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Use of Waste by-products In Concrete with Bacteria

Ravindranatha, Mohit Goyal, P.Krishna Chaitanya, Nikhil Awasthy

ABSTRACT-The major problem the construction industry concurs with is the high maintenance cost of the concrete. Various natural processes such as weathering, faults, land subsidence, earthquake, changes in moisture and temperature, have the tendency to create cracks in concrete. Therefore, to counter these effects, it has become necessary to come up with ways which will not only help in counteracting but also in improving the quality of concrete. In the present experiment, cement was partially replaced with Fly Ash and GGBS and Bacillus Pasteurii was used as an admixture. GGBS and Fly Ash, when used with this bacterium resulted in the increase of the strength characteristics of cement.

Keywords: Fly-Ash concrete, GGBS concrete, Bacillus Pasteurii, Admixture-Bacteria, partial replacement etc

1. INTRODUCTION

Nowadays in the construction industry conventional use of materials is either costly, not easily available or is harmful for nature in one way or the other. Not only that even in other industries there is high production of wastes and other by-products which can be used in preparation of concrete and hence saving the use of natural resources.

Concrete has different properties and it has some limitations as it is weak in tension and has less ductility and less resistance to cracking. The primary reason for the cracking of concrete can be attributed to porosity in texture (microscopic level) of structural members which allows moisture and water to seep into the concrete members and hence, leads to corrosion of steel reinforcements. Although, here exists a variety of waterproofing agents and surface treatments like the water repellants such as silanes or siloxanes which are used to enhance the durability of concrete structure, they suffer from various limitations like incompatibility, susceptibility to UV radiations and are also expensive.

A technique was proposed in remediating cracks and fissures in concrete by microbiologically inducing calcite precipitation. We add Microbes like Bacillus Pasteurii in the GGBS as admixture and this can induce the precipitates of calcite. It can increase the durability performance of concrete with increase in the concentration of bacteria. [1] Moreover, this calcite layer can also improve the impermeability of the specimen, thus increasing its resistance to alkaline, sulphate and freeze-thaw attack.[2]Also, use of bacteria Pasteurii results in increase of compressive strength in fly ash concrete and has self healing effect by filling in the pores with bacteria cells.[3] Addition of bacteria can increase compressive strength up to 16.94% at 7th day, 17.3% at 28th day and 17.6% at 56th day.[4] Also lead to significant improvement in the split tensile strength.[5]

Fly ash, also known as flue-ash is a byproduct from coal based thermal power plant. Owing to its pozzolanic properties, fly ash can be used as a replacement for some of the Portland cement content of concrete[6] Also, Fly ash can add to the concrete's final strength and increase its chemical resistance and durability. Fly ash offers environmental advantages; it also improves the performance and quality of concrete. Fly ash affects the plastic properties of concrete by improving workability, reducing water demand, reducing segregation and bleeding, and lowering heat of hydration. Fly ash increases strength, reduces permeability, reduces corrosion of reinforcing steel, and increases sulphate resistance. Fly ash reaches its maximum strength more slowly than concrete made with only Portland cement. The techniques for working with this type of concrete are standard for the industry and will not impact the budget of a job.

GGBS or Ground Granulated Blast Furnace slag is a byproduct of steel industry. GGBS can be used to improve strength, greatly reduce permeability, increase durability and performance in aggressive environment. Moreover, to achieve greatest strength at most favorable cost benefit ratio, it has been observed that optimum proportion of slag appears to be 50% or less of the total cementitious material.

- *Ravindranatha is currently serving as the Assistant Professor in Manipal University, India,*
- *Mohit Goyal is currently pursuing bachelors degree program in Civil engineering in Manipal University, India, PH-9886526685. E-mail: m.goyal0815@gmail.com*
- *Nikhil Awasthy is currently pursuing bachelors degree program in Civil engineering in Manipal University, India, PH-8867626444. E-mail: nikawasthy93@gmail.com*
- *P. Krishna Chaitanya is currently pursuing bachelors degree program in Civil engineering in Manipal University, India, PH-9886658737. E-mail: krishna02chaitanya@gmail.com*

2. MATERIALS

2.1 Cement

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Ordinary Portland Cement- 43 grade complying with IS: 12269-1987 was used for the preparation of concrete, the properties of which are in accordance with Indian standard code.

2.2 Aggregates

Fine aggregate used in the experiments were locally available river sand with specific gravity 2.76 and fineness modulus 2.91. Also, quarried and crushed granite stones of maximum size 20mm were used as coarse aggregate of which, specific gravity and fineness modulus was found to be 2.8 and 7.19 respectively.

3. TESTS CONDUCTED

Slump flow test was performed as per IS: 1199-1959(Clause 5.1). Compressive strength test, Flexural Strength test were carried out at an interval of 3, 7, 14, 28 and 56 days in accordance with the guidelines mentioned in IS: 516-1959. Moreover, Split Tensile Strength was also carried out according to IS 5816-1976.

4. METHODOLOGY

4 .1 Specimen casting and curing

The mix design of the concrete specimen were prepared in accordance to the guidelines mentioned in IS 10262-2009. Ordinary concrete specimen mixes were designed using cement, water, coarse aggregate and fine aggregate only. Further, concrete specimen mixes were also designed separately by partial replacement of cement with Fly Ash or Ground Granulated. Table 1 gives the different combination of mixes used in the experiment.

TABLE 1: DIFFERENT COMBINATIONS FOR CASTING

MIX DESIGNATION	Cement kg/m3	Water kg/m3	Coarse aggregate kg/m3	Fine aggregate kg/m3	Fly ash 30 %	GGBS 30%
NORMAL CONCRETE	438	197	1017.4	799.3	0	0
30% FLYASH +70% CEMENT	306.6	197	1017.4	799.3	131.4	0
30% GGBS +70% CEMENT	306.6	197	1017.4	799.3	0	131.4

4.2. Preparation of Bacterial Culture

Initially, 25 grams of LB broth (Luria Bertani Broth Miller) was added in 1 liter of distilled water and mixed well so that no solid particles could be seen. The flasks were plugged with cotton and covered with paper before tying it with a rubber band so that it could be sterilized by boiling up to 100 degree Celsius. The bacteria were extracted from the bacterial colonies with the help of inoculation loop from the Petri dish. This bacterium was then transferred to conical flask, shaken well and plugged back again (inoculation). After inoculation the flasks were shaken overnight in a rotary shaker and the liquid inside turns turbid, thus, indicating the presence of bacteria.

5. RESULTS

The entire research has been divided into 3 experiments based on the bacterial solution which was used for the experiment. The outcomes of the compressive strength test, flexural strength test and split tensile strength on the different specimen of the experiment have been mentioned. Also, bacteria solution was added for both the mixes for fly ash and GGBS.

5.1. Experiment 1

In this mix, the bacterial solution of 1800 ml was used, i.e. each concrete specimen received 40ml each. The results of the compressive strength test, flexural strength test and split tensile strength are mentioned in Figure 2, Figure 3 and Figure 4.

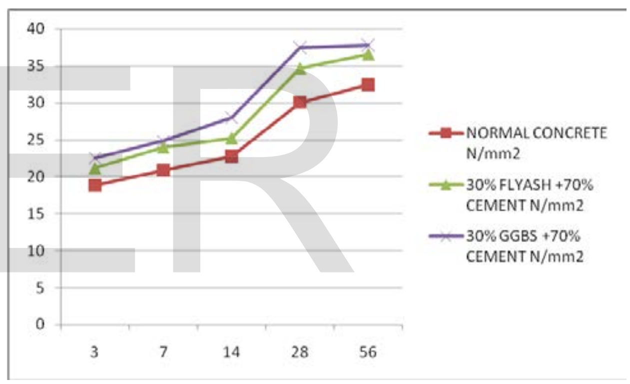

FIGURE 2: COMPRESSIVE STRENGTH TEST RESULTS PERFORMED ON DIFFERENT MIXES

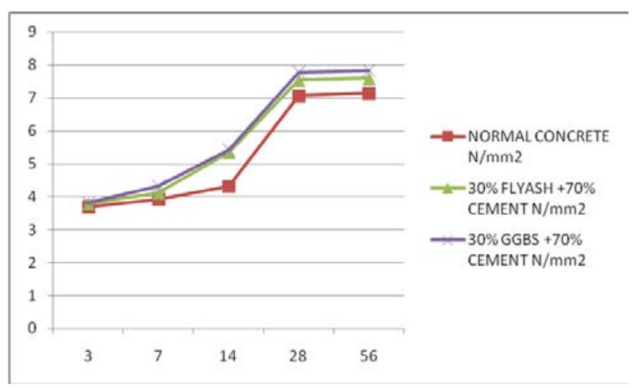

FIGURE 3: FLEXURAL STRENGTH TEST RESULTS PERFORMED ON DIFFERENT MIXES

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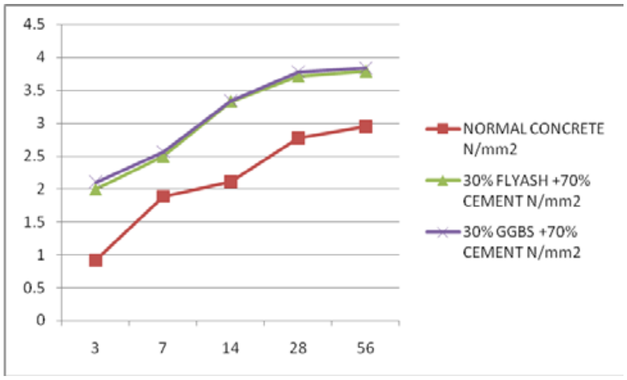


FIGURE 4: SPLIT TENSILE STRENGTH TEST RESULTS PERFORMED ON DIFFERENT MIXES

5.2 Experiment 2

In this mix, the bacterial solution of 2250 ml was used, i.e. each concrete specimen received 50ml each. The results of the compressive strength test, flexural strength test and split tensile strength are mentioned in Figure 5, Figure 6 and Figure 7

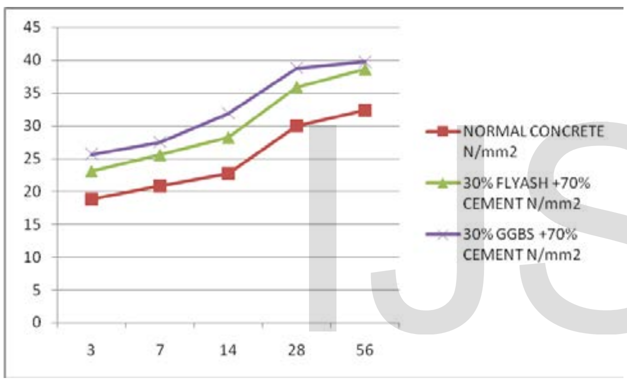


FIGURE 5: COMPRESSIVE STRENGTH TEST RESULTS PERFORMED ON DIFFERENT MIXES

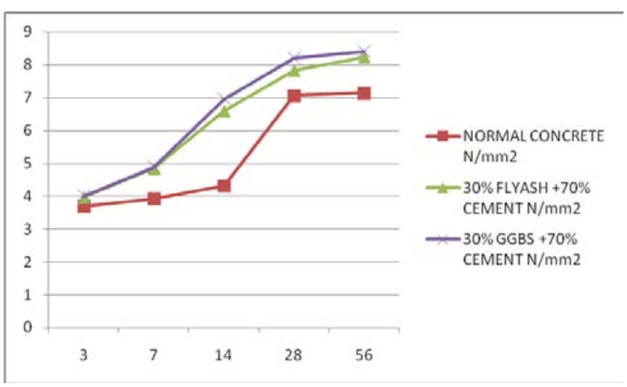


FIGURE 6: FLEXURAL STRENGTH TEST RESULTS PERFORMED ON DIFFERENT MIXES

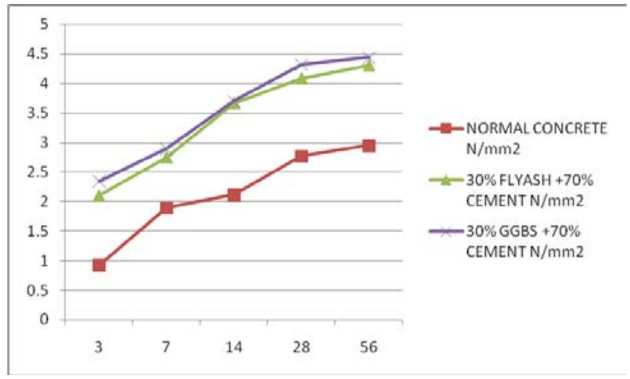


FIGURE 7: SPLIT TENSILE STRENGTH TEST RESULTS PERFORMED ON DIFFERENT MIXES

5.3. Experiment 3

In this mix, the bacterial solution of 2700 ml was used, i.e. each concrete specimen received 60ml each. The results of the compressive strength test, flexural strength test and split tensile strength are mentioned in Figure 8, Figure 9 and Figure 10.

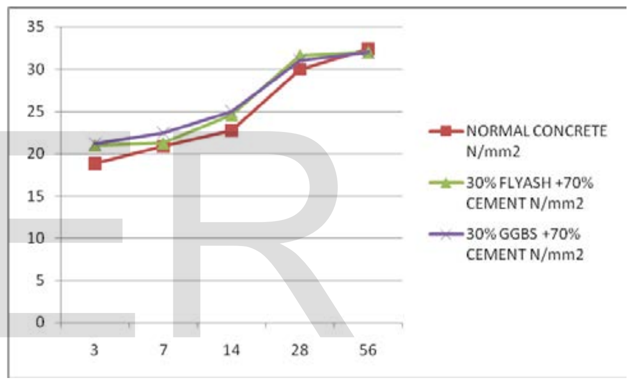


FIGURE 8: COMPRESSIVE STRENGTH TEST RESULTS PERFORMED ON DIFFERENT MIXES

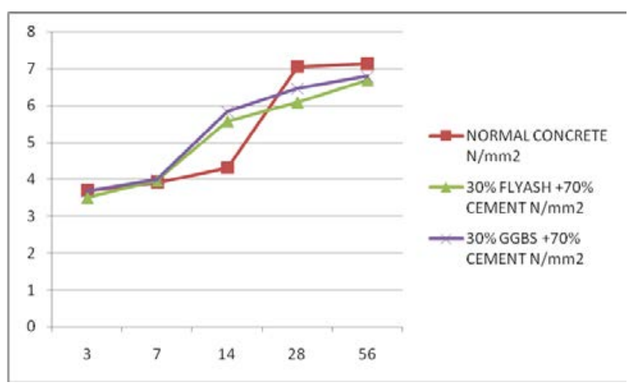
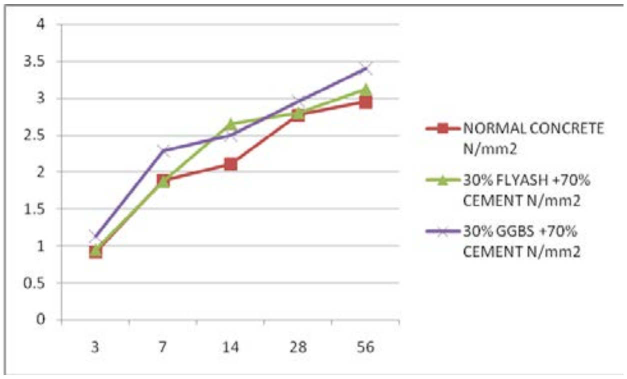


FIGURE 9: FLEXURAL STRENGTH TEST RESULTS PERFORMED ON DIFFERENT MIXES



` **FIGURE 10: SPLIT TENSILE STRENGTH TEST RESULTS PERFORMED ON DIFFERENT MIXES**

From the results of the three experiments, we can observe that the concrete containing GGBS and the normal concrete can resist maximum and minimum compressive strength respectively out of the three different mixes. It can also be observed that concrete containing GGBS achieves maximum split tensile strength and flexural strength when 40 ml and 50 ml bacterial solution was used but loses this trend after 14 days with 60ml bacterial solution when flexural strength test was performed. Also, 50ml bacterial solution proves to be effective in increasing the split tensile strength, compressive strength and flexural strength of the specimen as compared to 40ml and 60 ml bacterial solution. Finally, it can be observed that the strength increases with days.

VI. CONCLUSION

The test results show a significant improvement in strength. The strengths obtained from different concrete mixes states that it is very sustainable and durable material and can be used as a suitable replacement for ordinary Portland cement. The slump achieved was 100mm. There was significant improvement of compressive strength with more than 15% in fly ash and 20% in GGBS. Finally, there is a further scope of research as this experiment is concentrated on M25 concrete. Effect of bacteria on higher grade of concrete with and without use of different mineral admixtures (silica fume, metakeolin etc) should be designed and its compatibility, durability and performance should be studied.

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