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An Investigation on High Strength Concrete using Fibers with Al_2O_3

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Abstract: Since the earliest days, many investigations and improvements were brought to upgrade the physical and mechanical properties of concrete.

Fiber reinforced concrete is one among those progressions which provides suitable, functional and economical way for conquering micro cracks and same kind of deficiencies. Considering concrete is weak in tension accordingly some measures has to be adopted to conquer this deficiency.

Human hair is usually strong in tension; therefore it can be used as a fiber reinforcement material. Human hair fiber is an alternative non-degradable matter accessible in plenty and at cheap cost.

Additionally, it generates environmental problems. Micro Al_2O_3 is another admixture added to implement the compressive strength Experiment was carried out on concrete cubes of standard sizes with addition of various percentages of human hair fiber and similarly i.e., 0.5%, 1%, 1.5% by weight of cement, fine and coarse aggregate and results were compared concrete of M60 grade.

For every percentage of human hair and micro Al_2O_3 added in concrete, 3 cubes were examined for their respective compressive strength at curing periods of 3 days, 7 days, 28 days.

The change in compressive strength of concrete is measured and studied. The outcomes obtained display us that the optimum content of human hair fiber with micro Al_2O_3 to be added to M60 grade of concrete is 0.5%, 1%, 1.5% weight of cement fine and coarse aggregate together and consequently there has been a significant increase in mechanical properties of concrete.

Index terms: Human hair fiber, Micro Al_2O_3 , workability, Fiber reinforced concrete, High strength concrete.

I. INTRODUCTION

Concrete is a composite material developed by mixture of finely granulated cement, aggregates of multiple sizes and water with essential physical, chemical and mechanical characteristics. The researchers, in present emphasizes on Nanotechnology to produce a new creation of concrete materials that could achieve the sustainable concrete structures. Evolution of materials is must for advanced performance for specific engineering properties and varying the bulk-state of materials regarding composition or microstructure or Nanostructure.

It's been the conventional route for synthesizing new materials. In India, the excessively used construction material is concrete with annual consumption surpassing 100 million cubic meters. It is conventional that the ordinary concrete designed on the basis of Compressive strength does not meet various workable circumstances such as impermeability, resistance to frost, thermal cracking sufficiently.

Concrete is generally classified as Normal strength concrete (NSC), high strength concrete (HSC) and ultra high strength concrete (UHSC). Fibre Reinforced Concrete (FRC) is concrete containing fibrous material which growths as structural and is obtaining significance. It contains short discrete fibres that are uniformly dispersed and randomly adapted. The idea of using fibres as reinforcement is not new.

Fibres has been used as reinforced since ancient times. Historically, horsehair was used in mortar and straw in mud bricks. In the early 1900s, asbestos fibres were used in concrete, and in the 1950s the concept of composite materials came into being and fibre reinforced concrete was one of the topics of interest.

Later, the use of asbestos for concrete reinforcement was dejected due to the related health risks. New materials like steel, glass, and synthetic fibres replaced asbestos for reinforcement. Accomplish research is still in progress on this important technology, and research into new fibre reinforced concretes continues today.

The role of Nano Al_2O_3 in increasing the mechanical properties of cement has been carried out by few researchers. The optimized level of Nanoparticles to attain the ultimate strength was reported.

II. MATERIALS AND TEST METHODS

The following materials were used for making concrete mix.

- 1) ACC cement of 53 grade.
- 2) Fine aggregate.
- 3) Coarse aggregate.
- 4) Human hair fiber.
- 5) Micro Al_2O_3 .
- 6) SP430.
- 7) Water.

Ordinary Portland Cement of 53 grade cement was used in this research. The fine aggregate was natural sand which is easily obtainable and the coarse aggregate having a size of 12mm and 20mm. There are no particular sizes for human hair fiber. The size of Micro Al_2O_3 of 10 micron.

A. Cement

The crude materials recommended for manufacturing the Portland cement are calcareous materials as like limestone or chalk, and argillaceous material such as shale or clay. There are two cases stated as wet and dry courses subject to either the mixing and pulverizing of raw materials is executed in wet or dry condition. The raw materials used in the production of cement contains usually of lime, Silica, alumina and iron oxide. Such oxides collaborate mutually to design greatly complex composites in the kiln up to the high temperature.

B. Fine Aggregate

Fine aggregates are initially sands earned from the land or marine environment. Fine aggregates highly consist of natural sand or crushed stone with most particles passing through a 4.75mm sieve. The fine aggregate used in this study is river sand which is gained from local company.

C. Coarse Aggregate

The shape and size of coarse aggregates is very crucial as it many times governs both fresh properties as well as the long term properties of concrete. Size of these aggregates varies from 4.75mm to 80mm. For normal concrete works we use below 40mm size of coarse aggregate.

D. Human Hair Fiber

Human Hair as innovation to the field of Fibre Reinforced Concrete, utilization of Human Hair as fibre achieved its important. Chemically, about 80% of human hair is created by a protein known as Keratin, with high grade of fur-coming from the amino acid cysteine - which is typical to distinguish it from other proteins. Keratin is laminated complex formed by various structures, which offers the hair strength, flexibility, durability and functionality. Basically, the hair thread has a cylindrical structure, greatly organized, formed by inert cells, most of them keratinized and dispersed following a very precise and pre-defined design. Hair composes a very rigid structure in the molecular level, which is efficient to provide the thread both flexibility and mechanical resistance. Human hair has about 65-95% of its weight in proteins, 32% of water, lipid pigments and other components.

E. Micro Al_2O_3

In this research, the Compressive strength of concrete with various amounts of aluminium oxide microparticles(% wt of cement) having standard particle size of 10 microns were partially added to cement paste (Portland cement together superplasticizer) and the Compressive strength of the specimens has been calculated. The results shows that aluminium oxide microparticles are adequate to increase Compressive strength of concrete and change the negative effects of adding superplasticizer. Aluminium oxide microparticles as a partial replacement of cement up to 4%wt could accelerate C-S-H gel generation as a result of increased amount of crystalline calcium hydroxide at initial age of hydration. The increased aluminium oxide microparticles content of more than 4%wt leads to reduced Compressive strength because of unsuitable dispersion of microparticles in concrete mix.

1) *Details Of Tests:* The following tests are performed on concrete blocks,

- a) Workability
- b) Compressive strength

Three cubes (150x150x150mm) for each mix were casted and tested for compressive strength for 3, 7 and 28 days. After casting specimens were tested with the machine.

III. TESTING PROCEDURE

A. Mixing

Mixing process was prepared in two stages by pan mixing. Firstly, cement, micro Al_2O_3 , fine aggregates, coarse aggregates of 12mm and 20mm, Human hair fiber on SSD condition and binder were mixed together in concrete mixer for 2.5 minutes. At the end of the dry mixing, a well-shaked super-plasticier SP430 and water added in the concrete mixer and the wet mixing was continued for another 3 minutes. To ensure good homogeneity in the mix fresh concrete was mixed for another 2 minutes. Hence the mix is prepared for casting.

B. Curing

The specimens were demoulded after 24 to 48 hours of casting and were kept submerged in a clean water tank for curing. After 3, 7 and 28 days of curing the specimens were taken out of water and were permitted to dry under shade for few hours.

C. Workability

- 1) *Slump Cone Test*: Vertical settlement of a standard cone of fresh concrete (actually frustum of a cone) under its own weight is called slump. The cone of concrete in a slump test may sometimes fail in shear, thus casting doubts on the stability of the concrete system. Lack of stability is termed as segregation. Slump cone values for different mix proportions are following.

Table 3.1. Slump cone test values for various mix proportions

S.no	mix notation	Percentage of Human hair	Percentage of micro Al_2O_3	Slump cone values in cm
1.	M1	0	0	10.5
2.	M2	0.5	0.5	9.9
3.	M3	1	1	9.2
4.	M4	1.5	1.5	8.7

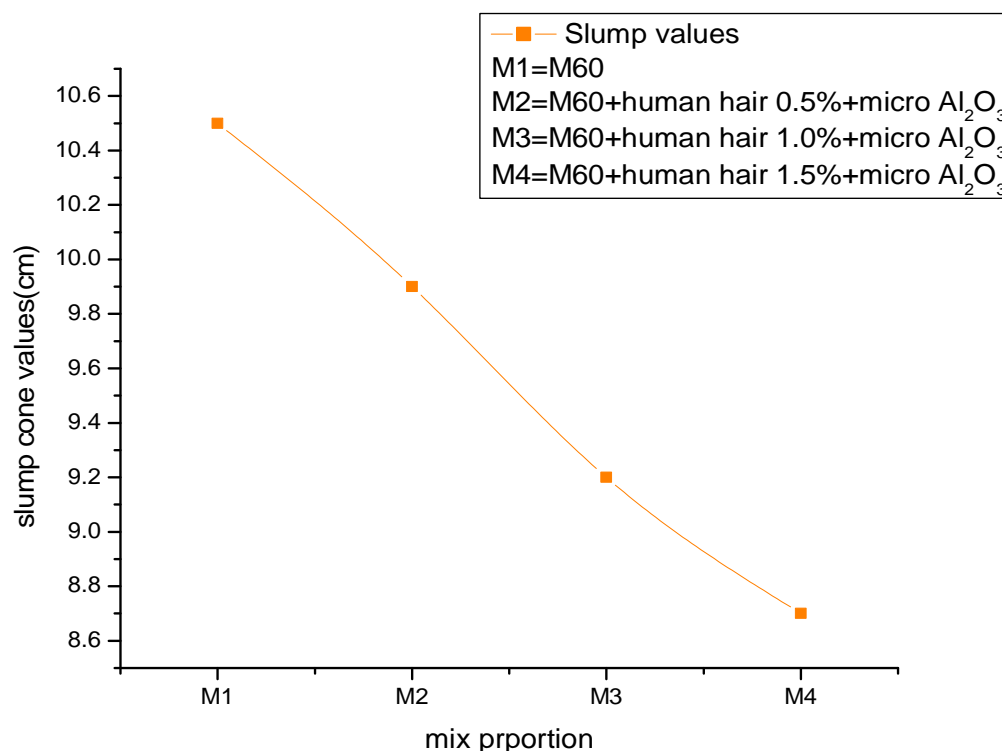


Fig 3.1.Slump Cone values for various mix proportions

- 2) **Compaction Factor Test:** Compaction factor is a measure of the density of concrete to which a fresh blended concrete can be compacted for a standard input of energy respective to the theoretical maximum density it can have relating to zero air content. This theoretical maximum density can be calculated in the laboratory as that concluded by full of compatibility of fresh concrete.

Table 3.2. Compaction factor values for different mix proportions

S.no	Mix notation	Percentage of Human hair	Percentage of micro Al_2O_3	Compaction factor values
1.	M1	0	0	0.94
2.	M2	0.5	0.5	0.90
3.	M3	1.0	1.0	0.88
4.	M4	1.5	1.5	0.83

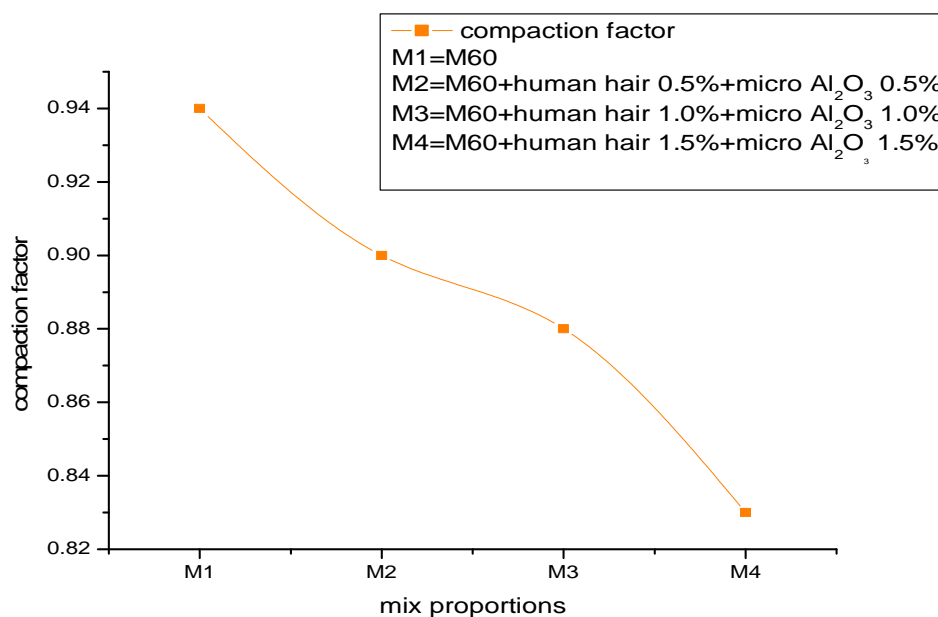


Fig 3.2. Compaction factor values for various mix proportions

- 3) **Vee-bee Test:** Vee bee test is executed to know the consistency of concrete. In this test Vee bee consistometer utilized to find out the time desirable to force the fresh concrete to flow to a standardized extent is called the Vee bee time. It is measure of the mobility of the fresh concrete.

Table 3.3. Vee-bee time values for different mix proportions

S.no	Mix notation	Percentage of human hair	Percentage of human hair	Vee –bee time in secs
1.	M1	0	0	5
2.	M2	0.5	0.5	11
3.	M3	1.0	1.0	13
4.	M4	1.5	1.5	16

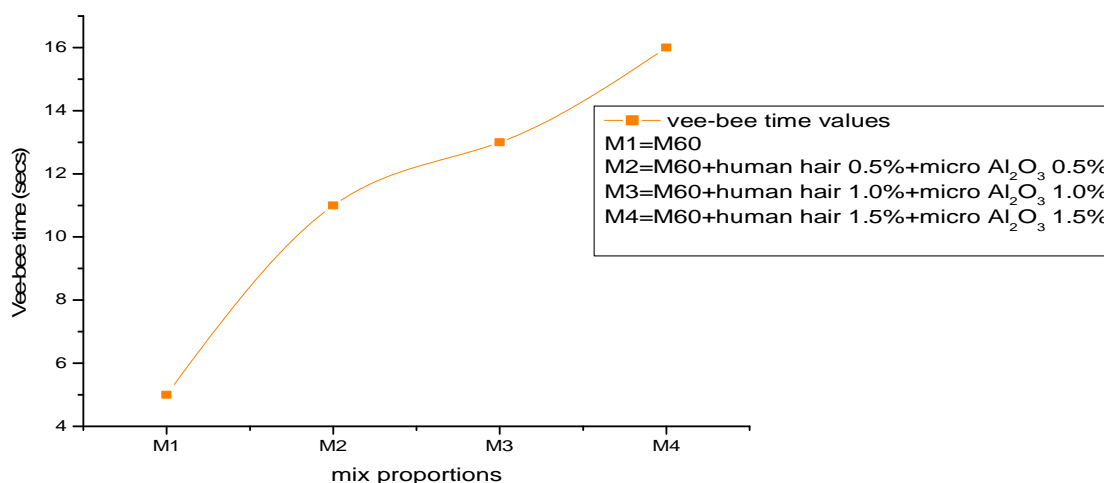


Fig 3.3. Vee-bee time values for different mixproportions

IV. RESULTS AND DISCUSSION

A. Compressive Strength

For designers, Compressive strength is one of the most important engineering properties of concrete. It is a standard industrial practice that the concrete is classified based on grades. This grade is nothing but the Compressive Strength of the concrete cube. Cube samples are basically tested under a Compression testing machine to acquire the Compressive strength of concrete. The test requirements differ country to country based on the design code. According to Indian codes, Compressive strength of concrete is defined as the Compressive strength of concrete is given in terms of the characteristic Compressive strength of 150 mm x 150 mm size cubes tested at 28 days (fck). The characteristic strength is defined as the strength of the concrete below which not more than 5% of the test results are expected to fall. All the concrete specimens were tested in a 3000KN capacity automatic Compression testing machine with 0.5KN/sec rate of loading until the specimens are crushed. Concrete cubes of size 150mm x150mm x 150mm and cylinders of size 150mm diameter x300mm height are tested for crushing strength. The displacements were automatically recorded through 3000KN digital Compression testing machine. The maximum load applied to the specimens has been noted and dividing the failure load by the area of the specimen, the Compressive strength has been determined.

$$\text{Compressive strength} = \frac{\text{Load}}{\text{Area}} \text{ in N/mm}^2$$

The test arrange of 3000KN Compression testing machine with specimen as shown in fig.4.1.



Fig 4.1. Test setup for Compressive strength of Cube

Table 4.1. Compressive strength values for various mix proportions

S.no	Mix notation	Percentage of human hair	Percentage of micro Al_2O_3	Compressive strength of cube in MPa		
				3 days	7 days	28 days
1.	M1	0	0	39.82	46.84	67.83
2.	M2	0.5	0.5	43.57	51.65	68.92
3.	M3	1.0	1.0	47.63	55.40	70.20
4.	M4	1.5	1.5	47.04	53.64	68.35

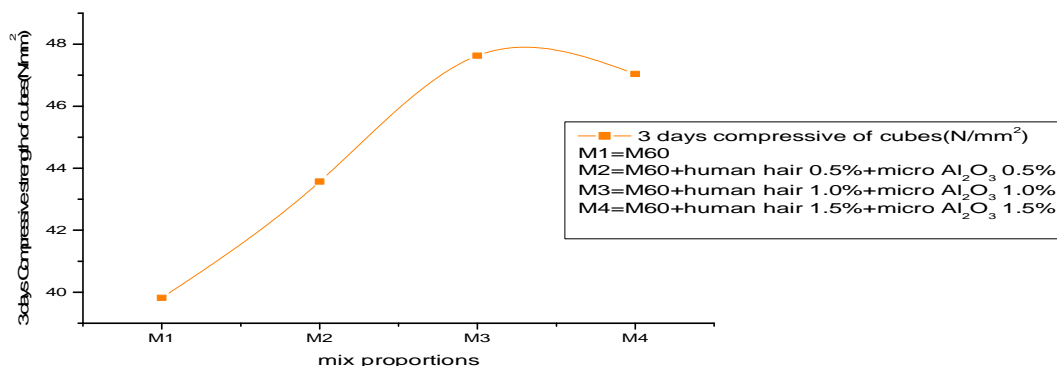


Fig 4.2. Compressive strength values of different proportions of 3 days curing

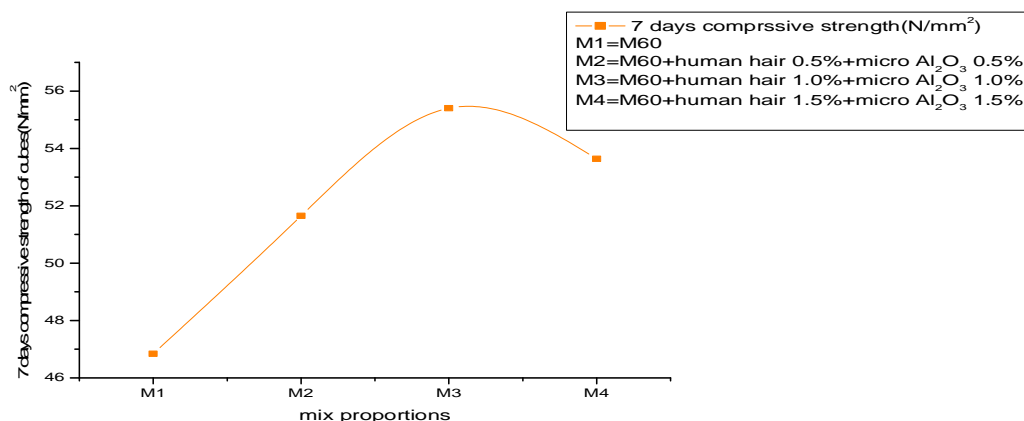


Fig 4.3. Compressive strength values of different proportions of 7 days curing

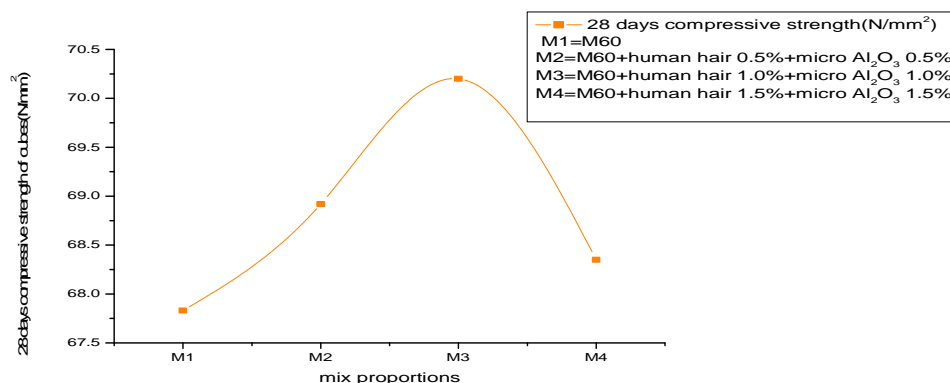


Fig 4.4. Compressive strength values of various mix proportions for 28 days curing

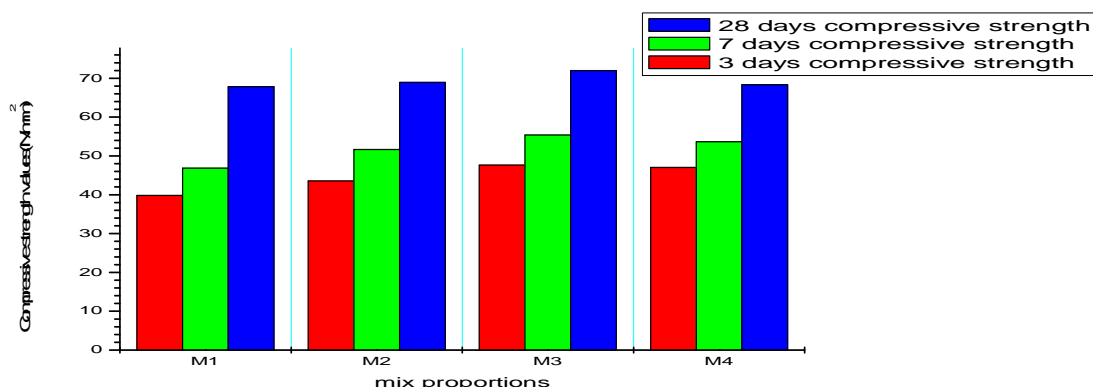


Fig 4.5. Super imposed bar graph for periods of 3,7 and 28 days of Human hair fiber and micro Al_2O_3 replacement with cement Vs Compressive strength

From the above results and graphs shows that the Compressive strength of M60 concrete is high due to addition of admixtures. The optimum point of compressive strength occurs at 1.0% .

V. CONCLUSION

- A. In fiber reinforced concrete constructions, the utilization of human hair waste is efficient.
- B. Micro Al_2O_3 is also increases the strength properties to the concrete.
- C. The addition of admixture as human hair and micro Al_2O_3 , decrease the workability.
- D. Hence the test performed it is examined that great increase in the properties of concrete.
- E. It is well examined that maximum strength gained at 1.0% of replacement of Human hair fiber and micro Al_2O_3 .
- F. Fiber reinforced concrete reduces the crack formation and propagation. It is applicant to seismic resistant structures.

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