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Improvement in Compressive Strength and Bond Strength of Concrete Containing Fly Ash Along with Fibers

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***Abstract*- As we know that there is lot of insufficiency of raw materials used in the construction and there is immediate need to prevent the pollution caused by the manufacturing of building materials used in construction. Therefore we can replace some amount of raw material which is insufficient in availability, with the waste materials such as fly ash, silica fume, slag, different type of fibers etc. usage of these waste material will ultimately reduce the construction cost with multiple advantages in improvement of various strength parameters.**

Our main aim is to investigate the compressive strength and bond strength of prepared reference mix M25 with locally available materials and after that we have studied the effect of incorporation of Fly ash alone and then Fly ash along with fibers, which are being added by weight of cement as a replacement.

1. INTRODUCTION

Now a days waste material production is increasing which leads to problem of its management. Thus it emphasized on use of waste material as a partial replacement of locally available materials used in construction, so that we can effectively protect our environment from waste accumulation which in turn helps us to improve overall economy.

Fly ash concrete is prepared by replacing cement partially by specific amount of Fly ash in concrete

which will improve its engineering properties. The use of Fly ash for its pozzolanic properties and special particle size characters render quality up gradation at no extra cost or may be even as reduced cost.

Fibers in cement matrix are secondary reinforced material and acts as crack arrester which helps us to restrict the growth of flaws in matrix which prevents these from enlarging under land, into cracks which eventually leads to failure. Thus fiber reinforced concrete is concrete made of cement, fine and coarse aggregate and discontinuous discrete fibers, when two different kinds of materials with contrasting properties of strength and elasticity. Thus when we use these materials as a replacement, durability and strength of concrete is improved with reduction in rate of heat liberation.

2. NEED AND OBJECTIVE

As per previous research carried out it is observed that investigation of various properties of fly ash concrete has been carried out but study on bond strength of fly ash concrete containing synthetic fiber is rare and scanty. Thus present research was planned to evaluate “Improvement in compressive strength and bond strength of concrete containing fly ash along with fibers”.

2.1 OBJECTIVE

Our objective is to investigate the effect of partial replacement of cement with fly ash in varying percentages (40% and 50% by weight of cement), also incorporating different percentages of fibers (0.20%, 0.35% and 0.50%) on bond strength and compressive strength of concrete at various moist ages viz, (7, 28 and 56 days).

3. LITERATURE REVIEW

Use of fibers in brittle matrix materials has a long history going back at least 3500 years when sun baked bricks reinforced with straws were used to build 57m high hill of aqua quf near Baghdad .in more recent years, asbestos fibers has been used to reinforce cement products for about 100 years, cellulose fibers for at least 50 years, and steel polypropylene and glass fibers have been used for same purpose for past 30years.

Mehta, P.K., investigated that in order to understand the benefits of using fly ash in concrete, the physical manifestations of the chemical reaction should be looked at. The properties of concrete are influenced by many factors. One of the factors that is particularly very important in the strength properties of the interfacial bond between the cement matrix and the aggregates. That interfacial bond is called transition zone in the Portland cement is very weak because of the presence of very large crystals of $Ca(OH)^2$, which find space here due to the wall effect next to the coarse particles.

Gopalaratnam and Abu-Mathkour studied the effect of fiber embedment length. fiber diameter and matrix quality on the fiber pull-out characteristics. They observed that the average bond strength is inversely proportional to the embedment length and that the average bond strength of an interface increases, with an increase in fiber diameter.

Hague M.N. et al., reported that the compressive strength of HVFC with a given aggregate cement ratio, decreases as the fly ash content increases. In case of super plasticized concrete, there is almost negligible strength loss between the mixes 0.40 to 0.50. The rate of strength variation seems to be dependent on the consistency and presence of different admixtures.

Langley has reported the result of the investigations carried out to determine the effects of incorporating high volume of ASTM class F fly ash on concrete with 50% replacement level of cement by fly ash. Test results indicated that fly ash concrete show substantial increase in compressive strength, split tensile strength and flexural strength from the ages of 28 days to 365 days.

Mayfield and Zelly reported Mechanical treatment of the fibers have been found more effective in improving bond than chemical treatment.

Tattersall et al. reported that the failure of steel fiber reinforced concrete is generally attributed to the failure of the bond between fibers and matrix. Variation in matrix properties, such as water-cement ratio and aggregate-cement results in different bond strengths, the best results were obtained from a fiber with looped end and indented fiber In a report produced by the Materials Technology Division of the Concrete Society (1973), it was stated that the optimum properties of SFRC have not yet been reached, since, in most of the reported work, the majority of fibers have pulled out of the matrix before reaching the ultimate strength.

Peter has stated that the Bond stress further increases with the decrease in diameter and increase in surface roughness.

4. MATERIALS

4.1 FIBERS

Recron 3S fiber improves plastic and hardened concrete properties, and is also alkali resistant. It is engineered and manufactured from virgin polyester which is exclusively used for cementitious based products like concrete. The fibers used were supplied by reliance industries limited.
Properties of recron 3S fiber given by reliance industries limited are as given below:

1. Melting point =250^0 C
2. Specific gravity = 1.36
3. Cross-section of fiber = Triangular
4. Dispersion= Excellent
5. Acid and salt resistant =Excellent
6. Drying shrinkage = 0.03%

4.2 FLY ASH (FA)

Fly ash was procured from the Guru Gobind Singh Super Thermal Power Plant Ropar (GGSSTPP at Ropar in Punjab) in one lot. To assess the properties of fly ash, the properties based on laboratory tests conducted by Central Soil and Material Research Station, New Delhi and CBRI, Roorkee were used.

Fly ash of class F is known also as pulverized fuel ash which is the by product obtained by electrostatic and mechanical method from flue gases of power station furnaces fired with pulverized coal. Thus Fly ash is complicated in its chemical and physical compositions. It is basically heterogeneous combination of glassy and crystalline phases. Its three principal constituents are SiO_2 (25 to 60%), Al_2O_3(10 to 30%), and Fe_2O_3(5 to 25%). Therefore it can be subdivided into two classes viz Class F and Class C. According to ASTM C 618-99 (1999). If the sum of above mentioned three ingredients is 70% or greater it is categorized as Class F, otherwise as Class C.

4.3 AGGREGATES

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and affects economy. The aggregate consist of inert and course materials. Fine aggregate in concrete assists in producing workability and uniformity in mixture. The fine aggregate also assists the cement paste to hold the coarse aggregate particles in suspension. This action promotes plasticity in the mixture and prevents the segregation of the paste and coarse aggregates. The coarse aggregates are used primarily for the purpose of providing bulk to the concrete. IS: 383-1970 defines the fine aggregate as the aggregate most of which pass through 4.75 mm IS sieve. The coarse aggregates are defined as aggregates most of which are retained on 4.75 mm IS sieve.

4.3.1 COARSE AGGREGATES

Locally available crushed stone aggregates passing through 10 mm is sieve was used. The aggregate were first sieved through 10 mm sieve and then through 4.75 mm sieve. They were then washed to remove dust and dirt and were dried to surface dry condition. The properties of aggregates were found to conform the requirements of IS: 383-1970.

4.3.2 FINE AGGREGATES

In this research work, locally procured sand of Ghaggar river available at Zirakpur and conforming to grading zone II was used. The sand first was sieved through 4.75 mm sieve to remove any particles greater than 4.75mm and then was washed to remove the lumps of clay and other foreign material.

4.4 CEMENT

Ordinary Portland cement (OPC) of 43 Grade (Ultratech) from a single batch was used for all the concrete mixes. The grades of cement which are available varies due to the presence of high quality limestone, modern equipment, better particle size distribution, finer grinding and better packing. Cement taken was fresh and without any lumps with uniformity in its colour. The cement was tested as per IS: 8112- 1989 for its normal consistency, Initial and Finals setting time, Specific gravity and compressive strength for 3,7 and 28 days.

5. EXPERIMENTAL PROCEDURE

5.1 MIX PROPORTIONING AND CASTING

On the basis of concrete mix design by IS:10262-2009, we had prepared three trial mixes with constant water- cement ratio which is 0.50. For each mix six cubes were cast and tested at 7 and 28 days. For trial number-3, the compressive strength obtained was slightly above the target mean strength. Thus, this mix was adopted for the further study and its proportioning is given below:

The complete procedure was adopted as per IS: 516-1999 in making and casting operation. The materials used were weight accurately before casting.

MIX PROPORTIONING AS PER IS: 10262:2009

Cement	390 kg/m^3
Water	195 kg/m^3
Fine aggregates	610.10 kg/m^3
Coarse aggregates	1073.43 kg/m^3
Water cement ratio	0.50

5.2 TESTING AND RESULTS

5.2.1COMPRESSIVE STRENGTH TEST

The specimen were cube of the size (150mmX150mmX150mm), which were moist cured for 7, 28 and 56 days and tested immediately after removal from water and its surface water was wiped off. The specimen were tested on 100 tonne capacity universal testing machine. The load was applied gradually without shock till failure of specimen occurred. Thus, load at failure was noted down and compressive strength was found out.

5.2.2 BOND STRENGTH TEST

The cylindrical specimen of size (100mmX 200mm), with embedded length of 200mm were removed from curing tank at the age of 7, 28 and 56 days and tested immediately after the removal from the tank. The test was conducted as per IS: 2770 (part I)-1967. The specimen was mounted in the machine UTM and load was applied so that bar is pulled axially from cylinder till pull out failure occur. Thus, load of failure and bond strength was founded.

TABLE 1. VARIATION OF COMPRESSIVE STRENGTH WITH AGE (CEMENT REPLACED BY FLY ASH AND FIBERS) SIZE OF THE SPECIMEN = 150MMX150MMX150MM

Mix Designation	% Replacement by Fly ash	% Replacement by Fiber	Compressive strength for 7 Days (N/mm^2)	Compressive strength for 28 Days N/mm^2)	Compressive strength for 56 Days (N/mm^2)
M0	0	0	23.71	34.87	38.41
M1	40	0	15.60	23.36	26.43
M2	50	0	11.25	17.01	19.79
M3	40	0.20	16.18	24.23	27.38
M4	40	0.35	16.77	24.98	28.87
M5	40	0.50	17.44	26.09	29.65
M6	50	0.20	11.77	17.92	20.71
M7	50	0.35	12.50	18.62	21.59
M8	50	0.50	12.78	19.27	22.32

TABLE 2.VARIATION OF BOND STRENGTH WITH AGE (CEMENT REPLACED BY FLY ASH AND FIBERS)SIZE OF THE SPECIMEN = 100MMX200MM, EMBEDDED LENGTH = 200MM

Mix Designation	% Replacement by Fly ash	% Replacement by Fiber	Bond strength for 7 Days (N/mm^2)	Bond strength for 28 Days N/mm^2)	Bond strength for 56 Days (N/mm^2)
M0	0	0	3.17	4.59	5.09
M1	40	0	2.14	3.20	3.57
M2	50	0	1.65	2.45	2.87
M3	40	0.20	2.30	3.31	3.81
M4	40	0.35	2.25	3.41	3.81
M5	40	0.50	2.45	3.65	4.15
M6	50	0.20	1.76	2.62	3.05
M7	50	0.35	1.78	2.62	3.14
M8	50	0.50	1.93	2.86	3.32

6. CONCLUSION

The following conclusions can be drawn on the basis of present study:

1. With the increase in cement replacement with fly ash, the compressive strength was observed to decrease. However, at each level of replacement an increase in compressive strength was observed with the increase in age.
2. Fly ash concrete upto 40% of cement replacement with fly ash is good enough in terms of compressive strength to be used for most structural applications.
3. On addition of fibers to fly ash to concrete mixes, only marginal increase in compressive strength was observed.
4. With increase in replacement level of cement content in fly ash, bond strength tends to increase. However, addition of fibers has resulted in improvement of bond strength.
5. Bond strength is found proportional to compressive strength.

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