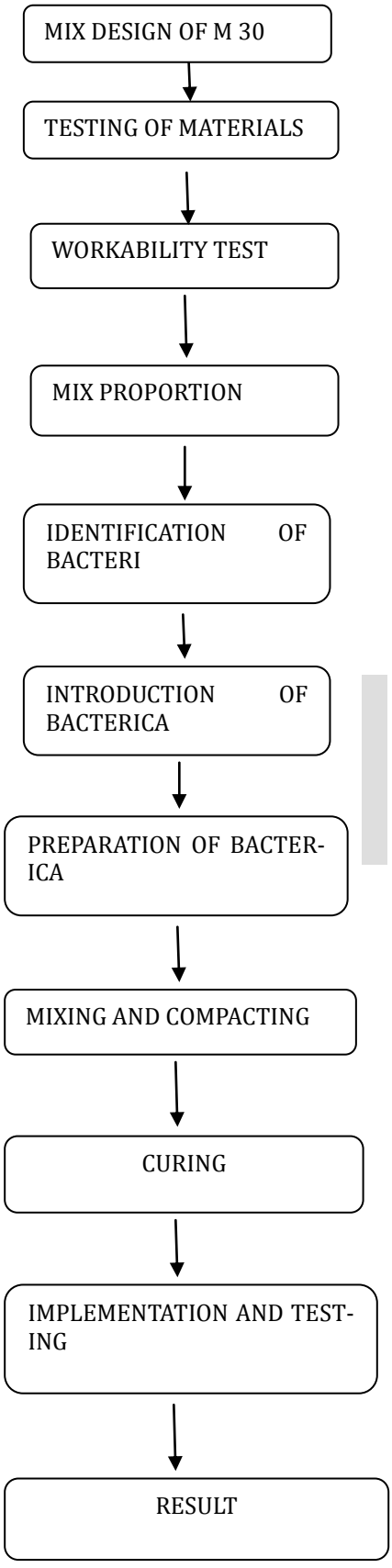


Table -1:

MIX PROPORTION				
Water	**Cement**	**Fine Aggregate**	**Coarse Aggregate**	**Bacteria E-coli**
186 Lit/m^3	502.7 Kg/m^3	482.32 Kg/m^3	1172.67 Kg/m^3	10 ml
0.37	1	0.96	2.33	10ml

2.3 Bacteria(ESCHERICHIA COLI)

Escherichia coli is an obligate aerobe bacterium used as a larvicide for mosquito control. It forms spherical end spores. Bacillus spherical is a gram positive bacteria, with rod shaped cells that form chains-Medium-sized, smooth colonies with an entire margin. and also Rod-shaped cells. Gram-variable, large, spore-forming rods with a diameter < 0.9 μm. Cataloes -positive. Lecithin's-negative. Does not attack sugars. Grow thing range of Temperature : 37oc Optimum Temperature- 35-37oc

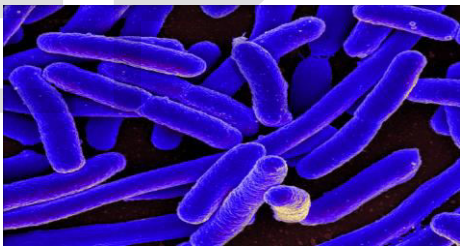


Fig 3.8

2.4 Ability of the Bacterial Concrete to Repair the Cracks

Both attention will be given on closure of cracks (blocking the path for ingress of water and ions) and on re-gaining mechanical properties. Cracks in concrete specimen subjected to various loading situations will be investigated before and after the healing. For this impregnation techniques and SEM will be applied. (scanning electron microscope). On the other hand the micro-organisms such as bacteria, cyono bacteria, algae, lichens, yeasts, fungi and mosses etc. Which are omnipresent and omnipotent are responsible for metabolism action that results in a microbial deposition of a protective CaCO3 layer. Aiso, this process results in re-establishment of the cohesion b\n particles of mineral building materials and protects against further decay of stone material. To prove the positive effects of microbial CaCO3 precipitation. The increase

in porosity in concrete leads to increase in capillary water uptake, increase in gas permeability along with higher carbonation rate, high chloride migration and freeze-thaw damage.

2.5 Hand Mixing

Hand mixing is practiced for small scale concrete works. Hand mixing should be done over an impervious concrete or brick floor of sufficiently large size to take one bag of cement. Spread out the measured quantity of coarse aggregate and fine aggregate in alternate layers. Pour the cement on the top of it, and mix them dry by shovel, turning the mixture over and over again until uniformity of colour is achieved. This uniform mixture is spread out in a thichness of about 20 cm. This operation is continued till such a good time a good uniform , homogenous concrete is obtained. It is a particular importance to see that the water is not poured but it is only sprinkled. Water in a small quantity should be added towards the end of the mixing to get the just required consistency. At that stage, even a small quantity of water makes difference. After that the bacteria medium is sprinkled over the concrete mixture.

2.6 Placing

It is not enough that a concrete mix correctly designed, batched, mixed, it is of utmost importance that the concrete must be placed in systematic manner to yield optimum results. The precautions to be taken and methods adopted while placing concrete in the moulds.

2.7 Hand Compaction

Hand compaction of concrete is adopted in case of small concrete works. Sometimes ,this method is also applied in such situation, where a large quantity of reinforcement is used, which cannot be normally compacted by mechanical means. Hand compaction consists of rodding, ramming or tamping. When hand compaction is adopted, the consistency of concrete is maintained at a high level. Tamping is one of the usual methods adopted in compacting roof or floor slab or road pavements where the thickness of concrete is comparatively less and the surface to be finished smooth and level.

2.8 Curing

Concrete derives its strength by the hydration of cement particles. The hydration of cement is not a momentary action but a process continuing for long time. Curing can also be described as keeping the concrete moist and warm enough so that the hydration of cement can continue. More elaborately, it can be described as the process of maintaining a satisfactory moisture content and a favorable temperature in concrete during the period immediately following placement, so that the hydration of cement may continue until the desired properties are developed to a sufficient degree to meet the requirement of service. The casted cubes and cylinders are immersed in water tanks for 3 days, 7days, 14 days and 28 days.

2.9 Workability of Concrete

Workability is the amount of useful internal work required to produce full compaction of concrete. It depends on, Workability is the amount of useful internal work required to produce full compaction of concrete. It depends on,

1. Types of aggregate
2. Grading of coarse and fine aggregate
3. Quantity of cement paste
4. Consistency of the cement paste

2.10 Slump Test

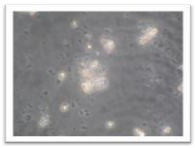
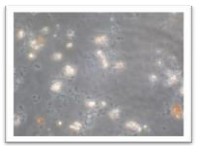
Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. The deformation shows the characteristics of concrete with respect for segregation The thickness of the metallic sheet for the mould should not be thinner than 1.6mm. for tamping the concrete , a steel tamping rod 16mm dia, 0.6 meter along with bullet end is used. The mould is then filled in four layers, each approximately ¼ of the mould. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section. After the top layer has been rotted, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by rising it slowly and carefully in a vertical direction. This allows the concrete to subside. This subside is referred as slump of concrete.

The value of slump = 90 mm

2.11 Bacteria Viability Test

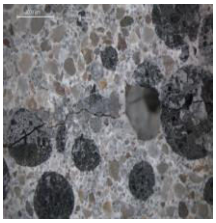
A piece of bacterial cement mortar of 365 days age was inoculated in nutrients broth and kept in orbital shaker for 24 hrs. After 24h incubation, a loop full of culture is taken from the broth and streaked on agar plate. Once colonies are formed their morphological characteristics and microscopic

observations match with Eshrecho coli. This confirms the presence of E - coli even after 365 days in cement mortar. Photo contrast pictures in Fig 6 shows that bacteria are still viable in cement mortar.

Phase contrast microscopic pictures identify microorganisms and white calcium carbonate crystals formation

3 RESULT




crack forming Crack self healing

4. CONCLUSIONS

As a conclusion, SHC appears to be much more efficient than usual concrete. It will definitely reshape how architects think and design. By comparison, we notice that it has more advantages than disadvantages and will transform concrete from an Eco-harming into an Eco-friendly material, as it reduces the CO2 emissions significantly (10ml to 40ml) than the conventional concrete. The conventional concrete is healing up to 40ml of E-coli bacteria But if more than 40 ml of bacterial solution is used, than the not healing for concrete. Therefore up to 40 ml of bacterial solution is preferred.

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