Experimental Investigation on Durability Aspects of Bacterial Concrete

Shaik Mohammed Mansoor, P.Jagannathan, K.S.Satyanarayanan

Abstract: ***This paper presents the effect of Bacillus subtilis on the durabilityof fly ash enriched with bacteria. Cement is replaced with fly ash enriched with bacteria in three different proportions (25%,30%, and 35%).Tests performed after curing specimens for 28 days. Test results indicate fly ash enriched with bacteria has enhanced the durability of concrete. Maximum increase in strength and resistant to chloride ingress and water absorption was negligible was observed at 25% fly ash enriched with bacteria. This improvement in durability of concrete is due to deposition of bacteria on cell surface within pores. The present work shows the impact of Bascillus subtilis on durability of concrete made by partially replacing cement with fly ash. Usage of fly ash enriched with bacteria not only increases strength durability but also helps to achieve early day strength.***

Keywords: Fly ash, Bacillus Subtilis, Durability, Chloride Permeability, water absorption.

I. INTRODUCTION

Concrete is the most widely usedadvancement material in construction industry. It has forte of being thrown in any attractive form yet plain concrete anyway has low rigidity, restricted malleability and little protection from breaking. It is presently perceived that quality of cement alone isn't adequate, to the level of harmful of the ecological condition to which concrete is uncovered over as long as it can remember is imperative. In this manner, both quality and durability must be considered unequivocally at the planning stage itself. To do this, a durable structure should be delivered. For concrete structures, one of the significant types of ecological assault is chlorides and sulphatesingress, which prompts corrosion of the fortifying steel and a consequent decrease in the quality, workableness and feel of the structure. This may prompt early fix or untimely substitution of the structure. A typical strategy for forestalling such weakening is to keep chlorides from entering the structure by utilizing moderately invulnerable substitutes of cement in concrete. The limit of chloride particles to invade the solid should then be alluded for setup of value control purpose.The defenselessness of cement is obviously related to the pore structure of the cement paste matrix. This will be impacted by the water and cement proportion of the concrete, the addition of supplementary materials helps to refine pore structure by prolongating heat of hydration.

This is particularly valid for cement containing slower responding beneficial supplementary materials, for example fly ash require a more extended time to hydrate and helps to attain sustainable environment. Fly ash is most commonly used as supplementary material for cement because it not only helps to refine pore structure of concrete by prolongating heat of hydration but it also helps in reduction CO_2 from atmosphere. Howeverthe only problem with cement partially replaced with fly ash is it is also not resistant to environmental harsh conditions. Therefore to overcome such problems bacillus subtilis is used which helps in self curing of cracks formed on concrete and helps of reduce permeability of chlorides and sulphates in concrete

II. EXPERIMENITAL

Experimental Program

The experimental work was carried to study different durability aspects of fly ash enriched bacterial concrete after curing for 28days and to get acquainted with use supplementary materials.

Cement

The cement utilized in this analysis is OPC 53 grade and the tests conducted on the cement as per IS 2720 Part 3 and IS 12269:2013 and the results obtained are shown in Table1

TABLE 1: Physical Properties of Cement

S.No.	Properties	Value
1	Specific Gravity	3.10
2	Fineness	5%
3	Consistency	31%
4	Early setting time	126 min
5	Final setting time	180 min

Fine Aggregate

The sand utilized for this experiment was locally procured river sand. The tests were conducted as per IS 383:1970 and the results are shown in Table 2.

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TABLE 2: Physical Properties of Fine Aggregate

S.No	Properties	Value
1	Specific gravity	2.66
2	Water absorption	1.8%

Coarse Aggregate

The aggregate used for this experiment crushed stone having size 12.5mm. The tests were carried out on course aggregate as per IS 2386:1963 and the results are shown in Table 3

TABLE 3: Physical Properties of Coarse Aggregate

S.No.	Properties	Value
1	Impact test	16.66%
2	Specific gravity	2.66%
3	Water absorption	0.5%

Water

Clean water accessible in the lab, was utilized for casting of concrete sample and same water was used for curing of samples

Fly Ash

Fly ash is by product of cement and it is most broadly used supplementary material for cement. Class F type fly ash is used in our experiment.

Bacteria

Bacillus subtilis solution is mixed in concrete mix.To attain early day strength in concrete and to make it resistant from sulphate attacks and it is obtained from Synkro Max Biotech Private Limited ,Chennai.

Mix Proportion

Control concrete mix is made as per IS 10262-1982 to obtain compressive strength of 40mpa after 28days curing and other mixes were made by partially replacing cement with fly ash and bacteria. There are totally seven mixes made for this experiment they are (CC, CFA25%, CFA30%, CFA35%, CFAB25%, CFAB30%, CFAB35%) where CC represents control concrete and CFA25% represents 25% of cement partially replaced with fly ash by weight. Mix ratio for M40 grade concrete is 1:1.3:2.6.

Rapid Chloride Penetration Test (RCPT)

We all know that for reinforced concrete main form of ecological attract is chloride ingress. which is responsible for rust of steel reinforcement in order to ensure durability of structure. Concrete should pass some acceptable levels of resistance against chloride resistance to determine that one of the tests used is RCPT.This test is conducted according ASTM C1202in this test the specimen of 50mm thick and 100mm diameter is placed between the two glass molds as shown in figure 1 and one glass mold in poured with 3%NaCl and the other mold is poured with 0.3% of NaOH and the specimen is exposed to 60 volts DC current for period of 6 hours and the total charge passed is calculated and compared with the criteria mentioned to know the quality of concrete in Table 4

Table 4 Inference for RCPT

S.No	Chargepassed(Coulombs)	Chloride ion penetrability
1	>4000	High
2	2000–4000	Moderate
3	1000–2000	Low
4	100–1000	Very low
5	<100	Negligible

Figure 1 Arrangement of samples for RCPT

Sorptivity

This test is done according to ASTM C1585 and can be used to find the capillary rise of absorption of water in concrete specimen a in this the specimen of 50mm thick and 100mm diameter is used the specimens are oven dried at temperature of 100 + 10 ^{o}C after that is cooled in room temperature and sealed from sides with tape or silicone gel and initial weight is recorded then specimens are placed in tub with two supports placed below them and then the tub is filled withwaterand not more than 5mm and specimens are weighed for every (1,2,3,4,5,9,12,16,20,25,30,46,60) minutes as shows in figure 2

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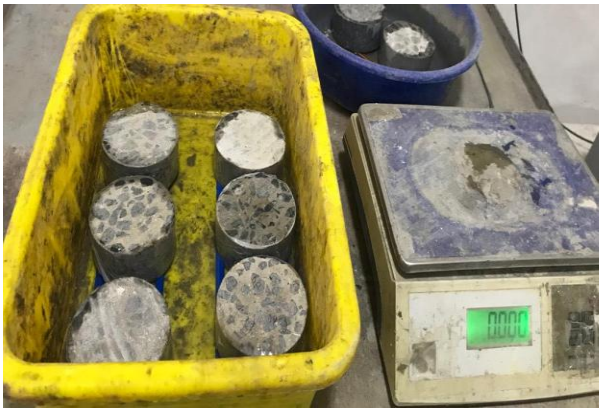

Figure 2 Arrangement of samples for Sorptivity

Rebound Hammer

This test is done as per IS 13311 (part-2):1992. This is one of Non destructive test this is used for measuring compressive strength of sample. The specimens used for test are cubes size of (100x100x100) mm. The grid shape is drawn on concrete specimen and then specimen is held tight on surface and then rebound hammer is pushed against the sample and reading a total of 16 readings are taken and average value is calculated. Based on criteria mentioned in Table 5 concrete quality is determined.

Table 5 Inference for Rebound Hammer

S.No.	Average rebound number	Quality of Concrete
1	Above 40	Very goodlayer
2	30to 40	Good layer
3	20to 30	Fair
4	Less than 20	Poor concrete
5	0	Delaminated

Ultrasonic Pulse Velocity (UPV)

This test is done as per IS 13311(part 1):1992. The specimens used forfor the test are cylinders size of 200mm long and 100mm diameter and cubes size of (100x100x100)mm. The specimen is placed between transducer and transmitter and waves are passed through sample from transmitter to transducer and reading are noted.The pulse velocity is calculated by specimen length/travel time. Based on criteria mentioned in Table 6 concrete quality is determined.

Table 5 Inference for UPV

S.No.	Pulse velocity	Quality of Concrete
1	>4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	< 3.0	Doubtful

III. RESULTS AND DISCUSSION

Rapid Chloride Penetration Test

RCPT values after 28days curing are shown in figure 3. From the results obtained it can be depicted that if the chloride penetration in concrete is low then it is good quality of concrete cause good quality concrete blocks the ingress of harmful chemicals from cracks due to which corrosion of reinforcement is prevented. From the results it can be observed that CFAB25 has lowest chloride penetration and by comparing with inference values from table 4 it can be said that the quality concrete is very good and specimen CC has highest chloride permeability from which by comparing with inference it can be depicted that the quality of concrete is moderate.

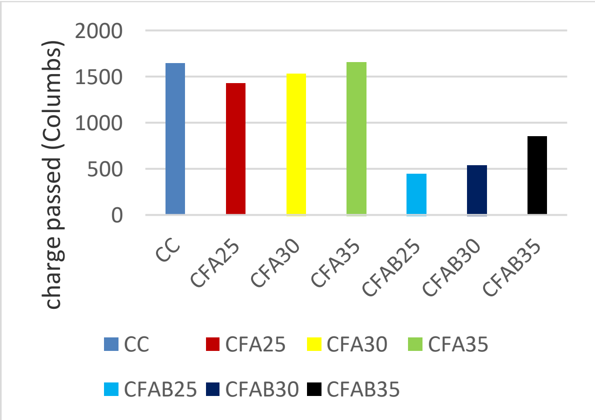

Figure 3 RCPT values after 28days of curing

Sorptivity

Itshows capillary rise in water. The higher value of sorptivity indicates the concrete water absorption is high. Lower value indicates low water absorption. Good quality concretes have water absorption >0.1mm/min.From figure 4 it can be interpreted that concrete specimen CCabsorption rate is high therefore the quality of concrete is not good.Comparatively CFA 25 and CFA 30 has lower absorption rate and the CFA 35 has higher water absorption due to high amount of fly ash. In specimens of flyash enriched with bacteria is seen that they are increasingly safe ingest less water when compared with other from which CFAB 25 ingests extremely less water 0.09.

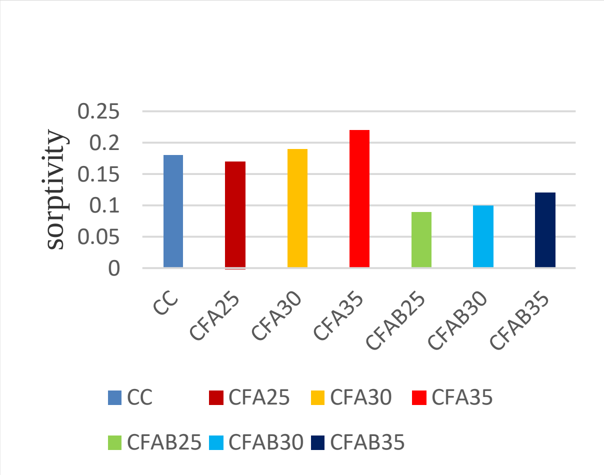

Figure 4 Sorptivity values after 28days of curing

Rebound Hammer

NDT was conducted with rebound hammer after 28days curing of sample. From figure 5 it can be observed that control concrete specimen has obtained a strength of 36.18 and comparing with reference given table4 the quality of concrete can be determined. It can be depicted that with accumulation of supplementary material fly ash the concrete has nearly obtained the same strength

Comparatively fly ash enriched with bacteria has obtained more strength nearly 1.27 time more than CC.

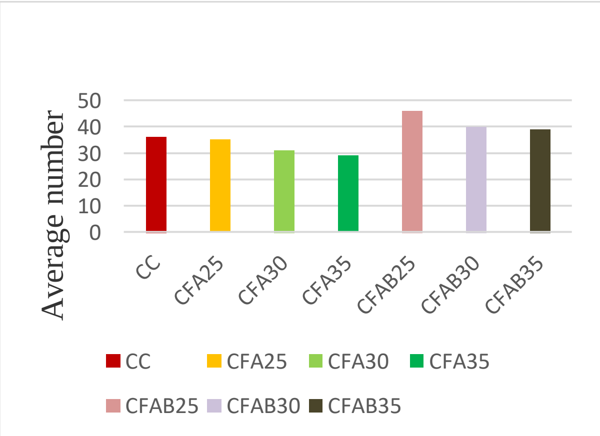

Figure 5 Rebound hammer values after 28days of curing

Ultrasonic Pulse Velocity

NDT was conducted with UPV after 28days on cylinder of size 200 length and 100mm diameter. This test is conducted to check the quality of specimen. From figure 6 it can be depicted that CC has higher pulse velocity and by comparing with the inference in table 5 it is determined concrete quality of CC is excellent comparatively with the addition supplements it is found that there is 1.06 times increase in CFAB25 when compared with CC

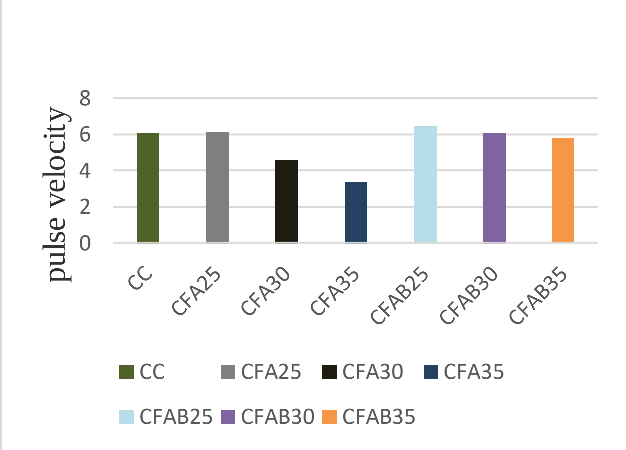

Figure 6 UPV values after 28days of curing

IV. CONCLUSION

It can be concluded that with the addition of additves or supplements such as fly ash and bascillus subtilis there is not only increase in stregth and duarbility it also increases life span of structure and reduces the maintainence cost of the strcuture.

- In RCPT it can be observed that CFAB25 has 3.65 times lower penetration when compared with CC this is due to bacteria helps to resist chloride permiability and helps in self healing of minute cracks which helps to avoid ingress of harmful suphate attacks
- In sorptivity it is observed that CFAB 25 has 2 times lower absorption when compared with CC and 1.8 times low absorption compared CFA25.
- From rebound hammer it can be observed that CFA25 and CC has certainely 1.33 times and 1.27 times lower strength when compared with CFAB25
- From UPV it can be depicted thatpulse velocity of CFAB25 is 1.06 times more when with CC and 1.10 times more compare to CFA25

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