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AN EXPERIMENTAL INVESTIGATION ON HIGH STRENGTH CONCRETE

S.Shameel Basha[1],Mrs.B.Ajitha[2]

[1]*Department of Civil engineering, JNTU Ananthapuramu,*
[2]*Assistant professor, Department of Civil Engineering, JNTU Ananthapuramu,*

Abstract: - Since the early times, many researches and advancements were carried to improve the physical and mechanical properties of concrete. High strength concrete may be termed as recent advancement in concrete world. Fibre reinforcement to High strength concrete is one among those advancements which offers a convenient, practical and economical method for overcoming micro cracks and similar type of deficiencies. Since concrete is frail in tension, hence some measures must be adopted to overcome this insufficiency. Human hair is generally strong in tension; hence it can be used as a fibre reinforced material. Human hair fibre is a substitute non-degradable matter obtainable in abundance and at low cost. It also creates environmental problems. Experiments were conducted on concrete cubes of standard sizes with addition of various percentages of human hair fibre i.e., 0.5%, 1%, 1.5% by weight of cement, fine and coarse aggregate and results were compared with those of plain cement concrete of M60 grade. For each percentage of human hair added in concrete, 9 cubes were tested for their respective compressive properties at curing periods of 3 days, 7 days and 28 days. The change in compressive strength of concrete is determined and analysed. The results obtained show us that the optimum content of human hair fibre to be added to M60 grade of concrete is 1% to the weight of cement, fine and coarse aggregate together and consequently there has been a significant increase in compressive strength of concrete.

Keywords: High strength concrete, Fibre, human hair.

1. INTRODUCTION

Concrete is the most versatile material in construction industry. It is therefore logical that extensive research is being carried out in the world over into various aspects of this unique material leading to its unprecedented up gradation. From its ultimate compressive strength in the range of 15 to 25 Mpa in the 60's, Engineers are now recommending and using concrete with strength of 100 Mpa for all specialised constructions.

Concrete mix design is the science of dealing with relative proportions of concrete materials to achieve the desired properties in the most economical way. As a universal truth, concrete is the most frequently described material in the construction industry. It is very promising in structures because it can be designed for strength varying from 10 N/mm^2 up to 100 N/mm^2 which is termed as its grade. A large number of building failures are accountable to concrete incompetence among several other factors. The process involved, from the design to construction stages in structures are largely those of choosing materials, components and structures which will meet the expected building standards and aesthetics on economy basis.

Concrete is defined as "High-Strength" mainly on the basis of compressive strength at a given age. In the 1970's, before the advent of super plasticizers, concrete mix that showed 40MPa or more compressive strength at 28 days were called high-strength concrete. Later, when 60 to 120 MPa concrete mixtures became commercially available, in 2002 the ACI Committee on High Strength Concrete revised the definition to cover mixtures with specific design of 55MPa or more.

Fibre Reinforcement in concrete containing fibrous material, which increases as structural and is gaining importance. It contains short discrete fibres that are uniformly distributed and randomly oriented. The concept 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 discouraged due to the associated health risks. New materials like steel, glass, and synthetic fibres replaced asbestos for reinforcement. Achieve research is still in progress on this important technology, and research into new fibre reinforced concretes continues today.

Why fibres are used in concrete?

Generally, concrete is poor in tension and possess a brittle nature. Hence fibres are add to increase its tensile strength and improve the characteristics of construction materials. Introducing of fibres to concrete makes it a homogeneous and isotropic material. When concrete cracks, the vigorously oriented fibres start functioning, stop crack formation and propagation, and thus improve strength and ductility. Fibres are generally used in concrete for the following reasons: (i) To arrest cracking due to both plastic shrinkage and drying shrinkage. (ii) They also minimize the permeability of concrete and thus decrease bleeding of water. (iii) Some types of fibres also create greater impact, abrasion and shatter

resistance in concrete. (iv) The fineness of the fibres access them to reinforce the mortar fraction of the concrete, late crack formation and propagation. This fineness also obstructs bleeding in the concrete, thereby decreasing permeability and gaining the surface characteristics of the hardened surface.

Quantity of fibre:

The amount of fibres added to concrete mix is measured as a percentage of the total volume of the composite (concrete and fibres) termed as volume fraction (V_f). V_f typically ranges from 0.1 to 1%. Also it can be taken as percentage by weight of cement, fine & coarse aggregate together that is used in preparing concrete. The increment in the volume of fibres, increase approximately linearly, the tensile strength and toughness of the composite. But use of greater percentage of fibre is merely to cause segregation and harshness of concrete and mortar.

Why human hair as fibre?

Hair is used as fibre reinforcing material in concrete for the following reasons:

It possess high tensile strength which is equal to that of copper wire having similar diameter. Hair, a non-degradable matter is creating an environmental problem so it is used as fibro reinforcing material which can minimize the problem. It also available in greater extent and at a very low cost. It reinforces the mortar and prevents it from spelling.

In this experimental study, human hair fibres are incorporated into concrete at content of 0% to 1.5% by weight of cement. Cube specimens are casted and cured properly for evaluating compressive strength properties. Those specimens which are made using human hair fibre reinforced concrete are tested at different curing periods (i.e. 3 days, 7 days and 28 days) respectively and the change in compressive strength when compared to plain cement concrete is observed.

2. MATERIALS AND METHODS

2.1 Cement:

The unprocessed materials used for the manufacture of cement mainly comprises of lime, alumina, silica, and iron oxide. These oxides form more complex compounds while reacting with each other in kiln. The relative proportions of these oxides compositions are responsible for influencing the various properties for cement, in addition to rate of cooling and fineness of grinding. Inn this study cement of 53 grade OPC is used. The properties of cement are furnished below.

S.NO	Physical Properties Of OPC 53 Gr Cement	Results
1	Specific Gravity	3.16
2	Standard Consistency	32%
3	Initial Setting time	35 min
4	Final setting time	265 min

Table 2.1 Properties of Cement

2.2 Aggregates:

Aggregate is a general term applied to those inert or chemically active materials which, when bonded together by cement, form concrete. Most of the aggregates are naturally occurring aggregates such as crushed rock, gravel and sand. Artificial and processed aggregates may be broken break of crushed air-cooled blast furnace slag. Light weights aggregates, such as pumice, furnace clinker, coke etc., are also used for the production of low density concrete.

Aggregates may be divided into two groups:

(a) Coarse aggregate
(b) Fine aggregate

2.2.1Coarse Aggregate:

Aggregate more than 4.75 mm are known as coarse aggregates. Natural gravel and crushed stone are the most common materials used as coarse aggregate for concrete. Natural gravels may be acquired from pits where they have been deposited by glacial or alluvial action, and are normally composed of flint, schist, quartz and igneous rocks. Coarse aggregates are obtained by crushing various types of granites, schist, gneiss, crystalline, hard lime stone and good quality sand stones. When very high strength concrete is required, very fine grained granite is perhaps the best aggregate.

2.2.2 Fine Aggregate:

The material smaller than 4.75 mm sizes are called as fine aggregates. Natural sands are generally used as fine aggregates. Sand may be obtained from pits, river, and lake or sea shore and may contain chlorides which may cause efflorescence, and may cause corrosion of reinforcement. Hence it should be thoroughly washed before use. Similarly, if river sand contains impurities such as mud etc. it should be washed before use.

The properties of aggregates are presented in the below table.

S.No	Parameters	Results
1	Specific Gravity (FA)	2.519
2	Water Absorption (FA)	0.200
3	Specific Gravity (CA)	2.7
4	Water Absorption (CA)	0.1
5	Elongation Index	26.32%
6	Flakiness Index	23.2%

Table 2.2 Properties of Aggregates

2.3 Water:

Water acts as lubricant for the fine and coarse grained aggregates and reacts chemically with cement to form the binding paste for the aggregate and reinforcement. Water is also utilized for curing the concrete after it has been cast into the forms.

Water used for mixing and curing shall be clean and free from injurious amount of oils, acids, alkalis, salts, sugar, organic materials and other substances that may be deleterious to concrete or steel. Portable water may be generally considered satisfactory for concrete mix. Fresh water available at the site of work is used in this investigation.

2.4 Human Hair:

Human hair fibre is originated by three main structures: cuticle, cortex and medulla. Proteins with αhelix structure which are encircled in the hair have long filaments of unknown micro fibres which relate to each other to form bigger structures, in order to manufacture cortex cells. This enchained structure allows the capillary fibre more strength and elasticity. The main factor to be consider in human hair is the high amount of the amino acid cistern, which may be degraded and after words may be re-oxidation under a disulphide bounding form. Hair is surprisingly strong. Cortex keratin is accountable for this propriety and its long chains are compressed to form a uniform structure which, besides being strong, is flexible. The locally available hair from sources such as saloons, which is brought into our requirements is used for this study.

3. EXPERIMENTAL TEST RESULTS

3.1 Results of Workability Tests

The tests were carried out on mixes with varying proportions of human hair. The proportions were 0.5%, 1% and 1.5%.The results of workability viz. Slump cone test and compaction factor test are presented below.

3.1.1 Slump Cone test:

S.NO	Mix Notation	Percentage of Human hair	Slump Cone Results in cm
1	M0	0	10.5
2	M1	0.5%	10
3	M2	1%	9.2
4	M3	1.5%	8.9

Table 3.1 Slump Cone Values

These results are plotted down in a graph.

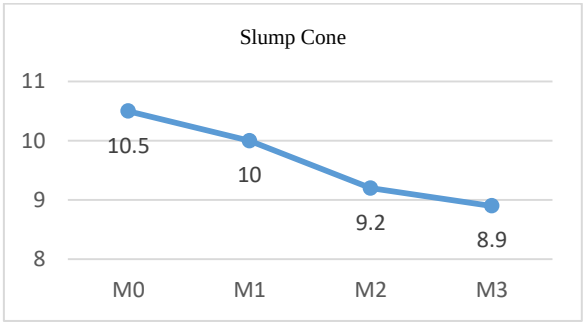

Fig 3.1 Slump Cone Test

From the above graph it can be clearly seen that the slump values decreases with the addition of admixture i.e. human hair to it. The workability is slightly affected due to the addition of fibrous material. It has been reduced from 10.5 to 8.9.

3.1.2 Compaction Factor Test:

S.NO	Mix Notation	Percentage of Human hair	Compaction Factor Values
1	M0	0%	0.930
2	M1	0.5%	0.900
3	M2	1.0%	0.905
4	M3	1.5%	0.890

Table 3.2 Compaction Factor test

From the above table it can be observed that the compaction factor values decreases with the addition of human hair to it when compared to normal concrete. The results are plotted in the following graph.

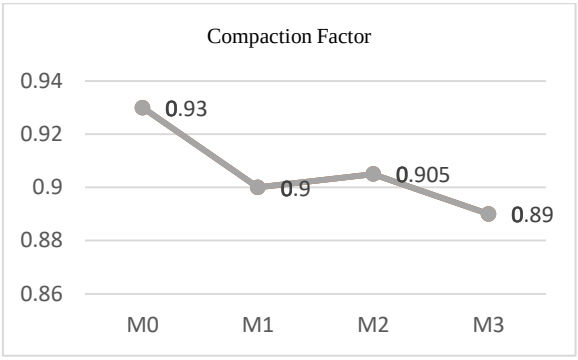

Fig 3.2 Compaction Factor

Here M0 – M60 grade Concrete
M1 – M60 + 0.5% human hair
M2 – M60 + 1% human hair
M3 – M60 + 1.5% human hair

3.2 Results of Compression strength test:

To test the compressive strength of concrete after and before mixing of human hair, different specimens were tested to determine its strength. Cubes of standard sizes were casted and tested at 3 days, 7days and 28 days respectively. The results of those specimens are furnished under table 3.3.

S.No	Mix Notation	Percentage of Human hair	Compressive strength in N/mm^2		
			3 days	7 days	28 days
1	M0	0%	40.75	48.36	68.85
2	M1	0.5%	41.58	49.02	70.24
3	M2	1%	42.69	50.26	73.85
4	M3	1.5%	40.92	49.85	69.95

Table 3.3 Compression Test Values

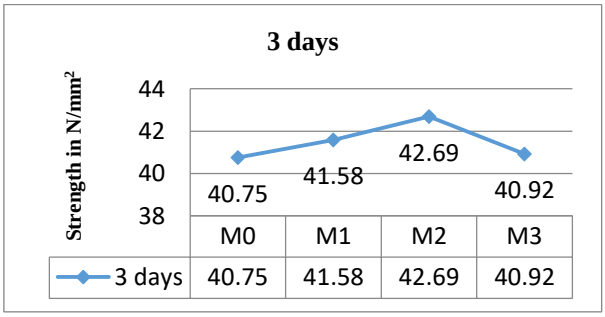

Fig 3.3 Compression test results for 3 days curing

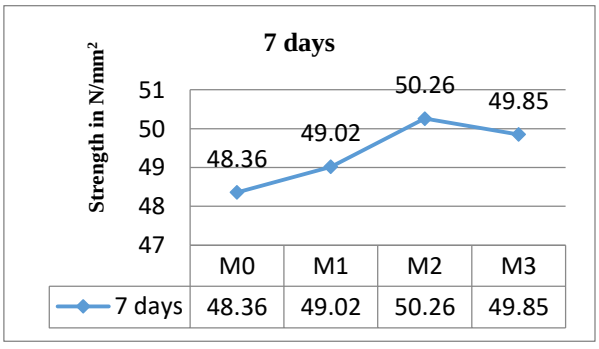

Fig 3.4 compression test results for 7 days curing

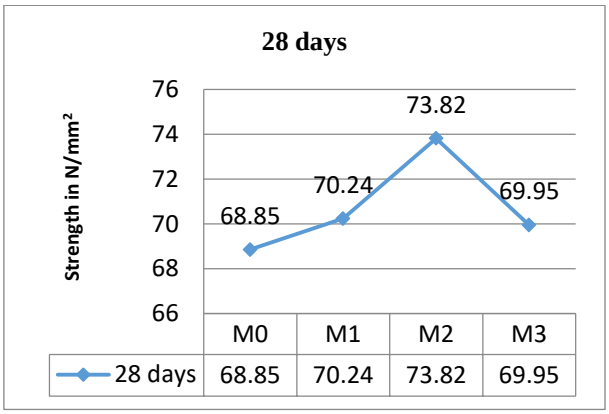

Fig 3.5 compression test results for 28 days curing

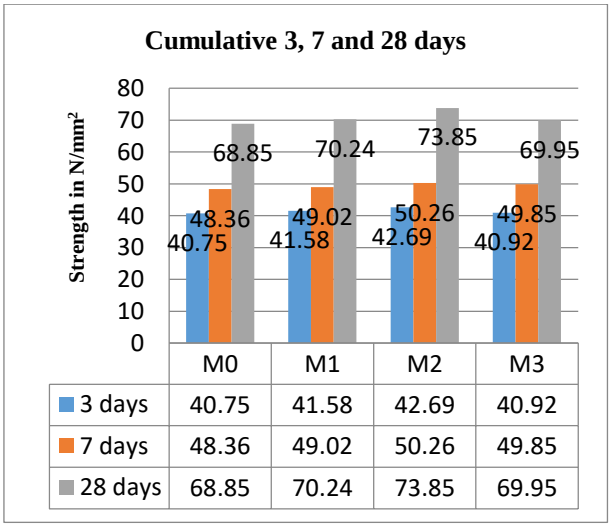

Fig 3.6 Cumulative Compression test results for 3, 7 and 28 days curing

Different mixes with varying proportions exhibited different values which are observed so far in this paper. By observing the results it is noted that there is an appreciable increment in compression strength of cubes when replaced with human hair. The values vary from 68.85N/mm^2 to 73.85 N/mm^2 at a percentage replacement of 1.0. The greater compressive strength may be achieved with the addition of human hair at optimum percentage.

4. CONCLUSIONS

- Human hair waste can be fruitfully used as a replacement in concrete structures.
- Though the workability results shows that it is affecting workability of concrete slightly, but it can be neglected as it is very less in comparison.
- There was an overall decrement of 13% in the workability of concrete.
- According to the tests performed, it is observed that there is remarkable increment in properties of concrete according to the percentages of hairs by weight of cement in concrete.
- The human hair fibre concrete has the high compressive strength compared to the normal Concrete
- There was an overall increase of 8.5% in the compressive strength of concrete specimens with the addition of hair fibres in different quantities.
- It is well observed that the maximum increase is noticed in the addition of 1% hair fibre, by weight of concrete, in all the mixes.
- Crack formation and transmission are very much decreased showing that FRC can be utilized in seismic resistant constructions.
- The addition of human hairs to the concrete not only improves various properties of concrete like tensile strength, compressive strength but also strengthens the binding properties, micro cracking control and also enlarges spalling resistance. The crack width is minimized to a greater extent.

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