Experimental Study On Concrete With Fly Ash And Effective Micro-Organism

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Abstract- *Environmentally sustainable construction materials with reduced heat of hydration have ever-growing demand worldwide. And one of the most common problems developed in concrete is about cracks. Cracks allow salts and water to seep through them and make the concrete weak. Corrosion of steel weakens the reinforced concrete in tension. Based on this factor, some modified cement concrete mixtures incorporated with optimum ratio of fly ash (FA) and effective microorganism (EM) were produced. In this study, a biological repair technique was used in which EM-1 Hariyali were mixed with concrete to reduce the heat of hydration. The experiments were carried out to evaluate the effect of Bacillus megaterium and fly ash on the compressive strength, Tensile strength and Flexural test for 7, 14, 28 days. In addition to above technique fly ash was partially added in the place of cement. The fly ash (0, 10, 20 and 30 %) was added by weight of cement in concrete mix with EM-1 (0,5,10 and 15%) and experiments were carried out.*

Keywords- Effective micro-organism, Heat of hydration, Biological treatment, Cracks, Compressive strength, Flexural strength, Tensile strength

I. INTRODUCTION

Concrete is the main building material majorly used for construction purposes, but the one thing which is inevitable in concrete are cracks. Due to its low tensile strength, micro crack occurs when the load applied is more than its limit and this is the reason for the seepage of salts and water. A lot of research works have been carried out in order to overcome the problems like workability, earlier strengths and the later strengths in concrete, which made a tremendous improvement in concrete technology. As these days the concrete is being used for wide varieties of purposes in different conditions. In some conditions, ordinary concrete may not be able to serve the required quality or durability performance. Hence, in these cases to modify the properties of the ordinary concrete, an admixture is used. Admixture is a material, other than generally used materials like cement, water and aggregates. This is added to the batch immediately before or during mixing. Mostly the admixtures are used to reduce the construction cost, to modify the properties of hardened concrete, to check the quality of concrete during mixing, transportation, placing and curing and to overcome certain emergencies during concrete batching. There are two such admixtures added in this paper which are economically, environmentally friendly, sustainable, easy to obtained.

1. Fly Ash

Fly ash is used as a supplementary cementitious material in the production of portland cement concrete. A supplementary cementitious material, when utilized in conjunction with hydraulic cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity, or both. A pozzolan is defined as a siliceous or siliceous and aluminous material that in itself possesses little or no cementitious value, but which will, in finely divided form and in the presence of moisture, chemically react with lime at ordinary temperatures to make compounds having cementitious properties. Pozzolans that are commonly utilized in concrete include ash, silica fume and a spread of natural pozzolans like calcined clay and shale, and volcanic ash. Historically, ash has been utilized in concrete at levels starting from 15% to 25% by mass of the cementitious material component. The actual amount used varies widely counting on the appliance, the properties of the ash, specification limits, and therefore the geographic location and climate. Ash that falls to rock bottom of the boiler's combustion chamber is named bottom ash. Together with bottom ash faraway from rock bottom of the boiler, it's referred to as coal ash. Depending upon the source and composition of the coal being burned, the components of ash vary considerably, but all ash includes substantial amounts of silica, aluminium oxide and quicklime, the most mineral compounds in coal-bearing rock strata.

2. Effective Micro-organisms

Effective Microorganism (EM) in cement-based material has shown huge potential as new additive. However, the effect of EM to the interior of the microstructure of the cement matrix caused by the inclusion of EM still must be extensively evaluated. In this present study, three different dilutions percentages of EM Mixed Solution (EMMS) were added in the cement paste namely were 5%, 10% and 15% of the total mixing water including no addition of EMMS as an impact specimen. This EM is environmentally friendly with zero harm to the environment. The result showed that the addition of EMMS in cement contribute to high increment up to hundred twenty percent of compressive strength reference to control at the stage of 28 days.

II. LITERATUREREVIEW

Ghasan Fahim Huseien a, Zahraa Hussein Joudah (2020)- The early compressive strength of proposed concrete was enhanced over 30% and therefore the durability was improved against the tough environment caused by the incorporation of OPC with 10% of FA and EM. The optimum concrete obtained with the FA and EM of 10% was asserted to be environmentally beneficial towards less heating.

Jagdish Virupakshi Patil(2017)-In comparison to ordinary Portland cement, the collection of fly-ash as a by-product requires less energy and it produces less the main objective of these paper is to see the difference between strength and workability of plain concrete and concrete mix by using fly ash.

R. Sri Bhavana, P. Polu Raja, S.S. Asadi(2017)–The Fly-ash (0,10 and 30%) was added by weight of cement in concrete mix and experiments were carried out. The experimental results show that 10% flyash replaced concrete with and without bacteria has more strength when compared to the conventional concrete.

Jamaludin M. Yatim, Mohamad Ismail, wan A.W.A Rahman (2016)–The results showed that the concrete containing EM had higher compressive strength along with better resistance to several environments. It showed that EM might be used as an admixture in concrete for many sorts of environment to enhance strength and sturdiness.

Vinit kumarsingh, Vikas Srivastava, V.C Agarwal, Alvin harison(2015)–In comparison to ordinary Portland cement, the collection of fly ash as a by-product requires less energy and it produces less the main objective of these paper is to see the difference between strength and workability of plain concrete and concrete mix by using fly ash.

III. METHODOLOGY

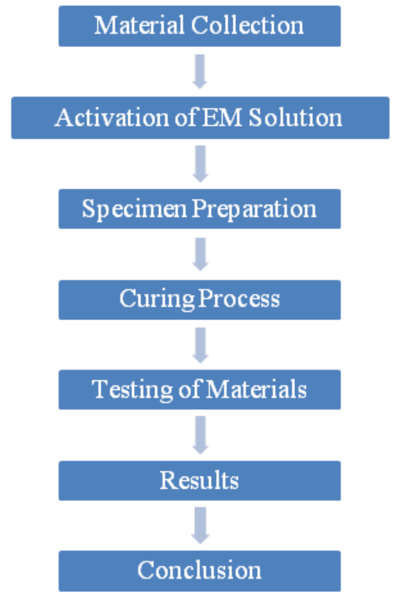

Fig.1 Methodology

IV. MATERIALS

Cement-Cement is a material that has a adhesion and cohesive properties which enables binding chunks of rock into one cohesive substance. Initial and final setting timeof the cement is checked. The initial setting was 25 minutesand the final setting time was 185 minutes. Specific gravityofcementwasfoundtobe3.35. Finally, we are using OPC (Ordinary Portland Cement) 53 grade.

M-Sand (Manufactured Sand) - The manufactured sand (MS) is a by-product of graining the crushed quarries and screening it. Considerable volumes of quarry fines are generated by the quarry while crushing the rock into aggregates. This manufactured sand is a substitute of river sand for concrete construction purposes. These are obtained from hard granite stone by crushing. The size of M-Sand is less than 4.75 mm.

Aggregates – Aggregate is a broad category of coarse to medium grained particulate material used in construction along with sand, gravel, crushed stone, slag, recycled concrete and geo synthetic aggregates. It consists about 60 to 70 percent of total concrete manufacture. Theses coarse aggregate are greater than 4.75mm but are usually in a range between 9.5mm to 3.75mm.

Fly Ash – Fly ash are also known as pulverized fuel ash. This is a coal combustion product that is composed of the particulates that are driven out of coal-fired boilers together with the flue gases. Ash falls to the bottom pf the fire box is called bottom ash. The components of fly ash vary according to the source and composition of the coal being burned. All this fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminium oxide (Al_2O_3) and calcium oxide (CaO).

Water and EM solution - The water used in the research was fresh tap water fit for drinking which consists of the optimum pH values. The Activated EM Solution was used in the production of the modified concrete samples which replaced the water content in the concrete like 5%, 10% and 15%.

V. EXPERIMENTALPROCEDURE

1. Activation of the EM solution

The effective microorganism (EM) concentrate was store bought which was perfectly prepared according to the source Japanese EM Technology. Activation of locally made effective microorganism is the mixing of the locally made EM with water and molasses or sweetening solution which serve as a growing medium for the micro-organisms. The mixture is called EM Activated (EM-A). The materials used were: air tight container; locally made EM; jaggery and chlorine free water.

The preparation procedure for locally made EM-A was as follows:

a) The total volume of locally made EM-A required was 5 liters.
b) Water was added in the container to make 5 liters.
c) 0.25 kg of jaggery was added which was 1part equal to the EM.
d) 0.25 liters of locally made EM was added.
e) The container was then shaken and the jaggery was fully dissolved, producing a mixture in the ratio of 1:1:4 (EM: jaggery: water)
f) The container was closed tightly and kept in a dark place for 7 days.

Fig. 2 Activation of the EM solution a) DAY 1 b) DAY 7

2. Preparation of specimen

The specimens required for the tests are prepared. The grade of concrete to be designed is M30. As a preliminary process the mix calculations are designed and the required ratios are obtained. In this project there seven different modified concrete combinations. The materials are weighed are the concrete mixes prepared. The specimens prepared are casted in cube (150mm * 150 mm * 150mm), cylinder (150mm * 300mm) and beam (100mm * 500mm * 100mm) shapes.

Fig. 3 a) Weighing the materials b) Mixing the concrete

3. Testing of Materials

There are various types of hardern testing and here to find the mechanical properties the tests ehich are done on the specimens which are cured for 7, 14 and 28 days are compressive strength test, split tensile strength test and flexural strength test. The optimum strength can achieved in various proportion are tested

Compressive strenght test:

The compression test is carried out on specimen cube of the shape of size (150mm*150mm). The test is carried out in the following steps:

After 28 days the specimens are tested under the load in a compression testing machine is applied uniformly at the rate of 14 N/mm^2 compression testing machine. The test is made in the following manner. The cubes of M30 grade of concrete with fly ash of 10%, 20% and 30%, EM solution of 5%, 10% and 20% and fly ash 10% with EM solution 10% are prepared with respect to the replacement of cementious substance and water.The results from the compression test are in the form of the maximum load the (cube) can carry before it ultimately fails. The compressive strength can be found by dividing the maximum load by contact the area of the test specimen. Metal mould preferably steel or cast iron are selected, cleaned and inner layer of specimen are applied with crude oil. Concrete is prepared in the calculated ratios and is filled into the mould in layer approximately 5 cm deep.Each layer is compacted the either by hand or by vibration. After the top layer has been compacted the surface of the concrete is brought to the finishing level using a trowel. When compacting is done by hand, the standard tamping bar is used and the strokes of the bar are distributed a uniform manner over the cross section of the mould.

Compressive Strength failure= $\frac{\text{Maximum load carried by the cube}}{\text{Contact Area}}$ Contact area of the cube = 15 cm x 15 cm = 225 cm^2

DESIGN MIX	COMPRESSIVE STRENGTH(N/mm^2)		
	7 DAYS	14 DAYS	28 DAYS
OPC + 10% FLY ASH	18	20	26
OPC + 20% FLY ASH	14	16	22
OPC + 30% FLY ASH	11	14	18
OPC + 5% EM	24.44	28.58	32.04
OPC + 10% EM	25.56	29.27	34.25
OPC + 15% EM	26.80	29.85	34.89
OPC + 10% FLY ASH + 10%EM	28.57	30.48	34.96

Fig. 4 Test report of compressive strength

Split tensile strength test:

Initially, take thespecimen from water after 7, 28 of curing; or any desired age at which tensile strength to be estimated. Then, wipe out water from the surface of specimen. After that, draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place. Now, record the weight and dimension of the specimen. Set the compression testing machine for the required range. Place plywood strip on the lower plate and place the specimen. Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate. Place the other plywood strip above the specimen. Then,bring down the upper plate so that it just touches the plywood strip. Apply the load continuously without shock at a rate within the range 0.7 to 1.4 MPa/min (1.2 to 2.4 MPa/min based on IS 5816 1999). Finally, note down the breaking load(P). Calculate the splitting tensile strength of the specimen as follows: T = 2P/ pi LD

DESIGN MIX	TENSILE STRENGTH (N/mm^2)		
	7 DAYS	14 DAYS	28 DAYS
OPC+10% FLY ASH	1.8	2	2.6
OPC+20% FLY ASH	1.4	1.6	2.2
OPC+30% FLY ASH	1.1	1.4	1.8
OPC+5% EM	3.74	3.89	3.91
OPC+10% EM	3.82	3.92	4.09
OPC+15% EM	4.12	4.46	4.62
OPC+10% FLY ASH+10% EM	28.57	30.28	36.96

Fig.5 Test report of split tensile test

Flexural strength test:

The test should be conducted on the specimen immediately after taken out of the curing condition so as to prevent surface drying which decline flexural strength.Place the specimen on the loading points. The hand finished surface of the specimen should not be in contact with loading points. This will ensure an acceptable contact between the specimen and loading points.Center the loading system in relation to the applied force.Bring the block applying force in contact with the specimen surface at the loading points.Applying loads between 2 to 6 percent of the computed ultimate load.Employing 0.10 mm and 0.38 mm leaf-type feeler gages, specify whether any space between the specimen and the loadapplying or support blocks is greater or less than each of the gages over a length of 25 mm or more.Eliminate any gap greater than 0.10mm using leather shims (6.4mm thick and 25 to 50mm long) and it should extend the full width of the specimen.Capping or grinding should be considered to remove gaps in excess of 0.38mm.Load the specimen continuously without shock till the point of failure at a constant rate (Indian standard specified loading rate of 400 Kg/min for 150mm specimen and 180kg/min for 100mm specimen, stress increase rate 0.06+/-0.04N/mm^2.s according to British standard).

DESIGN MIX	FLEXURAL STRENGTH (N/mm^2)		
	7 DAYS	14 DAYS	28 DAYS
OPC+10% FLY ASH	24.04	25.97	27.48
OPC+20% FLY ASH	22.15	22.81	25.69
OPC+30% FLY ASH	23.92	26.08	27.17
OPC+5% EM	25.68	28.93	29.12
OPC+10% EM	27.52	29.22	29.87
OPC+15% EM	28.64	30.15	32.54
OPC+10% FLY ASH+10% EM	28.53	30.23	33.85

Fig.6 Test report of flexural strength test

VI. RESULTS AND DISCUSSION

Compressive strength:

The size of cubical molds used in compression strength test was 150x150x150mm. Cubes are casted for 10%, 20% and 30% of fly ash with and 5%, 10% and 15% of EM-1 solution and then finally 10% of fly ash + 10% of EM-1 solution. Cubes are tested in compressive testing machine shown in figure after 7,14- and 28-days curing period. After curing cubes are placed in. Compression strength results are shown in below graphs. From the experimental results, it has been observed that cement replaced with 30% fly ash showed less compressive strength compared to 10% fly ash in both with and without EM-1 solution.

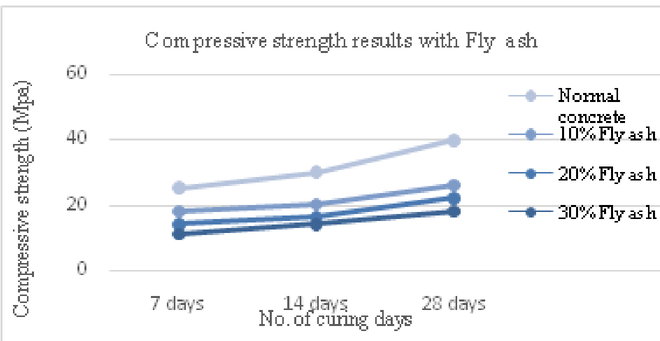

Fig.7 Compressive strength results with fly ash

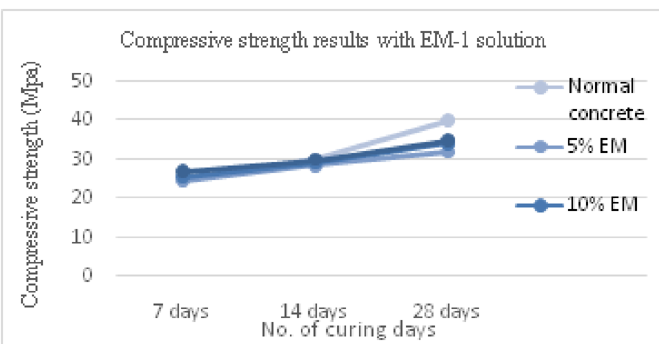

Fig.8 Compressive strength results with EM-1 solution

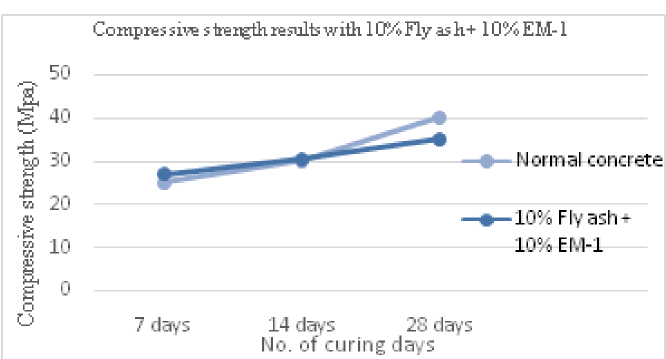

Fig.9 Compressive strength with 10% flyash +10% EM-1

Tensile strength test:

The sizes of cylindrical molds are 150mmx300mm for tensile strength test. Cylinders were casted for 10%, 20% and 30% of fly ash with and 5%, 10% and 15% of EM-1 solution and then finally 10% of fly ash + 10% of EM-1 solution. Cubes were tested in tensile strength machine shown in figure after 3-, 7- and 28-days curing. Tensile strength results are shown in graphs. From the experimental results, it has been observed that the 10% Fly ash + 10% EM-1 concrete showed more strength than normal concrete.

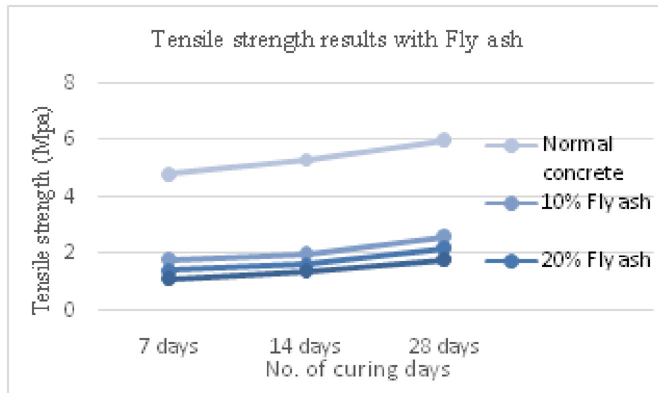

Fig.10 Tensile strength results with fly ash

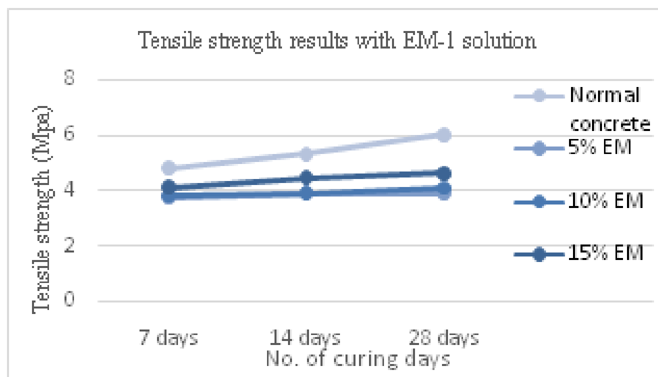

Fig.11 Tensile strength results with EM-1 solution

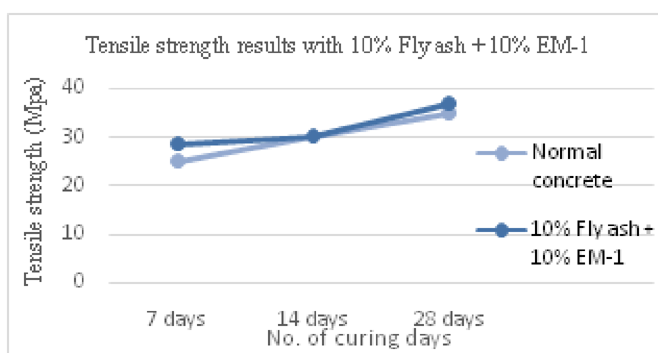

Fig.12 Tensile strength results with 10%flyash + 10%EM-1

Flexural strength test:

For flexural strength test 500x100x100mm molds are used. Prisms were casted for 10%, 20% and 30% of fly ash with and 5%, 10% and 15% of EM-1 solution and then finally 10% of fly ash + 10% of EM-1 solution. Beams were tested in flexural strength machine shown in fig.6 after 3-, 7- and 28-days curing. Flexural strength results are given in below graph. From the experimental results, it has been observed that cement replaced with 10% of fly ash showed more flexural strength with compared to 30% fly ash in both normal and EM-1 solution concrete.

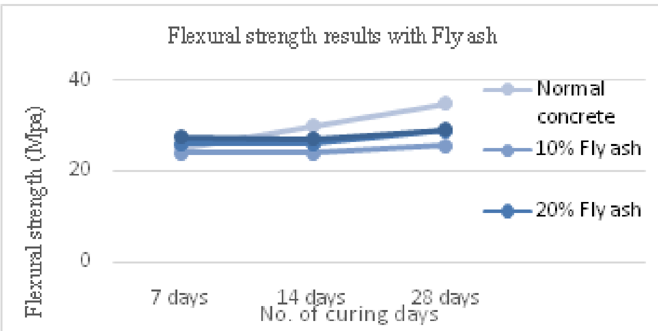

Fig.13 Flexural strength results with fly ash

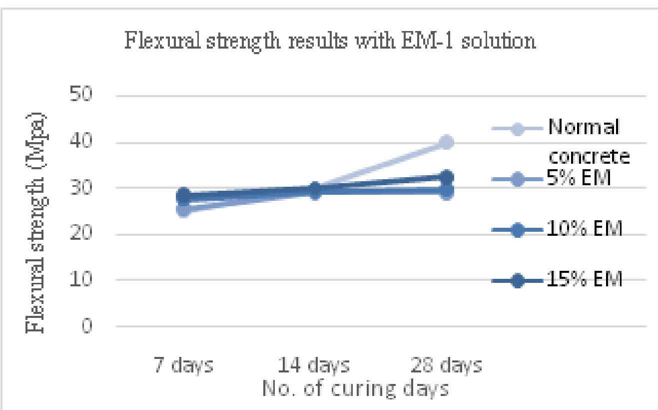

Fig.14 Flexural strength results with EM-1 solution

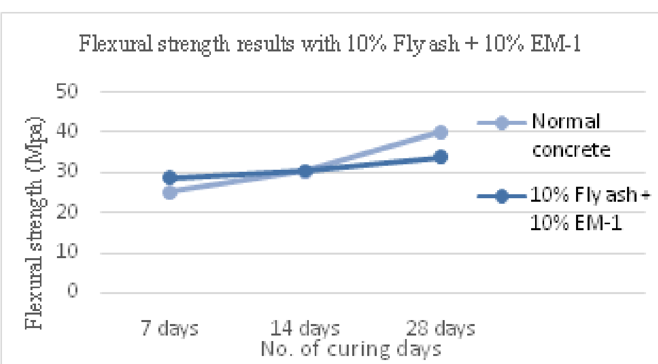

Fig.15 Flexural strength results with 10%flyash + 10% EM-1

VII. CONCLUSION

Effective microorganism was able to enhance the mechanical properties of concrete if an optimum dosage (10%) was added into concrete. Therefore, this concluded that the most economical and optimum percentage of EM-1 added into the concrete was 10% in which enhancing its design strength. EM-1 admixture is environmentally friendly and offers a relatively cheaper and better concrete admixture, and also Calcite precipitate of bacteria indirectly increases the strength of concrete by filling the voids. However, this study also showed that by replacing 30% of fly ash in concrete, the compressive strength was lower compared to the lower dosage, i.e., 10% of fly ash. Hence, the 10% EM-1 solution replaced in water + 10% fly ash replacement in cement shows best result while compared with normal other percent of both EM-1 and fly ash concrete. This concrete can be used in mass constructions and higher RC structures. From this study, it is concluded that this combination of concrete helps in reducing the heat of hydration and also helps in healing of cracks along with high strength.

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