Research article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

# Study on Self Healing Concrete by Bacterial Media

**Meenakshi***

Department of Civil and Structural Engineering, SCSVMV, Enathur, Kanchipuram.

## ABSTRACT

In this project we are introducing bacteria into the water that used for making concrete which precipitate calcium carbonate when it gets into contact with water and food need for it, and precipitates calcium carbonate and seals the cracks.

Self-healing concrete consists of a mix with bacteria (Bacillus subtilus) incorporated into the concrete and calcium lactate food to support those bacteria when they become active. The compressive strength of concrete in seven, fourteen days is much greater than normal concrete. The compressive strength of concrete in twenty eight day is also greater than normal concrete. Considering the $10^5$, $10^6$, $10^7$ concentration of bacteria all are giving approximately the same compressive value at 28 day. So $10^5$ concentration of bacteria itself enough to get the increased strength of concrete.

**KEY WORDS:** Compressive strength, Concrete, Cement, Healing of concrete.

## *Corresponding author:

**P.Meenakshi***

Department of Civil and Structural Engineering,

SCSVMV,

Enathur, Kanchipuram.

Email : meena_perumal@rediffmail.com , Mob No : 9498025234

## INTRODUCTION

Concrete is a vital building material that is an absolutely essential component of public infrastructure and most buildings. Concrete will continue to be the most important building material for infrastructure but most concrete structures are prone to cracking. Tiny cracks on the surface of the concrete make the whole structure vulnerable because water seeps in to degrade the concrete and corrode the steel reinforcement, greatly reducing the lifespan of a structure. Concrete can withstand compressive forces very well but not tensile forces. When it is subjected to tension it starts to crack, which is why it is reinforced with steel; to withstand the tensile forces. Structures built in a high water environment, such as underground basements and marine structures, are particularly vulnerable to corrosion of steel reinforcement. Motorway bridges are also vulnerable because salts used to de-ice the roads penetrate into the cracks in the structures and can accelerate the corrosion of steel reinforcement. Self-healing concrete[3] in general seeks to rectify these flaws in order to extend the service life of any given concrete structure. In general bacteria is induced in the form of pellets in concrete size ranges from 2 to 4mm. They are induced in the ratio of 20% to the total volume of concrete, they are clay pellets made of clay, bacteria[1] and food for bacteria (calcium lactate).It will comprise the volume of the harder material of concrete that is coarse aggregate, as bacterial pellets are not as hard as aggregate they will show impact on the designed strength. So the concrete is designed for higher grades than required, it will be a economical backdrop if the concrete is designed so. In this project the bacteria[2] is induced in water that used for making concrete, the culture of bacteria is introduced in water used for making and kept aside for some days to allow bacteria to develop, then the bacteria induced water is used for making the concrete.

## LITERATURE REVIEW

In the literature it has been clearly established that the use of bacteria improves the strength[4] and durability characteristics of concrete and hence the Bio-concrete can be used for carrying out repair of concrete structures and is yet to be established in an Indian background, the use of concrete made with supplementary cementitious materials or with recycled concrete. This will lead to the successful implementation of injecting or introducing the bacteria in concrete[5] for repair and strengthening. By introducing bacteria in water used for concrete no other material except bacteria food is added to the concrete so that the designed strength may not be affected and economical advantage instead of designing for higher strength than required.

## MATERIALS COLLECTED

### *Bacteria*

Bacillus subtilis (JC3) -

Bacillus subtilis is a gram positive bacteria, It can be grown easily, In labs in minimum cost, It is a non-pathogenic bacteria, it doesn't harm humans, so safe for use. The rate of growth of cells in the liquid will be $10^1$ per day.

### *Fine Aggregate*

Natural river sand with fraction passing through 4.75mm sieve and retained on 60 micron sieve is used and will be tested as per IS 2386. The fineness modulus of sand is 4.6605 with specific gravity around 1.612.

### *Coarse Aggregate*

Coarse aggregate is obtained by crushing bed rocks. There are three kinds of rocks, namely, igneous, sedimentary and metamorphic. These classifications are based on the mode of formation of rocks. Aggregates are the most important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. The ordinary fact that the coarse aggregates occupy 40-50 percent of the volume of concrete, the impact on various characteristics and properties of concrete is certainly considered. To know more about the concrete it is very essential that one should know more about the aggregates.

### *Cement*

The Portland Pozzolanic cement is manufactured by the intergrading of OPC clinker with 10 to 25 percent of pozzolanic material. A pozzolanic material is essentially a siliceous or aluminous material which while in itself possessing no cementitious properties, which will, in finely divided form and in the presence of water, react with calcium hydroxide, liberated in the hydration process, at ordinary temperature, to form compounds possessing cementitious properties. Portland pozzolana cement produces less heat of hydration and offers greater resistance to the attack of aggressive waters than ordinary Portland cement.

## MIX DESIGN

Concrete mix is defined as the appropriate selection and proportioning of constituents to produce a concrete with pre- defined characteristics in the fresh and hardened states. In general, concrete mixes are designed in order to achieve a defined workability, strength and durability. The selection and proportioning of materials depend on the structural requirements of the concrete, the environment to which the structure will be exposed, the job site conditions, especially the methods of concrete production , transport, placement, compaction and finishing. The method of concrete mix proportioning is applicable only for ordinary and standard concrete grades. The air content in concrete is considered as nil. The proportioning is carried out to achieve specified characteristic compressive strength at specified age, workability of fresh concrete and durability requirements.

## *Design mix for M20 Grade concrete*

1. Target mean strength:

$F_{cr} = F_{ck}+1.65s$

=20+1.65x4

=26.6mpa

2. Selection of water cement ratio:

=186+2(3)/100x186 =197.6kg

3. W/C=0.55

- Cement required = W/0.55
  =197.6/0.55
  =358.473kg/cum
- Volume of concrete = 1cum
- Volume of coarse aggregate = 0.62
- Volume of fine aggregate = 1-0.62
  =0.38
- Volume of cement =358.473/3x1000
  =0.1195
- Volume of water =197.6/1000
  =0.1976
- Volume of all in aggregate = 1-(0.115+0.176)
  =0.6829cum
- Mass of coarse aggregate = 0.6829x0.62x3.03x1000
  = 1117.93kg/cum
- Mass of fine aggregate = 0.6829x0.38x1.62x1000
  =665.31
- Total mass of concrete = (358.473)+(665.31)+(1117.9)+(197.16)
  = 2338.87cum

358.47: 665.7 : 1117.93

1 : 1.85 : 3.118

- Due to losses the above values are increased by 10%

394.320 : 731.841 : 1229.723

1 : 1.856 : 3.12

- Volume of cubes

= 0.15x0.15x0.15

= 0.003375cum

- For 9 cubes

=9x0.003375

=0.0306

- For 9 cubes
- Cement required =394.320x0.0306

= 12.0661

- Fine aggregate required = 731.841x0.0306

= 22.394

- Coarse aggregate required= 1229.723x0.0306

=37.629

- Water required = 216.876x0.0306

= 6.636

# METHODOLOGY

## *Culture of bacteria*

Primarily 12.5g of Nutrient broth (media) is added to a 500ml conical flask containing distilled water. It is then covered with a thick cotton plug and is made air tight with paper and rubber band. It is then sterilized using a cooker for about 10-20 minutes. Now the solution is free from any contaminants and the solution is clear - orange in colour before the addition of the bacteria Later the flasks are opened up and an exactly 1ml of the bacterium is added to the sterilized flask and is kept in a shaker at a speed of 150-200 rpm overnight. After 24 hours the bacterial solution was found to be whitish yellow turbid solution.Then take 13g of nutrient broth per liter of distilled water and sterilize it in the above procedure and allow for cooling after that add the bacterial solution in the media then allow to settle, stir the solution in regular intervals separate the solution in required quantity for desired concentrations, the concentration of the solution increases in the rate of multiple of ten per day.

## *Casting and curing of specimens*

The proportions and material for making these test specimens are from the same concrete used in the field.

Specimen: A total of 27 cubes of 150 x 150 x 150 mm size

## *Compressive Strength test*

Compression test was carried out on cube specimens. The cubes were of the dimension 150mmX150mmX150mm. Three samples for each age of concrete was tested and the strength was obtained as an average. The specimens stored in water were tested immediately on the removal from tank. The specimens were wiped off and the dimensions of the specimens and their weight were recorded before testing.

## RESULTS

**Table : 1 Comparison of compressive strength result in N/mm$^2$**

| **Specifications** | **Compressive strength in N/mm$^2$** | | |
|---|---|---|---|
| | 7 Days | 14 Days | 28Days |
| **Control mix** | 8.52 | 13.9 | 24.73 |
| **$10^5$ concentration** | 20.02 | 26.7 | 34.33 |
| **$10^6$ concentration** | 19.85 | 26.65 | 34.61 |
| **$10^7$ concentration** | 22.49 | 25.85 | 34.62 |

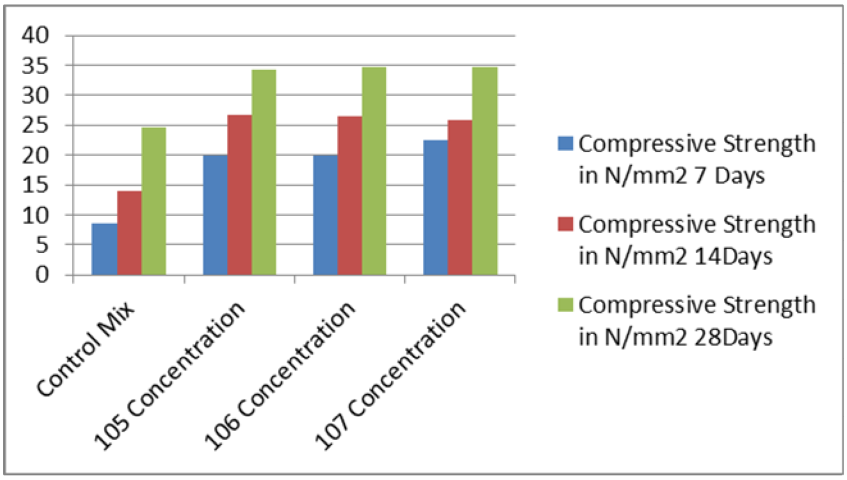


**Figure : 1 Compressive strength result in N/mm2**

## CONCLUSION

- As from the compressive strength values obtained it is known that the initial strength obtained and the strength of concrete is much higher than the designed strength.
- It is because of the pores and voids are filled by the calcium carbonate precipitated by the bacteria.
- Healing is not shown as much effective as process of micro casualization.
- Economically use of bacteria in broth will highly effect the cost of the project as the strength obtained is high than designed, so the concrete can be designed for lower grade mix than required.
- By using this type of concrete life of structures will be increased so that this type of concrete is use full in construction of historical structures.
- we can observe that the compressive strength results are not varied for all concentrations of liquid, so we can use $10^5$ concentration liquid instead of waiting for higher concentrations.

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