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Improvement Properties of Concrete, Partially Replace Cement with Metakaolin, Quartz Powder for Binary and Ternary Mixes.

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ABSTRACT—

Test conducted on concrete revealed that the performance of concrete with microorganisms in it showed higher strength and better characteristics when compared to control concrete (without bacteria). This happened due to the presence of calcite precipitating bacteria in concrete which filled the pores inside matrix and the cracks appeared on the surface with thin calcium carbonate crystals. Bacteria is only able to precipitate Calcium carbonate when it gets nutrition i.e rich calcium course and moisture. However the moisture requirement and food requirement of the colony of bacteria is so less that it can be fulfilled with the moisture present in air and minute food particles travelling in air .Whitish-yellow colored crystals were observed near the crack surfaces when visual inspection of the crack was done at 7 days of concrete casted. As the investigation further continued for 28 days it was observed that the highest crack healed in comparison to both isolate and control concrete was found in Standard concrete system. The concrete with Standard culture of bacteria showed highest compressive strength 60.92 (MPa) when compared to compressive strength of Isolate concrete 54.74 (MPa) and control concrete specimen 38.80 (MPa).Only those bacterial isolates can be used in crack healing of concrete which show positive urease activity and endospore formation. It is a fact that the microscopic organisms which are unable to frame endospore can't survive in an exceptionally highly alkaline environment of new concrete.

Keywords— microorganisms, higher strength, control concrete, self-supporting, calcium carbonate, compressive strength.

I. Introduction

To accomplish a compressive quality, we can remove the coarse totals and accomplish consistency and homogeneity in the blend. The pozzolanic properties of materials like silica fume, fly ash and so forth are utilized to accomplish high density and strength. HSC incorporates bond of higher grade (for the most part OPC 53), quartz powder, quartz sand, steel fibres and silica fume, steel aggregates and a superplasticizer (III generation). We likewise utilize superplasticizers so as to decline water-cement ratio with extra advantage of getting great workability. [9], Here comes up the two new challenge. One is the extensive production of cement and concrete give rise to some hazardous environmental effects to concrete leads to negative environmental effects. The second one is durability of concrete. In concrete the cracks are the major shortcoming in concrete structures, Cracks are responsible for deterioration of concrete ne it Micro or Macro cracks. We need to overcome these two challenges. We know that key constituent of concrete is cement and aggregates. Some facts related to concrete is that the key constituents of concrete are cement and aggregates.[10], [11] The making of cement only leads to 7% CO2 emission by human's activities, which is a huge number. By knowing these facts, it is difficult to say concrete is a sustainable material[12]–[14]. To avoid these phenomenon and make a eco-friendly concrete, concrete was replaced partially with come greener materials we replace concrete partially with greener choices like fly ash, blast furnace slag, or rice husk ash which are by results of iron, coal and agrarian materials or businesses and so on. Cracks in concrete make a major impact over durability and serviceable life of concrete. Cracks makes it easy for moisture, Carbon dioxide (CO2), Sulphate, gases and other liquids for trans-pass concrete effectively up to its centre and fortification which brings about rot of support and decrease the quality and sturdiness of cement. Therefore, it makes cracks themselves undesirable in concrete structures. The micro cracks can rehabilitate by concrete itself. This healing process is known as "Autogenic healing" which is also known as "Self-healing". [15]–[18]Therefore, cracks can be healed by mixing specific healing material in the concrete matrix. In this we will try to make HSC which will be capable to heal its cracks by itself if occurs to increase the life of concrete and give a concrete structure serviceable for more time. Bacteria plays a major role in making a self-healing 3 concrete. A type of bacteria that can must precipitate with calcite ($CaCO_3$) to form crystalline layer over cracked surface. The bacteria also should be alkali-resistant (alkaliphilic) in nature because concrete is extremely alkaline. [19]–[23]

Classification based on Gram strain

According to gram strain, bacteria can be classified into2 groups.

i) Gram Positive (gives positive results in gram strain test) &

ii) Gram Negative (gives negative results in gram strain test).

Classification based on Oxygen requirement

According to oxygen, required by bacteria can be classified into 2 groups.

i) Aerobic (tomic oxygen is required as terminal electron acceptor) &

ii) Anaerobic (does not require atomic oxygen as terminal electron acceptor).

Bacteria Used in Concrete

Concrete is extremely alkaline; its pH is about 11 to 13 and it mixed under high mechanical stresses. Therefore, immobilized bacteria must be alkaliphilic (alkali-resistant) and must have propensity to endure against the mechanical stresses. The key point against crack repairing is that the bacteria must precipitate with calcite ($CaCO_3$) to form crystalline layer over cracked surface. Bacillus spores show this kind of properties. The crack-filling phenomenon is due to the urease activities due to the alkaliphilic bacteria, which form calcite.[17],

In bio-concrete following Bacillus species can be used:

i) Bacillus pasteurii.

ii) Bacillus subtilis.

iii) Bacillus megaterium.

iv) Bacillus cohnii.

v) Bacillus halodurans.

vi) Bacillus pseudofirmus.

And other similar species.

Reproduction and growth of bacteria

Practically all microorganisms multiply by two-fold split technique. A solitary cell of bacteria, the "parent," copies its own DNA and becomes larger in size by expanding the contents of cell by multiple times. This multiplied substance is sent to each divided body of the cell. At that point, little opening rise in focal point of parent cell, at last parting it into two comparable "girl" cells which appeared in Figure 1.2 couple of bacterial animal groups like firmicutes and cyanobacteria increase through maturing. At maturing stage, little girl cell develops a posterity as the posterity of its parent . It begins as minuscule stub, develops till the size of its parent lastly separates.

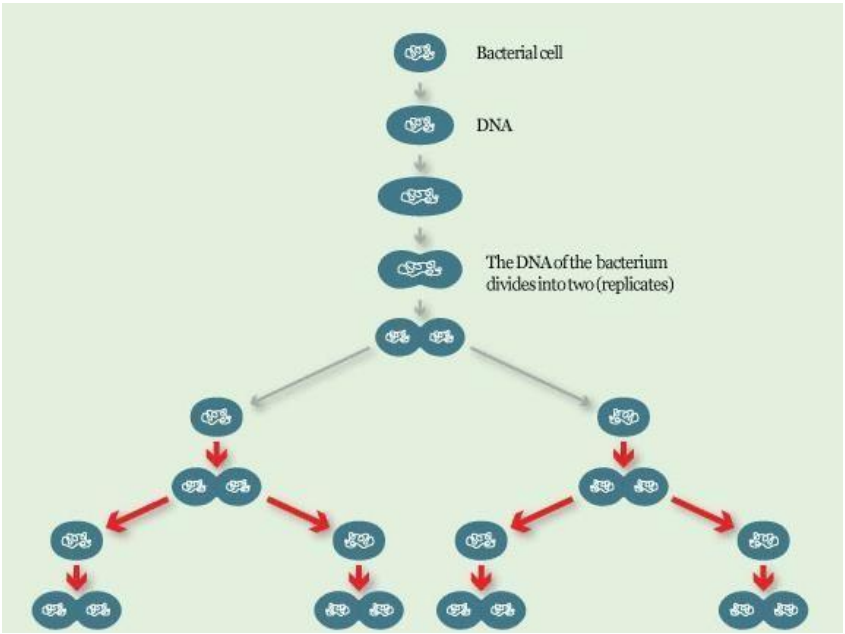

Figure 1. Bacteria Reproduction through Binary Fission

"Source: www. Microbiologyonline.org

How will HSC prove useful to construction industry?

The concrete possessing mighty compressive strength of over 150MPa can find various uses in construction industry such As.:

Because of high compressive strength, the structural members cast from HSC will be slender as compared to the structural members cast using ordinary concrete for taking up the same amount of load. The material prerequisite will be significantly lessened which will at last make the concrete economical. Likewise, because of decline in size of basic individuals, the dead load will be incredibly decreased.

Casting of HSC uses various mineral and chemical admixtures. These admixtures fill up the voids of cement and decrease the permeability of concrete. Because of this, the penetrability of outside material, for example, chloride and moisture is diminished. This makes the solid impervious to different corrosive assaults and warmth. In this manner, the durability of concrete is increment

HSC can locate its noteworthy application in pre-cast industry. This concrete can be used to cast bridge girders and various structural members of very high strength. Accelerated curing of this concrete can give very high early strength within 3 days of curing. Researchers have presumed that around 200MPa of compressive quality can be accomplished via autoclave curing of cement at 90°C for 3 days. These structural members can be utilized when the work must be done in less time.

HSC discovers its real application when it is utilized with fibers. Different sort of fibers can be added to HSC to enhance its ductility and toughness. Incorporation of fiber reinforcement in HSC can eliminate the structural steel completely. Various foot-over bridges constructed using fiber reinforcement and HSC have indicated great serviceability and durability. High compressive strength of HSC makes it a reasonable material for establishment of tall structures, underground shelters and different other auxiliary portions.

Advantages of High Strength Concrete

- The structures made will be sooner available for us.
- The cross section of columns and beams of large structures are reduced.
- Ultra-high strength concrete can give a highly durable structure.
- Concrete with any desirable mechanical properties can be made.

Limitations of High Strength Concrete

- Extra care is required while placing High Strength Concrete which may not be required while using conventional concrete.
- For making Ultra-high strength concrete good quality control is required.
- The cost will be increased because in use of HSC we need to do test at site as well.
- The mix of concrete may require some special materials and skilled labor as well

Advantages of Self-Healing Concrete

- Cracks in concrete is a major reason of structure failure as it will corrode the reinforcement, with this new technology bacteria will be able to utilize calcite and form less cracks, which will give structure a new stability.
- It is claimed to increase the structural integrity for many years.
- By doing more research its scope can be expanded to dams, bridges, swimming pools, sewer and construction exposed to harsh conditions.

OBJECTIVES OF STUDY

- Based on an exhaustive literature review, to make a concrete having strength 40MPa or above.
- To develop concrete, partially replace cement with Metakaolin, Quartz powder for binary and ternary mixes.
- By adding the bacteria at 105 cells/ml concentration in mixing water, Which will induce the self-healing properties in concrete.

II. LITERATURE REVIEW

The authors Achal et al. (2013) studies the effect of inducing bacteria on the durability of concrete, in their study they used Bacillus. sp. CT-5 which was isolated from cement. Cubes of

70.6 mm is utilized in the study, according to IS 4031-1988. Cement and sand are altogether blended, When pores in the matrix get filled, it will scarce the availability of nutrients, and the bacteria may end up dying or endospore formation. They inferred that the compressive strength had significantly increased by almost about 36% for mortar solid shapes which contained microbial cells.

The enhancement by Bacillus sp. CT-5 in compressive strength is brought by testimony of $CaCO_3$ on exposed. They likewise reasoned that in the underlying time frame microbial cells acquired great nourishment because the matrix was still porous. There might be another possibility because of high pH of cement the initial growth might be slow till the bacteria accumulate itself the environment.

The matrix with bacteria in it will produce a less porous structure and which will also be less porous. When pores in the matrix get filled, it will scarce the availability of nutrients, and the bacteria may end up dying or endospore formation. They also concluded that with different types of bacteria there will be different increase in strength. In Bacillus sp. CT-5 increase was 36 %, in Sporosarcina pasteurii the increase was 18% and in Shewanella sp. Increase was 25%.

The authors Ramchandra et al (2001) in their other study, studied the effect of using micro- biologically-induced mineral precipitation for concrete remediation. The concluded that microbial- stopping was influenced by the porosity of medium, the quantity of cells present, and the total volume of supplement included. They made Portland concrete mortar light emissions 25.4 x 25.4 x 152 mm. The examples were relieved in water 28 days and afterward left presented to air. The kept up the cut-width consistent at 3.175 mm while the profundity of slices ran from 3.175 mm to 9.525 mm. For each mix of break width, they threw a sum of 10 examples. The initial five examples were utilized as a standard without filling the breaks.

Different examples with splits were loaded up with blend od sand and B. pasteurii. The sand utilized went through the U.S. standard strainer No. 16 yet was held on the U.S standard strainer No. 4. The microbes suspension was blended in with sand to a last convergence of 3.8 x 109 cells for every cm3. The bars with and without microorganisms were tried for their solidness following 28 days utilizing a three-point stacking technique with a range of 127 mm. They made Portland concrete mortar Cube of measurements 50.8mm x 50.8mm x 50.8mm. The examples were restored in water 28 days and afterward left presented to air. The kept up the cut-width steady at 3.175 mm while the profundity of slices went from 3.175 mm to 9.525 mm.

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J.Sahaya , et.al Ultimate goal of this research is to investigate the behavioral study of natural fiber in concrete structure. The coir fiber recently attracted an interest as a sustainable fiber composite material, because of some specific mechanical property that can be compared to an artificial fiber. The Coir fiber is treated and examined before using natural latex before using in concrete, so that it should not be affected by moisture content present in conventional concrete. In this experimental study of 28 days the compressive strength and split tensile strength were carried out using different coir fiber of different length of 20mm, 25mm and 30mm respectively of different amount of percentage as0.5%, 0.75% and 1%. Encouragement should be given for the use of natural fibers that are easily locally available materials, in the field of civil engineering.

The outcomes of the experiment are listed below:

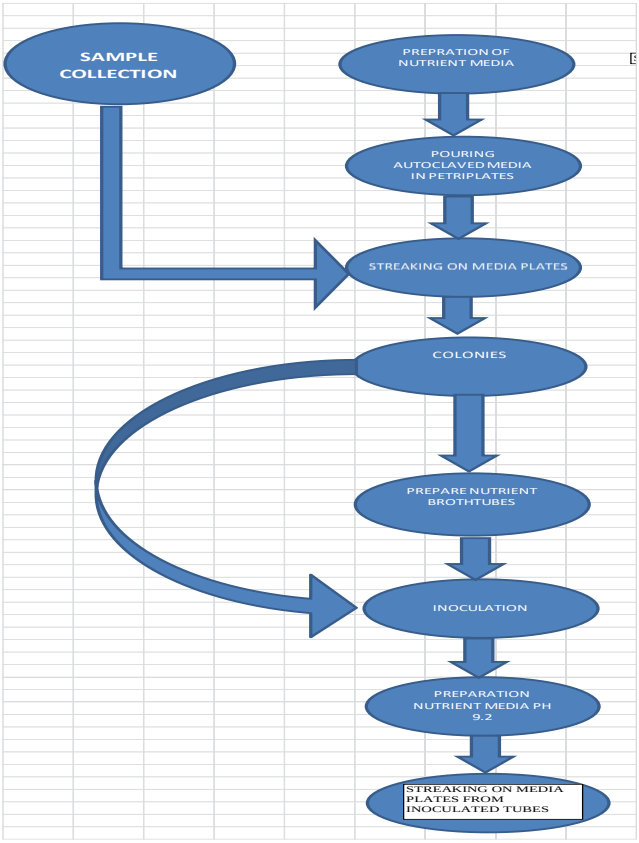
Using coir fiber in civil construction reduces the worse environmental pollution factors and can also bring several improvements in concrete characteristics.Coir fiber used in cement also improves the resistance of concrete from sulphate attack.Compressive strength is also improved up to desired amount of certain percentage. In Addition of coir fiber also arrests the micro cracks present in the concrete.

Modani et al [20]: Today researches all over the world are focusing on ways of utilizing either industrial or agricultural wastes as a source of raw materials for the construction industry. These wastes utilization would not only be economical, but may also help to create a sustainable and pollution free environment. Sugar-cane bagasse is one such fibrous waste-product of the sugar refining industry, along with ethanol vapor. Bagasse ash mainly contains aluminum ion and silica. In this paper, untreated bagasse ash has been partially replaced in the ratio of 0%, 10%, 20%, 30% and 40% by volume of fine aggregate in concrete. Fresh concrete tests like compaction factor test and slump cone test were undertaken along with hardened concrete tests like compressive strength, split tensile strength and sorptivity. The result shows that bagasse ash can be a suitable replacement to fine aggregate.On the basis of experimental investigation carried out, the following conclusions can be drawn.The fraction of fine aggregates i.e. 10% to 20% can be effectively replaced with a bagasse ash (untreated) without a considerable loss of workability and strength properties.The compressive strength results represent that, the strength of the mixes with 10% and 20% bagasse ash increases at later days (28 days) as compared to7 days that may be due to pozzolanic properties of bagasse ash.The Sorptivity test result shows that the sorptivity coefficient increases with increase in percentage of bagasse ash which indicate more permeable concrete that is due to porous nature of SCBA and the impurities in it.In its purest form the bagasse ash can prove to be a potential ingredient of concrete since it can be an effective replacement to cement and fine aggregate.

kumar and Patel India is a second country in major sugar producing countries after Brazil. Due to that many of the time there is increase in bagasse as a byproduct from the sugar mill. Bagasse is the fibrous residue of sugar cane after crushing and extraction of juice. Sugar cane bagasse ash is the waste by product of the combustion of bagasse after the complete burning process, for energy in sugar factories. Sugar cane bagasse ash is disposed of in landfills and is now a days becoming an environmental burden. In this experimental research study concrete cubes, beams prism and cylinders of M25 grade were casted and tested to examine various properties of concrete like workability, compressive strength, split tensile strength, modulus of elasticity and flexural strength. Sugar cane bagasse ash was partially replaced with cement at that is 2, 4, 6 and 8 % by weight of cement in concrete. From the results we can conclude that optimum amount of sugar cane bagasse ash that can be replaced with cement is 6% by weight without any admixture. It has been studied that in the above research work some others have replaced cement in concrete from different materials, some replaced cement from SBA in varying proportions but their work is with limited to some extent in less no of parameters. In this experimental work we consider all possible parameters and conditions which influence the strength of concrete for grades, particularly for M25 and M30

III. METHODOLOGY

we will isolate the Bacteria from the samples and side by side we will do the optimization process. Meanwhile, we will test the materials for their properties. In the second stage after isolation of bacteria, we will prepare a mix design. The mix of concrete will be based on the results obtained from Puntke Method. In stage 3 we will test the concrete specimens for compressive strength, Flexural Strength and Tensile Strength. Crack quantification will also be done in stage 3



Compression test

IS 516: 1959. was the standard used to conduct this test. The capacity of materials to withstand against load applied on its surface without getting splitted or cracked is known as the compressive strength of concrete. Compressive strength is the capacity of material to bear the loads on its surface with no split or deflection. This test was performed by making concrete cubes having each side of 150 mm. Cubes were kept for curing. The compression test is conducted at interval of 7 days, 14 days and 28 days. The load is applied at a steady rate of 140 kg/cm2/minute (0.22 MPa/s) till the failure occurs. Compressive test was performed on the concrete cubes as shown in Figure

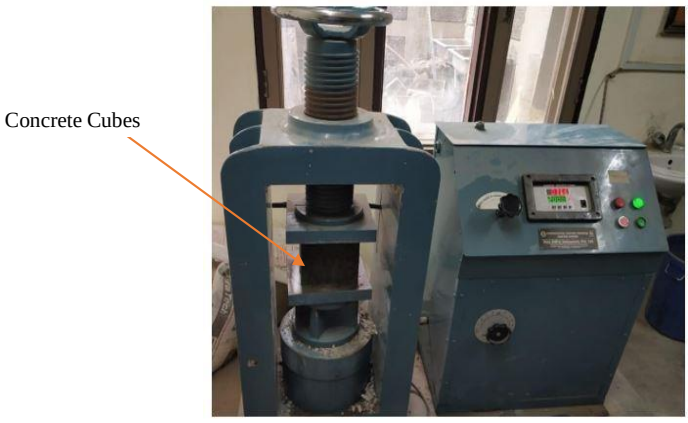


Figure 2 Compressive strength test under CTM

The formula for calculating compressive strength is as given in (Eq. 4):

Compressive Strength (N/mm2) = *P*

A (4)

Here, P = Load at Failure (N)

A = Specimen Area (mm2)

Table-1 Compressive Strength in N/mm2

Designation	Compressive Strength in N/mm2		
	7 Days	14 Days	28 Days
Control concrete	21.15	24.39	38.8
Standard concrete	27.64	24.76	60.92
isolate concrete	25.56	25.01	54.74

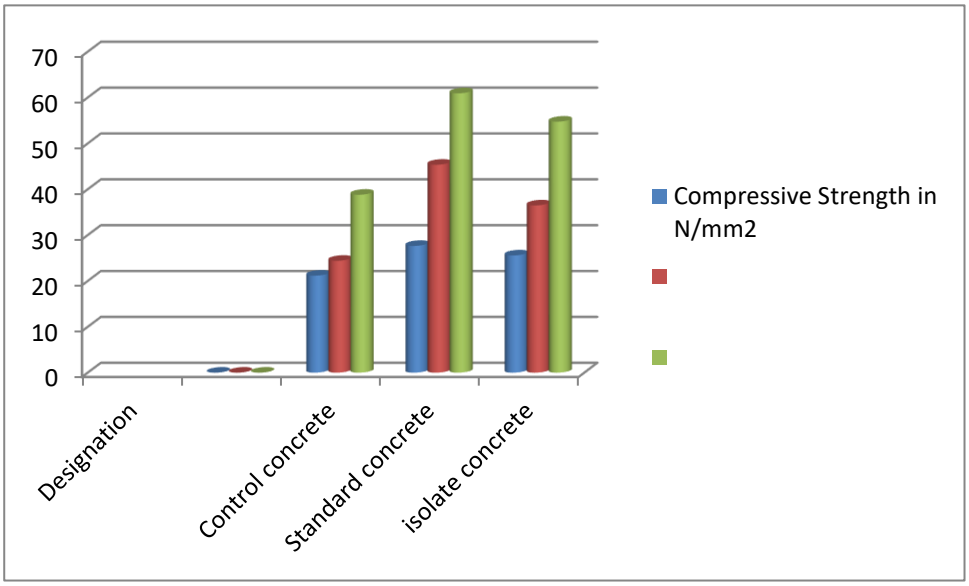


Figure 3 Compressive strength Graph

V. Conclusions

- It is better to use soil which is rich in lime and magnesia in order to obtain calcite precipitating bacteria. As the chances of getting one in such soil is quite higher For developing bacterial cells, it was observed that rather than using direct plate technique we should use enrichment culture technique. With the help of this technique we can limit the growth of other bacteria which are not required
- The concrete with Standard culture of bacteria showed highest compressive strength 60.92 (MPa) when compared to compressive strength of Isolate concrete 54.74 (MPa) and control concrete specimen 38.80 (MPa).Only those bacterial isolates can be used in crack healing of concrete which show positive urease activity and endospore formation. It is a fact that the microscopic organisms which are unable to frame endospore can't survive in an exceptionally highly alkaline environment of new concrete.

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