International Journal of Research
Available at https://edupediapublications.org/journals

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 04 Issue 02
February 2017

Bacterial Concrete Using Fly Ash as Partial Replacement

K. SRIRAMYA
Research Scholar in M.TECH (Structures) Aurora's Technological & Research Institute
Parvathapur(V), Ghatkesar(M), Ranga Reddy, Telangana
Email :- sriramyakoppula9@gmail.com

L. APARNA
Assistant Professor, M.TECH (Environmental Engineering) Aurora's Technological & Research Institute
Parvathapur(V), Ghatkesar(M), Ranga Reddy, Telangana
Email :- lapps235@gmail.com

ABSTRACT:-The target of this exploration work is to decrease the cost of the construction. Presently a days the industrial wastes are quickly expanding more. To use such materials and lessen such kind of waste in condition. The concrete is supplanted by the GGBS and fly fiery debris with microorganisms of 106 bacillus pasteurii in M40 blend. the GGBS and fly slag as taken in the extents of 10% by weight of concrete. From this exploration the outcomes are substantially more better as contrast with the tradition concrete. The solid structures have different solidness issues because of the distinctive physiological conditions and it results to unrecoverable harm to the structure and in the end lessening in the quality of solid structure. The primary explanation for the minimizing of the strength and mechanical parts of cement is the pore structure of cement. In the current years MICCP (microbiologically induced calcium carbonate precipitation) by the microorganisms considered as a domain well disposed strategy to upgrade the properties of cement, likewise for the repair of solid structure and to combine distinctive development materials. This paper shows a survey of various inquires about in the current years on the utilization of bacterial cement/bio-concrete for the upgrade in the solidness, mechanical and perme ation parts of cement. It contains thinks about on various bacteria's, their detachment procedure, diverse methodologies for expansion of microscopic organisms in cement, their impacts on compressive quality and water retention properties of cement and furthermore the SEM and XRD investigation of cement containing microbes.

Key Words: *GGBS1, flyash2, Bacullius Pasteurii3, Compressive Strength4 and Spilt Tensile strength4 etc…*

INTRODUCTION

Cement is the most broadly utilized development material on the planet. It frames real part in the development business as it is shoddy, effortlessly accessible and advantageous to cast. Notwithstanding its distinctive qualities in the development, it has numerous restrictions as it is feeble in strain, has constrained malleability and less imperviousness to splitting and because of forceful ecological specialists which eventually diminish the life of the structure which are constructed utilizing these materials. The essential explanation behind the breaking of cement can be credited to porosity in surface (infinitesimal level) of basic individuals which permits dampness and water to saturate the solid individuals and subsequently, prompts to consumption of steel fortifications. This procedure of harm happens in the early existence of the building structure and furthermore amid its life time. Engineered materials like epoxies are utilized for remediation. Be that as it may, they are not good, exorbitant, decrease stylish appearance and need steady upkeep. In this way bacterial initiated Calcium Carbonate (Calcite) precipitation has been proposed as an option and condition amicable break remediation and henceforth change of quality of building materials.

A novel procedure is received in re-interceding splits and crevices in cement by using Microbiologically Induced Calcite or Calcium Carbonate ($CaCO_3$) Precipitation (MICP) is a system that goes under a more extensive classification of science called bio-mineralization. MICP is exceedingly alluring on the grounds that the Calcite precipitation prompted subsequently of microbial exercises is without contamination and normal. The procedure can be utilized to enhance the compressive quality and firmness of split solid examples. Examine prompting to microbial Calcium Carbonate precipitation and its capacity to mend splits of development materials has prompted to numerous applications like break remediation of solid, sand union, reclamation of authentic landmarks and other such applications. So it can be characterize as the procedure can happen inside or outside the microbial cell or even some separation away inside the solid. Regularly bacterial exercises basically trigger an adjustment in arrangement science that prompts to over immersion and mineral precipitation. Utilization of these Bio mineralogy ideas in solid prompts to potential innovation of new material called ―Bacterial Concrete. There is developing acknowledgment all through the world that crude materials assets utilized as a part of the creation of bond are limited and non-renewable and should be moderated for future eras. With the target of achieving economical development a solid pattern supporting the expanded utilization of admixtures in cement is rising all through the world. The mineral admixtures are fundamentally the waste results of mechanical procedures, delivered to the tune of a large number of tones whose transfer is an awesome concern. Fiery debris from coal based power plants is one such waste which is liberally accessible in the distinctive parts of India. Cement can fill in as the most secure home of fly fiery remains and has a huge potential for its use. Fly fiery debris or pummeled fuel cinder, a mechanical misuse of coal based warm power plants, comprises of finely partitioned round particles of silicate glass adjusted with aluminum and press and can be utilized as a part of cement because of financial and specialized points of interest. Fuse of fly fiery remains brings about impressive upgrades in solid properties. Fly cinder is the most broadly utilized pozzolana on the planet Fly powder, otherwise called vent fiery debris is a repercussion from coal based warm power plant. Inferable from its pozzolanic properties, fly fiery remains can be utilized as a swap for a portion of the Portland bond substance of cement Also, Fly cinder can add to the solid's last quality and increment its synthetic resistance and toughness.

MATERIALS OF SELF HEALING CONCRETE

In the present examination program, standard 3D squares (150x150x150mm), standard pillars (100x100x500 mm), standard chambers (150mm breadth, tallness 300mm) were threw and tried for finding the Compressive quality, Flexure quality and Split Tensile quality properties for bacterial solid, typical concrete, bacterial cement with fly fiery remains as fractional substitution to bond and bacterial cement without fly powder.

The materials utilized as a part of this test study are Cement, Fine total, Coarse total, Water, Fly fiery debris, Bacillus odeyssei.

Cement

Cement is a binder, a substance that sets and hardens independently, and can bind other materials together. The most important factor considered for cement grading is the average compressing strength of the material in a given particular amount of time over a particular area in a particular composition of the cement mortar mixture.

The cement used for this research is 43 grade ordinary Portland cement (OPC). The cement was uniform color i.e., grey with a high greenish shade and was free from any hard lumps. It was tested for its physical properties as per IS 12269-1987 and their results are presented in the given table.

Physical Properties of Ordinary Portland Cement

S No.	Property	Test Method	Test result	IS standard
1	Normal consistency	Vicat apparatus (IS: 4031 part 4)	30%	-
2	Specific gravity	Sp. Gr bottle (IS 4031 part 4)	3.09	-
3	Initial setting time	Vicat apparatus (IS 4031 part4)	96 minutes	Not less than 30 minutes
4	Final setting time	Vicat apparatus (IS 4031 part4)	207 minutes	Not greater than 600 minutes
5	Fineness	Sieve test on sieve	9%	<10

Aggregate

Aggregates are utilized as a part of cement for certain reason. Totals ordinarily make up around 60 to 75 percent of volume of a solid blend. So we can state that, a large portion of the prerequisite of cement in its plastic state is influenced by total properties and, Gradation of total is one of them. The size, shape and degree of the total assume a vital part in accomplishing a legitimate cement.

Fine Aggregate

The sand which goes through 4.75mm strainer is said to be fine total. The locally accessible clean sand is utilized as fine total in the present investigation. The sand is tried for strainer investigation to decide the molecule estimate dispersion in a specimen of total, called degree. The other test to discover physical properties like fineness test, particular gravity and mass thickness test have led. The above test have been directed as per IS 2386-1963. The subtle elements of test outcomes are appeared in the given Tables.

Sieve Analysis of Fine Aggregate

S No.	IS Sieve Size	Weight Retained in (gms)	% of weight retained	Cumulative % Weight Retained	% Passing in each sieve
1	4.75 mm	4	0.4	0.4	99.6
2	2.36 mm	10	1	1.4	98.6
3	1.18 mm	108	14.4	15.8	84.5
4	600µ	362	36.2	49	51
5	300µ	398	39.8	91.8	8.2
6	150µ	78	7.8	99.6	0.4
7	Pan	4	0.4	100	0

Physical Properties of Fine Aggregate

S No.	Property	Test Method	Test Results
1	Specific gravity	Pycnometer (IS-1986 part-3)	2.61
2	Bulk density (kg/m^3) Loose Dense	(IS 2386-1986 part-3)	14.37 KN/m^3 16.04 KN/m^3
3	Fineness modulus	Sieve analysis(IS 2386-1986 part-3)	2.59

Coarse Aggregate

The aggregates which retain on 4.75mm sieve are coarse aggregate. Locally available aggregate of size 20mm have been used in the present experiment. It is free from impurities such as dust, clay particles and organic matter etc. For the coarse aggregate the sieve analysis test has conducted and also physical properties of coarse aggregate were investigated in accordance with IS 2386 -1963. The details of test results are shown given in the given tables.

Sieve Analysis Chart for Coarse Aggregate

IS Sieves Size	Weight Retained (kg)	Cumulative Weight Retained	Cumulative % Weight Retained	% Passing
20	2.240	2.240	45.22	54.78
10	2.170	4.410	89.03	10.97
4.75	0.440	4.850	97.92	2.08
Pan	0.103	4.53	_	0

Physical Properties of Coarse Aggregate

S No.	Property	Test Method	Value
1	Fineness modulus	Sieve analysis (IS 2386-1963 Part 2)	7.32
2	Specific gravity	Pycnometer (IS 2386-1963 Part 3)	2.59
3	Bulk density (kg/m^3) Loose Bulk density (kg/m^3) Dense	(IS 2386-1963 Part 3)	13.60KN/m^3 15.00KN/m^3

Water

Water that is suitable for drinking is satisfactory for use in from concrete. Water from lakes and streams that contains marine life also usually is suitable. When water is obtained from sources mentioned above, no sampling is necessary. When it is suspected that water may contain sewage, mine water, or wastes from industrial plants or canneries, it should not be used in concrete unless tests indicate that it is satisfactory. Water from such sources should be avoided since the quality of the water. In the present experimental program, portable water free from any amount of oils, acids, alkalis, sugar, salts and organic materials confirming to IS 456 – 2000 (1) is used for mixing and curing of concrete.

Fly Ash

Fly ashes are generally finer than cement and consist mainly of glassy spherical particles as well as residues of hematite and magnetite, char, and some crystalline phases formed during cooling Fly ash is the best known, and one of the most commonly used, pozzolanas in the world. Physical Properties of Fly Ash are shown in the given Table

Typical Oxide Composition of Fly Ash

S No.	Characteristics	Percentage (%)
1	Silica, SiO_2	52.16
2	Alumina, Al_2O_3	36.93
3	Iron Oxide, Fe_2O_3	4.23
4	Lime, CaO	4.67
5	Magnesia, MgO	Nil

Figure : Bacillus odeyssei

Working of Bio Concrete

Self-mending cement is an item that will naturally deliver limestone to recuperate breaks that show up on the surface of solid structures. Exceptionally chose sorts of the microscopic organisms family Bacillus, alongside a calcium-based supplement known as calcium lactate, and nitrogen and phosphorus, are added to the elements of the solid when it is being blended. These self-mending operators can lie torpid inside the solid for up to 200 years. In any case, when a solid structure is harmed and water begins to leak through the splits that show up in the solid, the spores of the microbes develop on contact with the water and supplements. Having been enacted, the microorganisms begin to feast upon the calcium lactate. As the microscopic organisms encourages oxygen is devoured and the dissolvable calcium lactate is changed over to insoluble limestone. The limestone hardens on the split surface, subsequently fixing it up. The utilization of oxygen amid the bacterial change of calcium lactate to limestone has an extra preferred standpoint. Oxygen is a basic component during the time spent consumption of steel and when the bacterial action has expended it all it builds the toughness of steel strengthened solid developments.

The two self-recuperating operator parts (the bacterial spores and the calcium lactate-based supplements) are acquainted with the solid inside independent extended mud pellets 2-4 mm wide, which guarantee that the specialists won't be initiated amid the concrete blending process. Just when airs out up the pellets and approaching water carries the calcium lactate into contact with the microscopic organisms do these get to be distinctly actuated. Testing has demonstrated that when water saturates the solid, the microbes develop and duplicate rapidly. They change over the supplements into limestone inside seven days in the research facility. Outside, in lower temperatures, the procedure takes a little while.

Bacterial Concrete with Fly Ash

Development of Bacterial solid utilizing fly powder is another idea. In which living life form or microbes called "Bacillus odysseyi" is blended in water with standard port land concrete alongside fine total and coarse total. The procedure look like simply like development of typical cement aside from the expansion of "Microbes" and "fly cinder". It has ended up being practical and proficient by utilization of mineral admixture like fly fiery debris.

Fly Ash is a siliceous material acquired from warm plants, is utilized as fractional substitution of customary Portland bond. Microbes moreover with fly cinder are utilized to acquire self-mending, workable, sturdy and solid cement. Bacterial solid utilizing fly fiery remains can be called as a "Savvy Bio Material" for repairing concrete.

RESULTS AND DISCUSSIONS

Test Results on Fresh Concrete

The workability tests i.e., Slump flow test, compaction factor test conducted on concrete are shown in the given table 1 and table2

Table 1: slump test results

S. No.	% of fly ash added to cement as replacement	Bacillus odeyssei cell/ml	Slump (mm)
1	10%	0	61
2	20%	0	59
3	10%	10^5	66
4	20%	10^5	62
5	0	10^5	65

From the tableit is clearly observed that the concrete to which only fly ash is added as replacement of 10%, 20% without mixing bacteria bacillus odeyssei is giving low results compared to concrete to which fly ash is added as replacement along with bacteria. Also the concrete to which bacteria bacillus odeyssei is mixed with 10% of fly ash replacement is giving good result compared to 20% fly ash replacement with bacteria. Hence it can be said from the above table that the results for slump test is giving better for the concrete to which fly ash is added 10% as partial replacement along with bacteria bacillus odeyssei of 10^5 cell/ml.

International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 04 Issue 02
February 2017

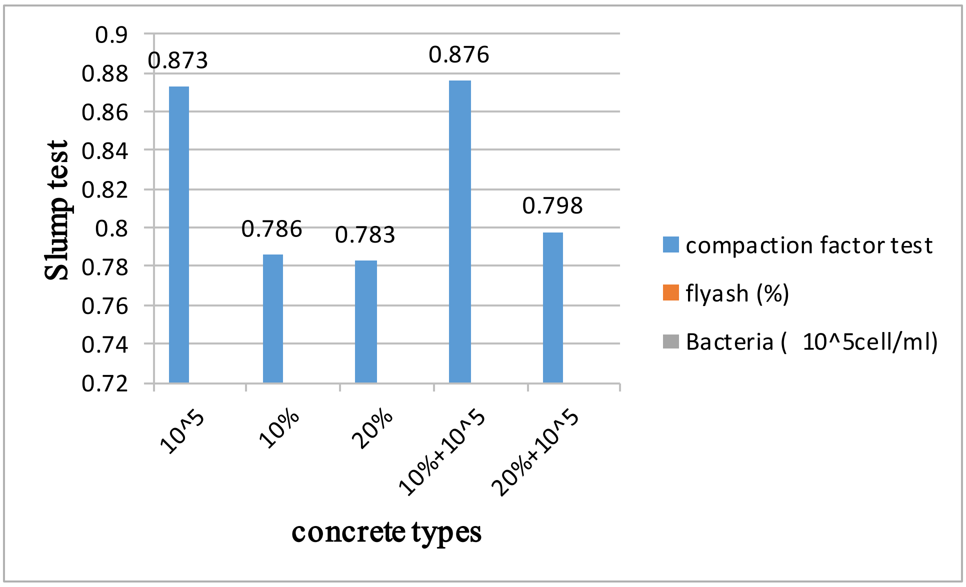

Figure 1: Slump test variation

From the Fig.5.1 the variation of slump test has been shown. The bacterial concrete with 10% of fly ash has got high slump value compared to bacterial concrete with 20% of fly ash, bacterial concrete without fly ash and fly ash based concrete.

Table 2: Compaction factor test results.

S. No	% of fly ash added cement as replacement	Bacillus odeyssei cell/ml	Compaction fac (mm)
1	10%	0	0.786
2	20%	0	0.783
3	10%	10^5	0.876
4	20%	10^5	0.798
5	0	10^5	0.873

From the table 2, it can be said that the compaction factor value for bacterial concrete with 10% fly ash has got good result compared to bacterial concrete with 20% fly ash .The concrete with 10% of fly ash has got increased compaction value compared to concrete with 20% of fly ash.

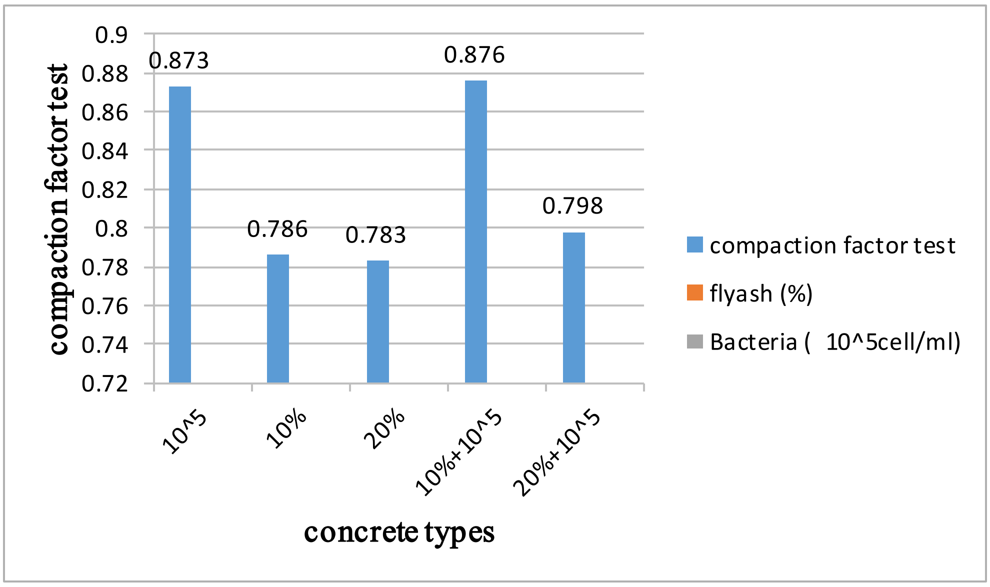

Figure 2: variation of compaction factor test

The Fig.5.2 shows the variation of compaction factor test conducted for different concrete types. The bacterial concrete with 10% of fly ash has got increased value compared to bacterial concrete with 20% of fly ash. The 10% fly ash based concrete got high value compared to 20% fly ash based concrete.

Test Results on Hardened Concrete

The strength test i.e., compressive strength, split tensile strength and flexural strength test results on hardened concrete at the age of 7 days, 14 days and 28 days of curing obtained for Bacterial concrete without, bacterial concrete with fly ash for 10% and 20%, fly ash based concrete for 10% and 20% and conventional concrete have conducted and their results are shown below in table 5.3, 5.4, 5.5 respectively.

The table 3 shows the test results for compression test conducted for cubes for 7, 14 and 28 days of curing. The concrete to which fly ash is added as replacement to cement for 10% has got increased value compared to concrete to which 20% of fly ash is added. The bacterial concrete to which fly ash is added for 10% has got increased value compared to bacterial concrete to which 20% of fly ash is added. Bacterial concrete without fly ash has got great strength compared to bacterial concrete with fly ash, fly ash based concrete and conventional concrete.

Table 3: compressive strength test (N/mm2)

S. No.	Concrete type	Bacterial concrete (cell/ml)	7 days	14 days	28 days
1	Conventional concrete	0	25	31.5	45.2
2	10% fly ash	0	25.25	32.2	45.30
3	20% fly ash	0	19.84	30.92	34.92
4	10% fly ash	10^5	30.05	35.2	49.85
5	20% fly ash	10^5	29.85	33.92	38.40
6	0%	10^5	36.25	34.76	49.06

The table 5.3 shows the test results for compression test conducted for cubes for 7, 14 and 28 days of curing. The strength for the concrete to which 10% of fly ash has added is increased for compared to conventional concrete at 7, 14 and 28 days. The strength is decreased for the concrete type to which fly ash added for 20%. In similar way the strength for concrete type to which fly ash added for 10% along with bacterial has achieved good strength compared to fly ash concrete without bacteria. Bacterial concrete has achieved great strength compared to bacterial concrete with fly ash and fly ash based concrete.

Table4: split tensile test (N/mm2)

S. no.	Concrete type	Bacteria concrete (cell/ml)	7 days	14 days	28 days
1	Conventional concrete	0	2.54	2.78	3.95
2	10% fly ash	0	3.20	3.43	4.02
3	20% fly ash	0	3.05	3.1	2.95
4	10% fly ash	10^5	3.95	4.06	4.11
5	20% fly ash	10^5	3.28	3.35	3.41
6	0%	10^5	4.16	4.98	5.02

Table 5: Flexural strength test

S. no.	Concrete type	Bacterial concrete (cell/ml)	7 days	14 days	28 days
1	Conventional concrete	0	4.08	4.67	5.2
2	10% fly ash	0	4.29	4.96	5.05
3	20% fly ash	0	3.12	3.34	3.98
4	10% fly ash	10^5	4.85	4.98	5.75
5	20% fly ash	10^5	3.32	3.92	4.05
6	0%	10^5	4.95	5.16	6.05

The table 4 shows the strength for split tensile has increased for the bacterial concrete to which 10% fly ash added as replacement and decreased for 20% fly ash for 7 days of curing, also the same was observed for the 14, 28 days of curing. The values have increased for the bacterial concrete with fly ash added for 10% compared to bacterial concrete with fly ash at 20%, bacterial concrete without fly ash and conventional concrete.

The table 5 shows the test values conducted for flexural strength test for 7, 14, and 28 days of curing .It can be seen that Bacterial concrete with fly ash at 10% has achieved greater strength compared to conventional concrete, bacterial concrete without fly ash, and fly ash based concrete for 7, 14, and 28 days of curing .

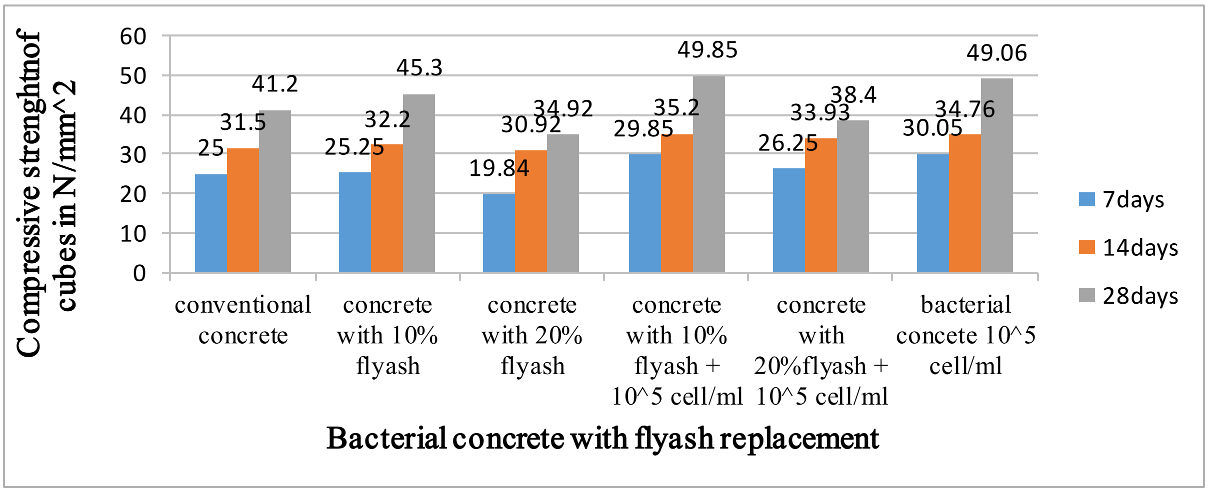

Figure 3: variation of compressive strength for different concrete types

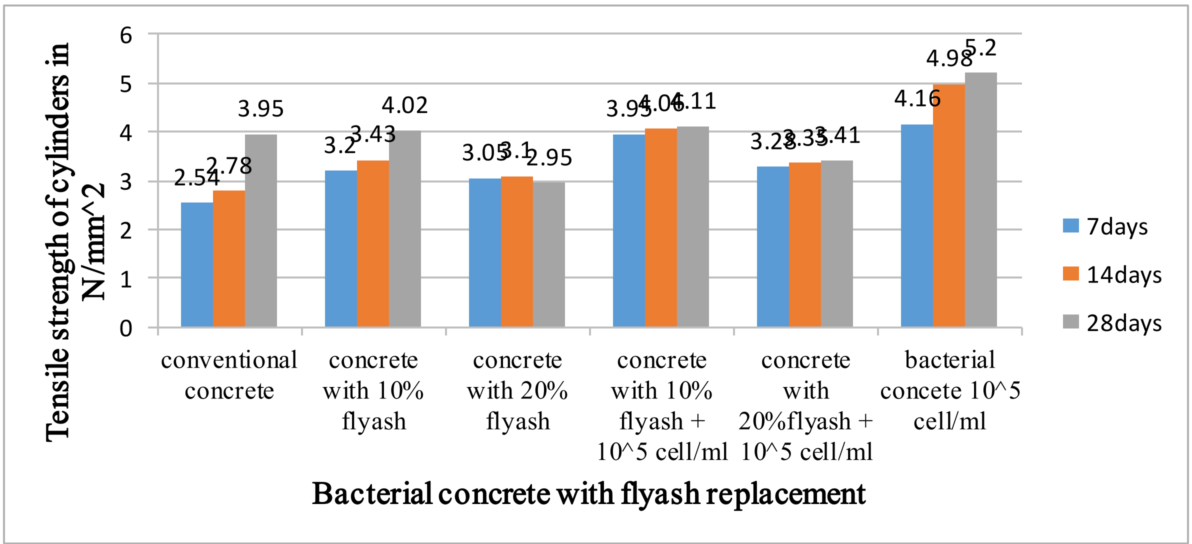

Figure 4: variation of tensile strength for different concrete types

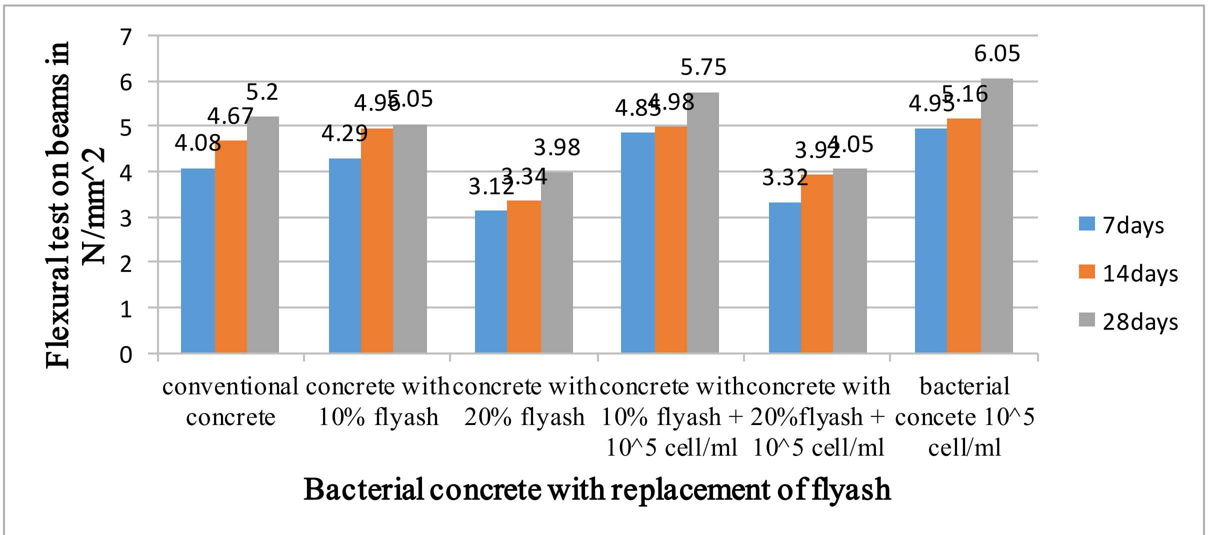

Figure 5: variation of flexural strength for different concrete types.

International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 04 Issue 02
February 2017

Fig3 shows the variation of compressive strength with different concrete types at 7days, 14 days and 28 days respectively. At 7days of curing the strength of hardened concrete is been gradually decreasing, at 14 days of curing the strength has increased compared to 7 days, whereas at 28days of curing it attains maximum strength and coincide with the linear values.

Fig.4 shows the variation of Split Tensile strength of concrete at 7days, 14 days and 28days. Here the value of tensile strength is decreasing at 7days of curing, strength has increased at 14 days of curing, and the strength has increased a lot more compared to 14 days curing at 28days of curing.

Fig.5 shows the flexural strength of the specimen at 7days, 14 days and 28days of curing with different concrete types. In this case the strength of the casted specimen is low at 7days of curing when compared to that of 14 days and 28days of curing which clearly indicates the Flexural strength of the specimen.

- It has been observed from the test results that the results for bacterial concrete with fly ash, bacterial concrete without fly ash , fly ash concrete and conventional concrete types has exhibit good workability.
- Workability characteristics i.e., slump test, compaction factor test has attained good result for the concrete to which fly ash added to 10% as partial replacement to cement along with the mixing of bacteria bacillus odeyssei.
- It is observed that the, the compressive strength for the bacterial concrete with fly ash at 10% has increased for 7, 14, and 28 days age of concrete compared to bacterial concrete with fly ash at 20%.
- It is observed that bacterial concrete with fly ash is achieved good compressive strength compared to bacterial concrete without fly ash at both 10% and 20%, fly ash based concrete and conventional concrete.
- Also for the tensile strength test the Bacterial concrete with fly ash at 10% and 20% has got increased value

compared to bacterial concrete without fly ash for 10%, 20% for 7, 14, 28 days ages of concrete.

- Flexural test conducted have shown that bacterial concrete with fly ash at 10% has received high strength compared to bacterial concrete without fly ash and bacterial concrete without fly ash at 20% and conventional concrete.
- Therefore from the experimental results, the compressive strength, split tensile strength and flexural strength increased for bacterial concrete with fly ash for 10%.
- Hence from the above all the results it can be said that strength has increased for the bacterial concrete, also which act as self-healing concrete.

CONCLUSION

All the mixes used in this study exhibits the good workability characteristics, in accordance with the IS 12269-1987 specifications.Workability characteristics i.e., slump test, compaction factor test has attained good result for the concrete to which fly ash added to 10% as partial replacement to cement along with the mixing of bacteria bacillus odeyssei. It is observed that the, the compressive strength for the bacterial concrete with fly ash at 10% has increased for 7, 14, and 28 days age of concrete compared to bacterial concrete with fly ash at 20%. It is observed that bacterial concrete is achieved good compressive strength compared to bacterial concrete with fly ash and bacterial concrete without fly ash at both 10% and 20%.

Also for the tensile strength test the Bacterial concrete with fly ash at 10% has got increased value compared to bacterial concrete without fly ash at 20% for 7, 14, 28 days ages of concrete. Flexural test conducted have shown that bacterial concrete has received high strength compared to bacterial concrete with fly ash and bacterial concrete without fly ash at 10%, 20% .Therefore from the experimental results, the compressive strength, split tensile strength and flexural strength increased for only bacterial concrete. Hence from the above all the results it can be said that strength has increased for the bacterial concrete, also which act as self-healing concrete.

The results show that the effect of bacteria has really worked out as it is giving great strength and as it is eco-friendly it is a very good material and is safe to use as it is totally harmless to living beings. This concrete can be used to prevent cracks and hence saving the structure from corrosion of steel.

REFERENCES

1. Dhaarani, M., Prakesh, K., (2014), "Durability study on HVFA based bacterial concrete- A literature study", volume-3, September 2014.
2. Gavimath, C.C., Mali, B.M., Hooli, V.R., Mallapur, J.D., Patil, A.B., Gaddi, D.P., Ternikar, C.R., Kavishankera, B.E., (2012), "Potential application of bacteria to improve the strength of cement concrete", volume-3, issue-1,PP 541-544.
3. Goyal, M., P. Krishna, (2015), "Behaviour of Bacterial Concrete as Self-Healing Material" Volume 5, Issue 1, January 2015.
4. Gun-Cheol Lee, G.C., Yan, S.J., Joumg, J.H., Choi, J.G., Joe, J.H.,(2011), "A fundamental study on CO2 absorption efficiency of cement motor mixed with Photosyenthesis Bacteria", PP 174-179.
5. Karma, V.V., George, R.P., Menaka, M., Sharath, D., Mudali, U.K., Venkataramana, B., (2012), "Biofilm formation and thermo-graphic evaluation of fly ash concrete in sea water", volume-3, May 2012
6. Kashyap, A.M.N., Ramya, S.P.S., (2014), "An experimental study on durability of concrete using fly ash and GGBS for M30 grade concrete", volume-10, issue-11, September 2014, PP 1-5.
7. Kumar, J., Pushpa, Prabhakara, R., (2014), "Eco-Bricks by Microbial Mineral Precipitation" Volume 2, Number 1 (2014), pp.77-84

Kumar, J.B.G.., Prabhakara, R., Puchma, H., (2013), "Effect of bacterial calcite precipitation on compressive strength of motor cubes", volume-2, issue-3, June 2013.

K. Sriramya

Research Scholar in M.TECH (Structures) Aurora's Technological & Research Institute
Parvathapur(V), Ghatkesar(M), Ranga Reddy, Telangana
Email :- sriramyakoppula9@gmail.com

L. Aparna

Assistant Professor M. TECH (Environmental Engineering) Aurora's Technological & Research Institute

Parvathapur(V), Ghatkesar(M), Ranga Reddy, Telangana

Email :-lapps235@gmail.com