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EXPERIMENTAL INVESTIGATION ON STRENGTH PROPERTIES OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH AND FIBRES

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Abstract : Concrete is one of the most used construction material in the world. Earlier the usage of conventional concrete was more, but now-a-days the concrete is experimented with the implementation of various different materials into it which is both natural and artificial materials, like partial replacement of cement with admixtures which makes the concrete mix more economical as the reduction in the cement content will be achieved with increase in the strength and is also eco-friendly. Fibres are also implemented in concrete which serves as a good reinforcement property to the structural element and makes it a good tension member. In this study, cement is replaced with 20% fly ash which is an industrial by-product and implementation of basalt fibre and polypropylene fibre is done in 0.3%, 0.6% and 0.9% variations for which the fresh and hardened concrete properties and the cost feasibility are also checked and compared with the values of conventional concrete. This study is carried out for M25 grade concrete with 0.4 water cement ratio.

IndexTerms **- basalt fibre, polypropylene fibre, fly ash, compressive strength, flexural strength, split tensile strength**

I. INTRODUCTION

Concrete is a fundamental unit for the infrastructural development of the entire world. Concrete is usually made with cement which is the common ingredient, but during the manufacturing process of cement, enormous amount of CO_2 is released into the atmosphere which is toxic to the nature and causes environmental pollution. Therefore, in the recent years, partial replacement of cement with admixtures is found to be a good methodology due to many advantages and its eco-friendliness. Plain concrete which is abundantly used in construction is good in compression but weak in tension. The weakness in tensile strength is due to the propagation of the internal micro cracks that are inherently present in concrete which eventually leads to the brittle fracture of the concrete. Therefore, fibres are usually used in concrete as they have superior resistance to cracking. They even decrease the permeability of concrete which in turn helps in the reduction of bleeding of water and hence enhances the seismic resistance of concrete by increasing the energy absorption characteristics of concrete.

The objective of this experimentation is

- To check the workability conditions of the concrete with fly ash and the concrete with fly ash and fibres and compare with the plain concrete.
- To check the strength properties of concrete in its hardened state i.e., compressive strength, flexural strength and split tensile strength of the concrete with fly ash and the concrete with fly ash and fibres and compare with the plain concrete.
- To check the cost feasibility of the concrete with admixture and fibres and then compare with the plain concrete.

II. MATERIALS

The materials that is used in this study are: cement, fly ash, fine aggregate, coarse aggregate, basalt fibre, polypropylene fibre, potable water. OPC 43 grade cement, potable water which is clear from impurities such as salts, clay, silt, gravel and other foreign bodies such as fine biodegradable and non-biodegradable waste, river sand confining to zone II, coarse aggregate of nominal size 20mm is used. Fly ash as partial replacement to cement is used which leads to reduction in water demand for the desired slump which in turn leads to the reduction of bleeding and drying shrinkage. Basalt fibre is a non-metallic fibre that do not lead to corrosion and is non-toxic to any other chemicals and atmospheric conditions. Polypropylene fibres being the synthetic hydrocarbon polymer are hydrophobic in nature and also absorb energy. These both fibres are used in 0.3%, 0.6% and 0.9% variations and then checked for their strength properties in both fresh and hardened state.

III. METHODOLOGY

The methodology implemented in this study is mix design is prepared and the quantity of the materials that is required for the project is listed. All the raw materials that is required for the experimental investigation is collected. Test on the raw materials is carried out. Then the test on fresh concrete is carried out. Now the test blocks are prepared with different fibre content in it and partial replacement of cement with fly ash, say:

Table I: Variations of the mix

CC	Conventional Concrete
C8F2	Concrete in which 20% cement is substituted by fly ash
C8F2B3	C8F2 + 0.3% Basalt fibre
C8F2B6	C8F2 + 0.6% Basalt fibre
C8F2B9	C8F2 + 0.9% Basalt fibre
C8F2P3	C8F2 + 0.3% Polypropylene fibre
C8F2P6	C8F2 + 0.6% Polypropylene fibre
C8F2P9	C8F2 + 0.9% Polypropylene fibre

After preparation of the blocks, curing is done and test on hardened concrete is carried out. The values of the various tests are tabulated and compared with the strength of the conventional concrete block and then cost feasibility is also checked.

IV. RESULTS AND DISCUSSION

4.1 Workability of fresh concrete (slump test)

Workability is the property where in the concrete can be compacted fully without any bleeding and segregation in final finished product. Workability consists of the four partial properties of concrete i.e., mixing, placing, compacting and finishing. Every job requires a particular workability. In this experimental study, Slump cone test is carried out. Unsupported concrete when fresh will loosely settles to sides and sinks, this settlement is called slump.

Table II: Slump values of fresh concrete

Details	Slump Value (mm)
CC	93
C8F2	91
C8F2B3	55
C8F2B6	38
C8F2B9	24
C8F2P3	59
C8F2P6	42
C8F2P9	30

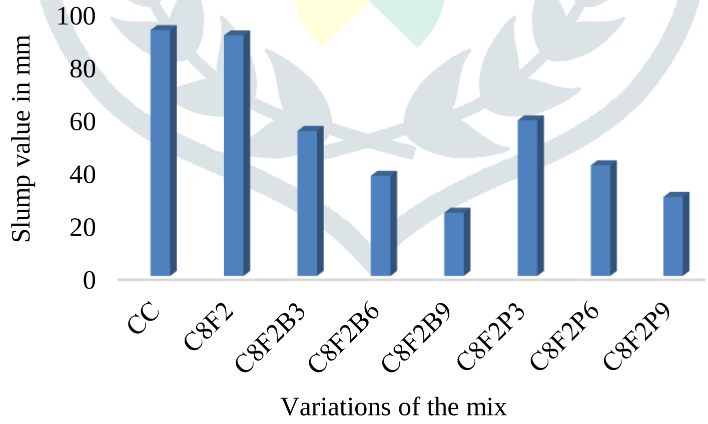

Figure I: Graph of slump values

4.2 Compressive Strength Test (CST)

The load which causes the specimen's failure per unit area of its cross section in uneasily compression under the provided loading rate is defined as the compression strength of the concrete.

Table III: Compression strength of 7 and 28 days specimen

Details	Average compressive strength (N/mm^2)	
	7 days	28 days
CC	20.29	29.18
C8F2	22.67	31.26
C8F2B3	26.96	36.29
C8F2B6	25.04	32.74
C8F2B9	19.85	28.15
C8F2P3	23.26	31.703

C8F2P6	24.89	33.93
C8F2P9	19.26	26.67

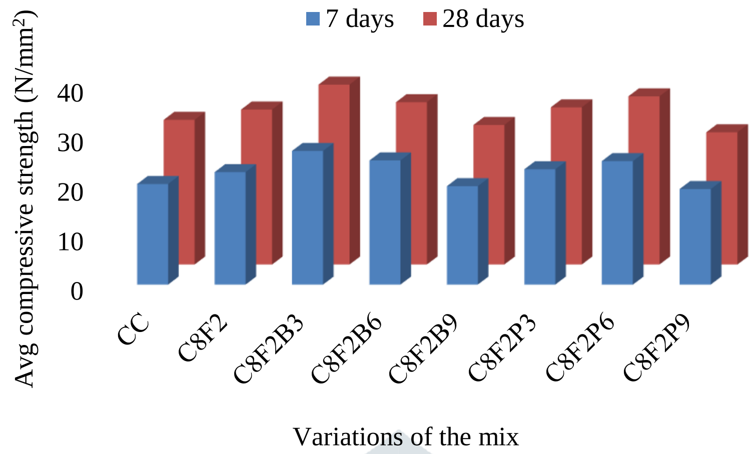

Figure II: Graph of compression strength

4.3 Flexural Strength Test (FST)

Table IV: Flexural strength of 7 and 28 days specimen

Details	Average strength in flexure (N/mm^2)	
	7 days	28 days
CC	4.365	6.23
C8F2	5.323	7.028
C8F2B3	5.997	10.462
C8F2B6	5.568	9.747
C8F2B9	5.29	8.8
C8F2P3	5.392	8.848
C8F2P6	5.698	9.258
C8F2P9	3.708	7.78

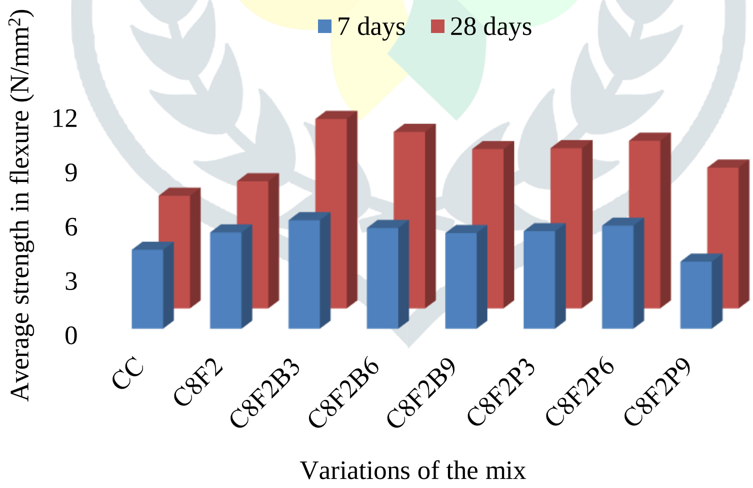

Figure III: Graph of flexural strength

4.4 Split Tensile Strength Test (STST)

A number of indirect methods has been developed to determine the tensile strength because of the troubles associated with direct tension test. The split tensile test is a universal test to check the tensile strength of the concrete.

Table V: split tensile strength of 7 and 28 days specimen

Details	Average tensile strength (N/mm^2)	
	7 days	28 days
CC	1.603	2.688
C8F2	1.934	2.829
C8F2B3	2.688	3.537
C8F2B6	2.216	2.924
C8F2B9	1.981	2.452
C8F2P3	2.452	3.065
C8F2P6	2.593	3.489

C8F2P9	2.028	2.593

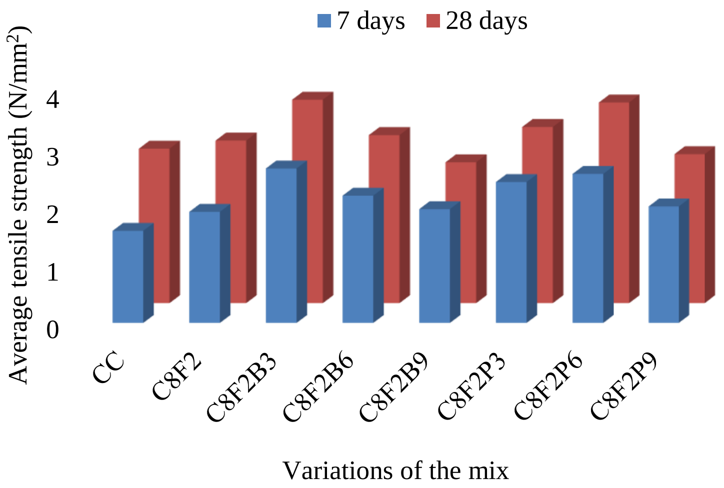

Figure IV: Graph of split tensile strength

V. CONCLUSION

- Usage of fly ash in the concrete provides increment in strength and is also economical.
- Fibres provide good reinforcement and are non-corrosive in nature.
- Fibres used in this experiment are non-toxic and does not react to the atmospheric conditions.
- The workability of the mix variations here is decreased due to the increment in percentage of fibre content.
- The C8F2 i.e., concrete with substitution of cement by 20% fly ash shows 7.13% increment in compressive strength, 5.25% increment in tensile strength and 12.84% increment in flexural strength when compared to CC.
- The C8F2B3 i.e., concrete with 20% fly ash and 0.3% basalt fibres shows 24.39% increment in compressive strength, 31.58% increment in tensile strength and 67.89% increment in flexural strength when compared to CC.
- The C8F2P6 i.e., concrete with 20% fly ash and 0.6% polypropylene fibres shows 16.26% increment in compressive strength, 29.8% increment in tensile strength and 48.6% increment in flexural strength when compared to CC.
- The mix variations of 0.6% and 0.9% basalt fibre and 0.9% polypropylene fibres shows decrement in strength when compared to their respective fibre mix.
- The cost feasibility of basalt fibre concrete is 1.16 times and polypropylene fibre concrete is 1.54 times more when compared to conventional concrete.
- Hence, we can conclude that 0.3% usage of basalt fibre and 20% substitution of cement with fly ash in concrete provides better strength and even the cost is less when compared to the polypropylene fibre concrete.

VI. FUTURE SCOPE OF STUDY

- The same variations of mix can be adopted for other grades of concrete.
- The same experimental study can be carried out for different exposure conditions.
- For a particular percentage of fibre content, cement can be substituted with other percentages of fly ash content and then check the best result.
- For the adopted fly ash content (say 20%), usage of different percentages of fibre content can be experimented other than 0.3%, 0.6% and 0.9%.
- Different mineral admixtures and chemical admixtures can be adopted for the same basalt and polypropylene fibre content.
- Many other artificial and natural fibres (say steel fibres, carbon fibres, asbestos fibres, coir, jute fibres, glass fibres, sisal fibres and so on) can be implemented for different admixture content or for the same variations of the mix.
- Other than admixtures, self-curing agents, water reducing agents can be implemented in the mix.
- River sand can be replaced by M sand which will be helpful in avoiding the depletion of natural resource.
- The coarse aggregate can be partially replaced or can be replaced in some percentages by broken paver aggregates, kadapa stone and so on which will be helpful in recycling the materials.

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