AN EXPERIMENTAL INVESTIGATION ON HAIR FIBRE AS FIBRE REINFORCEMENT IN CONCRETE

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Abstract:- *Fibre Reinforced Concrete (FRC) can give us the ample, practical as well as parsimonious technique for defeating cracking in the concrete and comparable kind of inadequacies. The concrete is frail in tension so a few stages must be taken to be received to conquer this insufficiency. The strength of Human Hair fibre is more in tension consequently may be utilized very finely as a fibrous stuff in concrete to furnish it with the rigidity which it needs. Hair Fibre (HF) a substitute non-biodegradable material is accessible in plenitude and at an exceptionally modest expense. It likewise makes ecological issues for its decay, present examination has been embraced to ponder its impact on plain cement concrete taking the following into account; flexural strength, crushing strength, compressive strength and micro-cracking control for making the cement concrete more financial and also to lessen natural issues.*

Keywords:- Hair Fibre, Fibre Reinforced Concrete, Compressive Strength, Flexural Strength.

INTRODUCTION

1.1 General

Almost everyone knows about concrete and its utilization. But not everyone of us have experienced Hair Fibre Reinforced Concrete (HFRC). What precisely it is? The huge amount of human and animal hair fibres are wasted annually because these are not always well managed or utilized. In India, every year 3 to 4 tons of human hair fibre is wasted. These composites have got a low density, a less expensive expense and also the acceptable mechanical properties making them an interesting source because of their simple availability and inexhaustibility of raw materials.

1.2 Introduction

The Fibre Reinforced Concrete (FRC) was designed by Joseph Monier, a French nursery worker in the year 1867. The utilizing of fibres for the reinforcement purpose is not a new idea and can be demonstrated by the following; since old times the fibres have been utilized as support in concrete. Verifiably, in cement mortar horsehair fibre was utilized and straw was used in case of mud blocks. During the early 20th century asbestos strands were utilized in cement concrete, and during 1950s idea of the composite material appeared, one of the subject of intrigue was fibre strengthened cement concrete. Once the wellbeing dangers related with the substance were found, there arose the need for discovering substitution to asbestos that was utilized in concrete as well as in other building materials. Onwards period 1960s, Glass (GFRC), Steel (SFRC) and manufactured filaments, for example, Polypropylene strands were utilized in cement, and investigation into new fibre strengthened solid proceeds with today. FRC can certainly be portrayed as composite including mortar or concrete, cement and discrete, uncontrollable, reliably scattered sensible fibre. Fibre is a material which possess lot of positive characteristic properties.

The civil structures which are build of steel strengthened concrete typically encounter the evil impacts of steel utilization by salt which in turn results in the sudden disillusionment of these civil structures. For enhancing as well as improving the existence cycle of those structures consistent upkeep and fixing is required. There are various ways to deal with point of confinement the mistake of the strong structures made of steel strengthened cement. The custom procedure is to adhesively invigorated hair fiber composites onto the structure. Hairs are utilized as a fibre strengthening material in cement to ponder its impacts on the compression, flexure and the cracking control to make the concrete economic and to lessen ecological issues made by the decay of hair. This moreover helps in the development of the solidness and versatility and upgrade the part and turning properties of the resultant composite. Regardless, this strategy another layer is incorporated, which is slanted to degradation. These hair fibre composites have been seemed to encounter the evil impacts of degradation when displayed to marine condition as a result of surface annoying.

For hair fibre reinforced concrete (HFRC) to be a practical development material, it must have the capacity to finish monetarily with a current fortifying framework. The fibre is a little bit of strengthening material having some specific quality properties. Fibre is frequently portrayed by a helpful parameter called angle proportion. Angle proportion of the fibre is the proportion of its length to the distance across. Run of the mill angle proportion ranges in between (30-150). The hair fibres are

utilized as a fibre fortifying material in cement to think about its consequences for the smashing, flexural, compressive strength and splitting control for the concrete management and to diminish the condition issues made by decay of hair.

One of the main usage of hair in concrete is to diminish natural issues made by the disintegration of hair. They are utilized as fibre strengthening materials in concrete to examine its consequences for the compression, crushing, flexural quality and splitting control to economies concrete. Concrete as a standout amongst the most broadly utilized building materials, made out of three primary components i.e. cement, sand and fillers in which they are reinforced together by bond and structure solid that is in actuality a man-made stone. Its compressive quality is satisfactory and rigidity is low. This shortcoming has plumbing issues including shrinkage in concrete and breaking of cement relies upon such a large number of variables including- the fixings, temperature, relative mugginess of concrete, measurement and the structure. In new cement because of shrinkage measurement changes and breaks are made and these splits in concrete increases penetrability, loss of surface and fortification consumption.

Along these lines, man squander hairs are utilized as regular strands to repay such frail rigidity of cement. With strengthening these normal strands the rigidity to a great degree increments inside the concrete. Coming about composite has reasonable respectability, progression and gives suitable utilization of concrete as an adaptable material to create elevated amounts of shape safe surfaces.

1.2.1 Advantages of Fibre Reinforced Concrete

1) Fibres decreases permeability/penetrability of liquids and henceforth lessen seepage of fluid.
2) These are useful in civil structures in light of the fact that these assistance in maintaining a strategic distance from erosion at the most extreme.
3) Also used to limit the cavitation and erosion damages in structures where high speed streams are experienced.
4) Fibres diminishes inwardly forces by closing the microscopic fractures or cracks from forming inside the concrete.
5) According to contemplates finished till now Fibre Reinforced Concrete (FRC) is observed to upgrade in various mechanical properties e.g. Sturdiness, Fatigue Strength, Impact Resistance, Flexure, Compression, Split Tensile Strength and Modulus of Elasticity.

1.2.2 Disadvantages

Uniformly spreading of filaments is one among the imperative things which need to be taken care about when blending fibres in the concrete blend, it must be spread all through the blend. This is found to be time consuming and difficult process at times. Fibre Reinforced Concrete (FRC) is observed to be more suitable for normal concrete workings if this limitation is evacuated by new and effective strategies and methods of fabrication.

1.2.3 Reasons to use Fibre in Concrete?

1) It helps in controlling the cracking which occur due to the plastic as well as drying shrinkages.
2) It also lessens down the porousness of concrete and consequently helps in lowering down the seeping of the liquid.
3) It produces more impact resistance, also increases strength, ductility, shatter and abrasion resistance.
4) Fineness quality of filaments enable them to fortify mortar part, delaying crack formations, propagation of concrete.

1.2.4 Why is Human Hair utilized as a fibrous stuff?

As per studies Human Hair is believed to be a non-biodegradable wastage, found usually in the public waste streams and can be the reason for tremendous ecological/biological problems. It is having properties like unique chemical composition, high tensile strength, high elasticity, thermal insulation and so on that makes it reasonable to be utilized as a fortifying material in the concrete. The usage of Human Hair as fibre fortifying material (FFM) in concrete is due to the accompanying causes:

1) Has a property of having greater flexibility which is like the copper wire with similar separation over.
2) Human Hair is non-biodegradable substance, hence can create natural issues so it is utilized as fibre fortified material (FFM) with the goal that the issue can be limited.
3) It is extremely cheap and is accessible in bounty.
4) It helps in prevention of spalling as it is used as reinforced substance in mortar.

1.2.5 Aim of the Project

Strength determination and to reduce the cracks using human hair as a fibre reinforced material.

1.2.6 Objectives of the Project

1) Increasing the strength.
2) Reducing the cracks.
3) To reduce the environmental issues by using non-degradable hair fibre as ingredients.

1.2.7 PREPARATION OF THE SPECIMEN

1.2.7.1 Material Collection:

Table 1: Materials Required (Taking 15% extra)

PROPORTIONS (Concrete M25)	**FOR 1 CUBE** (150×150×150)mm	**FOR 1 CYLINDER** (d=150mm,h=300mm)	**FOR 1 BEAM** (100×100×500)mm
Cement (kg)	1.652	2.589	2.447
Fine Aggregate (kg)	2.499	3.917	3.703
Coarse Aggregate (kg)	4.541	7.117	6.727
Water (L)	0.744	1.166	1.102
W/C Ratio	0.450	0.450	0.450
Hair Fibre 1% (kg)	.016	.025	.024
Hair Fibre 2% (kg)	.033	.051	.049
Hair Fibre 3% (kg)	.049	.077	.073

1.2.7.2 Hair Fibre Treatment Process:

Collection of the human hair which was required for preparedness of concrete specimen was gathered from the barber-shops/hair-salons and the excellence parlours. Before hair is included in the concrete specimen the treatment is an important matter. The treatment is worked out as per the following steps:-

1) *Separation process:*- The hair may contain wastes, separation of the hair from other wastes is worked out and the same is removed.
2) *Sorting process:*- Grouping is done as per the length, color and quality of it. Lengths and diameters of hair fibres are checked at random.
3) *Washing process:*- After sorting is done the chemical called acetone is used to wash the hair fibres so as to remove maximum impurities present in it.
4) *Drying process:*- Then the hair is put for drying either in oven or under the sunlight. After that it can be put away or stored with no worry for odour/decay.

MATERIALS AND METHODOLOGY

3.1 Materials

3.1.1 Cement

Extremely ground material which possess properties adhesive as well as cohesive in nature giving a coupling medium to the discrete fixing is termed as the cement. In a clear extent, a blend of normally happening argillaceous material and calcareous material to a halfway combination at high temperature are burnt together so as to obtain it. The create acquired on burning called clinker, Its designer, Joseph asp din called it Portland cement since when it solidified it deliver a material taking after stone from the quarries close Portland in England. During pounding of clinker gypsum or mortar of Paris is added to conform to setting time. The measure of gypsum is around 3 percent by weight of clinker. It additionally enhances the soundness of concrete. The cement which was used for the investigation was 43 Grade OPC confirming. The particular cement was in a good condition and free from any kind of impurities and moisture.
Test were carried on the cement and the results can be as shown as follows:-

Table 2: Cement Type and Properties

S.No.	**Characteristics**	**Values Obtained**
1.	Cement Grade	43 Grade (OPC)
2.	Initial Setting Time	30 min.
3.	Final Setting Time	500 min.

4.	Specific Gravity	3.15
5.	Normal Consistency	32%

Figure 3. 1: Consistency Test (LPU Concrete Lab)

3.1.2 Sand

Normal stream sand utilized in the concrete works is a granular material which is made of finely partitioned mineral and rock particles. In the inland constituent setting and the non-tropical beach front setting, the most well-known sand is the silica usually of quartz. The following carried tests and their results are as shown below:

Table 3 : Properties of Sand

S.No.	**Characteristics**	**Obtained Values**
1.	Water Absorption	0.83%
2.	Specific Gravity	2.64
3.	Fineness Modulus	2.35

3.1.3 Aggregate

These are considered as the most extracted materials on our planet. Aggregate is the term utilized for material for development that oppose compressive weight on establishment e.g. rock, slag, reused cement and sand. Aggregate are a part material. Coarse aggregate are acquired from stone quarries and stone. For the investigation process the coarse aggregates which were utilized were having the size of 10mm and 20mm. Test were carried on the coarse aggregates and the results can be as shown as follows:

Table 4: Properties of Coarse Aggregates

S.No.	Characteristics	Values Obtained
1.	Size Used	10mm and 20mm
2.	Fineness Modulus	6.65
3.	Water Absorption	0.2%
4.	Specific Gravity	2.6

3.1.4 Hair Fibre

The principle of hair organization is keratins which are proteins consisting of long chains of amino acids that form the cytoskeleton of all cells of external shell. Number of examinations unmistakably expressed that sulphur is the fundamental reason of solidarity of hair strings before crumbling despite natural pressure and these sulphur mixes connected with amino acids at abnormal states in hair lines. Sulphur in amino corrosive particles is neighbouring keratin protein till shape disulphide concoction chains. These chains are exceptionally impervious to acids disulphide execution, however in basic arrangement they can decay. In certainty antacid condition loses the hair lines. The potential effect of decreased quality in the cement mortar is as commendable yet we need to make reference to that the reason for this article is to research the effect of hair string responsible for shrinkage and splits which are caused in typical cement.

Table 5 : Properties of Human Hair Fibre

S.No.	Characteristic Features	Obtained Values
1.	Diameter	100-120µm
2.	Length	50-60mm
3.	Tensile Strength of Hair	380Mpa

Figure 3. 2: Hair Fibre (LPU Concrete Lab)

3.1.5 Water

Water is a raw material to make any kind of cementitious paste (be it plain cement concrete/reinforced/or with additives/simple mortar paste). It is what helps initiate the hydration reaction of the cement to turn that slurry of the mix to act as a binder between all its constituents (bulk matter). Assorted essentials for appropriateness of water for concrete based development are given in IS 456-2000 which is according to following: -
The pH estimation of water will be something like 6. Clean and Pure water was used for the casting as well as for curing of the specimen.

3.2 Methodology

The technique received to test the mechanical properties and quality of hair fortified cement is administered by:

3.2.1 Compressive Strength Test

The resisting/sustaining ability of a material while applying the gradual load is known as the compressive strength of the material. It is the extent of load at powerlessness to surface zone of strong model. Compressive strength is most generally perceived test coordinated on the particular hardened concrete, as it is a straightforward test to conduct and besides maximum appealing concrete properties are emotionally linked to it. The investigation is carried on models which are cubical of the size 150 × 150 × 150 mm. The test is finished in the going with advances: First of all the shape in a perfect world of strong metal, is used to set up the case of size 150 × 150 × 150 mm. Figured measure of hair fibre is consistently included into the strong mix physically. In the midst of the putting of concrete in the moulds it is compacted with the pressing bar with somewhere around 25 strokes for each layer. Following 24 hours the process of immediate submergence in the clean and fresh water of the precedents which are ousted from moulds is carried out. Following 28 days the models are attempted under the stack in a weight testing machine. The stack is associated reliably at the rate of 14 N/mm2 in the weight testing machine.
The results from the weight test are as the most extraordinary load the strong shape can pass on before it finally comes up short. The compressive quality can be found by partitioning the greatest load by the contact region of the test example.
Compressive Strength = stack/cross sectional zone

Let, P = most extreme load conveyed by the solid shape before the disappointment
A = contact territory typical to the heap
σ = greatest compressive pressure
Along these lines, σ= P/A
The apparatus used for this test are:-

1) Compression Testing Machine-1000KN (CTM)
2) Cubes of size (150mm × 150mm × 150mm)

Figure 3. 3: Compressive Strength Testing of a Sample (LPU Concrete Lab)

Figure 3. 4: Cube of size (150mm × 150mm × 150mm) (LPU Concrete Lab)

3.2.2 Tensile Strength Test

Tensile Strength or Elasticity testing is pulling on 2 finishes of a material to quantify how much strength is required to extend the material to breaking. Elasticity is the manner by which a material opposes extending and breaking when lengthening power is connected, instead of compressive quality where estimates a material's protection from pressure.
The concrete is great in pressure compel and feeble in strain constrain. So the fortification has been given in cement concrete to keep the split development.

The apparatus used for this test are:-

1) Compression Testing Machine-1000KN (CTM)
2) Cylinder (d=150mm, h=300mm)

Figure 3. 5: Tensile Strength Testing of a Sample (LPU Concrete Lab)

Figure 3. 6: Cylinder (d=150mm, h=300mm) (LPU Concrete Lab)

3.2.3 Flexural Strength Test

Flexural strength testing is among most widely recognized system utilized to gauge the elasticity of cement concrete. Albeit concrete isn't intended to oppose coordinate pressure, the learning of rigidity is of significance in evaluating the heap under which splitting create. The test is exceptionally helpful particularly in connection to the structure of street chunks and runways in light of the fact that the flexure pressure is a basic factor in these cases. Flexural strength is one proportion of elasticity of cement. It is a proportion of an unaltered strengthened solid bar or chunk to oppose breaking. At the end of the day, Flexural testing is utilized to decide the flex or twisting properties of a material.

The apparatus used for this test are:-

1) Compression Testing Machine-1000KN (CTM)
2) Beam of size (100mm×100mm×500mm)

Figure 3. 7: Compressive Strength Testing of a Sample (LPU Concrete Lab)

Figure 3. 8: Beam of size (100mm×100mm×500mm) (LPU Concrete Lab)

3.3.4 Workability Test

Workability is a simply physical property of newly blended cement concrete. New concrete is believed to be serviceable in the event that it very well may be effortlessly transported, set, compacted, and completed with no isolation. The simplicity of setting, compacting, and completing of cement in the coveted way is called Workability.

Concrete must be useful so it accomplishes greatest thickness with a sensible measure of compaction exertion. On the off chance that solid isn't useful or moderately less serviceable, it won't be compacted to its coveted thickness bringing about less quality and porosity at last. On the off chance that solid isn't useful, one won't have the capacity to put it well.

Some tests for the determination of workability of the cement concrete can be listed as under:-

1) Vee Bee Test
2) Compaction Factor Test
3) Flow Table Test
4) Slump Test

Slump Test

The consistency/workability of the concrete can be tested by a number of different tests. Of those, the most common is the slump test.

The “slump cone” is a sheet metal “frustrated” cone, 300 mm tall. The bottom diameter (D) is 200 mm, and the top (d) is 100 mm. It is placed on a stable surface, usually of steel. The cone is fitted with small steel tabs at the bottom. The operator stands on those tabs to hold the cone firmly on the surface. Placing of concrete into the cone is done in 3 layers, each being compacted in turn with 25 “rods” of a 16 mm diameter, bullet ended rod.

After compaction is complete, and the concrete is struck off at the top, and excessive concrete is cleaned away from the external of the cone, especially any lying on the surface. The operator firmly holds the cone down manually, and carefully steps away from the cone. The operator then carefully lifts the cone, and places it inverted adjacent the concrete. The tamping rod is positioned across the top of slump cone so that it runs across above the mound of concrete. A steel rule is used to measure down from the underside of the rod to the normal height of top of concrete. That value is recorded as the “slump”. Values can range from zero to 250 mm plus. Very rarely will one see a 270 mm value. That may be the case for concrete with super-plasticiser, or self-compacting concrete, or concrete with (say) 7 mm maximum particle size or all three.

The apparatus which are used for this test are:-

1) Tamping Rod
2) Slump Cone
3) Measuring Scale

Figure 3. 9: Measuring of Slump (LPU Concrete Lab)

Figure 3. 10: Slump Cone (D=200mm, d=100mm, h=300mm) (LPU Concrete Lab)

RESULTS AND DISCUSSIONS

4.1 Fresh Properties

4.1.1 Workability

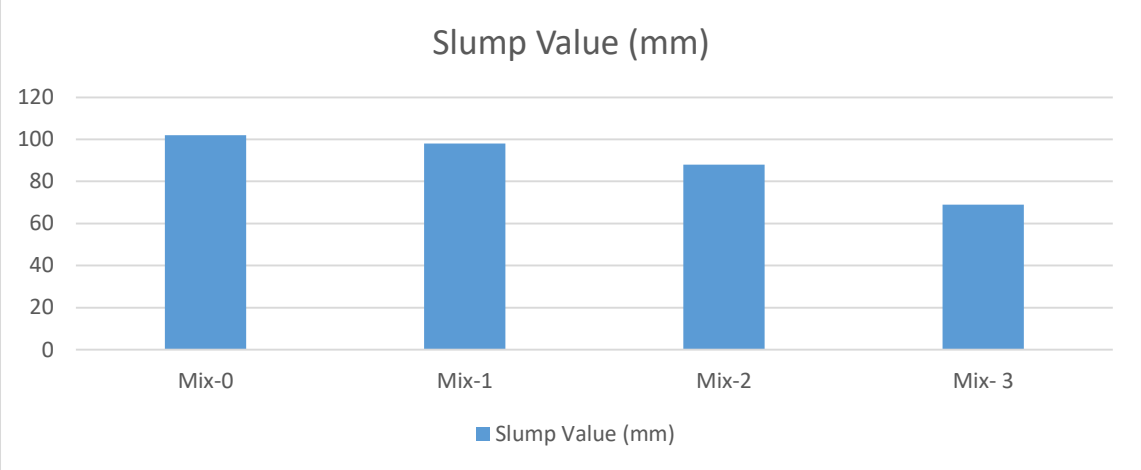
Table 4. 1: Results of Workability of the Mixes (Grade M25)

S.No.	**Mix Designation (%)** (Concrete M25)	**Slump Value[mm]**
1.	Mix-0	102
2.	Mix-1	98
3.	Mix-2	88

4.	Mix- 3	69

During observations significant decrement in workability of the concrete mixture was seen by increasing percentage of hair fibre. It is seen the maximum decrease in slump value is at 3% hair content by nearly 32% compared to the mix with zero percent hair fibre added.

Chart 1: Comparison in the Slump values of different mixes of M25 grade



4.2 Hardened Properties

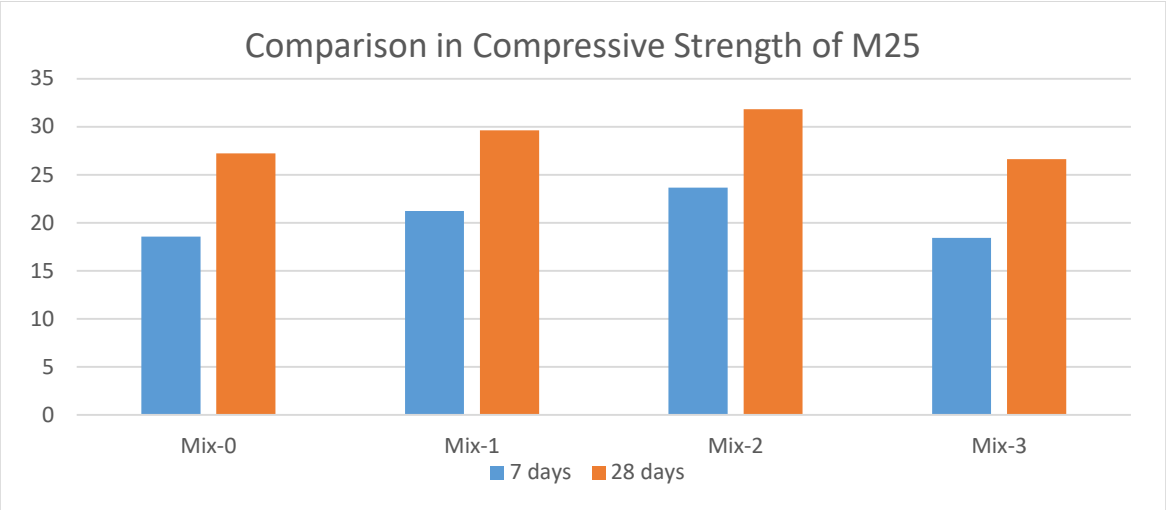
4.2.1 Compressive Strength

Table 4. 2 : Results of Compressive Strength Test (M25 grade)

Mix Designation (%) (M25 Concrete)	**Compressive Strength [N/mm^2]**	
	7- Days	28-Days
Mix-0	18.54	27.22
Mix-1	21.21	29.62
Mix-2	23.64	31.81
Mix- 3	18.42	26.62

In case of Compressive Strength Testing, it is observed there is significant increment in the strength by the increasing content of the hair fibre (upto 2%) by weight of cement. While when we go on adding 3% hair the decrement in the strength is observed. At 1% hair fibre, it is found that the strength increases by 14% as compared to the zero mix concrete at 7 days and 8.8% at 28 days when we compare it with the normal concrete/zero mix concrete at 28 days and when 2% hair is added the strength increases by 27% as compared to the zero mix concrete at 7 days and 16.8% compared to zero mix concrete at 28 days.

Chart 2: Comparison in Compressive Strength of M25 grade



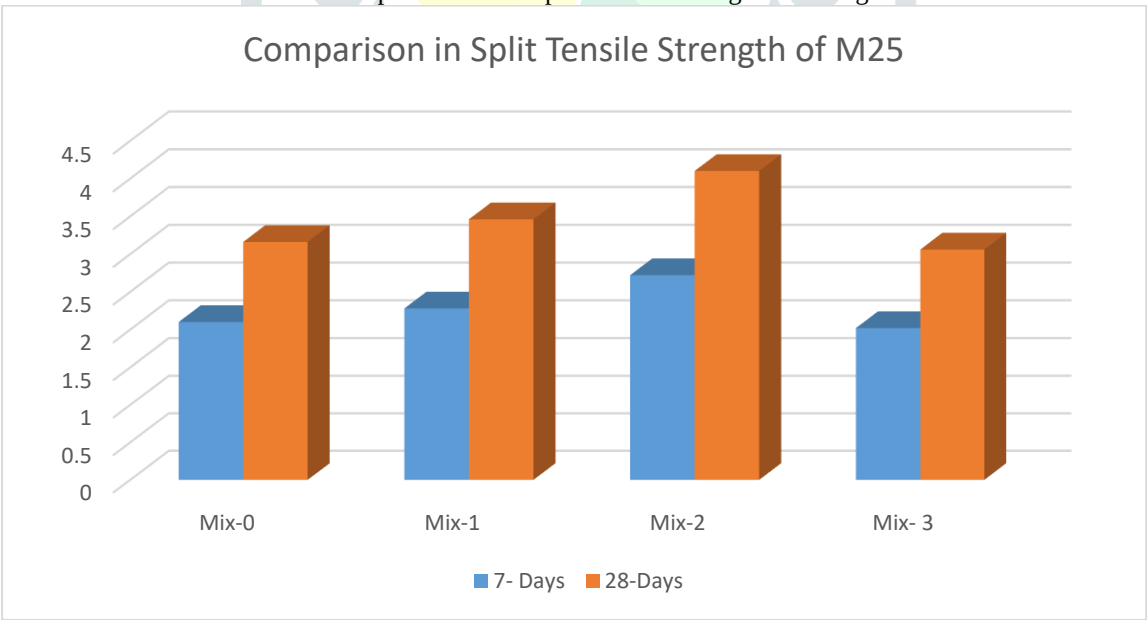
4.2.2 Split Tensile Strength

Table.4. 3: Split Tensile Strength Test Results (M25 grade)

Mix Designation (%) (M25 Concrete)	**'Split Tensile Strength' [N/mm^2]**	
	7- Days	28-Days
Mix-0	2.10	3.16
Mix-1	2.28	3.46
Mix-2	2.72	4.10
Mix- 3	2.02	3.06

It is found to be increased at percentages 1 and 2 of the hair fibre by weight of cement. At 7 days curing period, increment in strength was observed by 8.5% at 1% hair and nearly 29.5% at 2% hair when comparing it with zero mix concrete. And, at 28 days curing period, strength increment was observed by 9.4% at 1% hair and 29.7% at 2% hair as compared to the zero mix concrete.

Chart 3: Comparison in the Split Tensile Strength of M25 grade



4.2.3 Flexural Strength

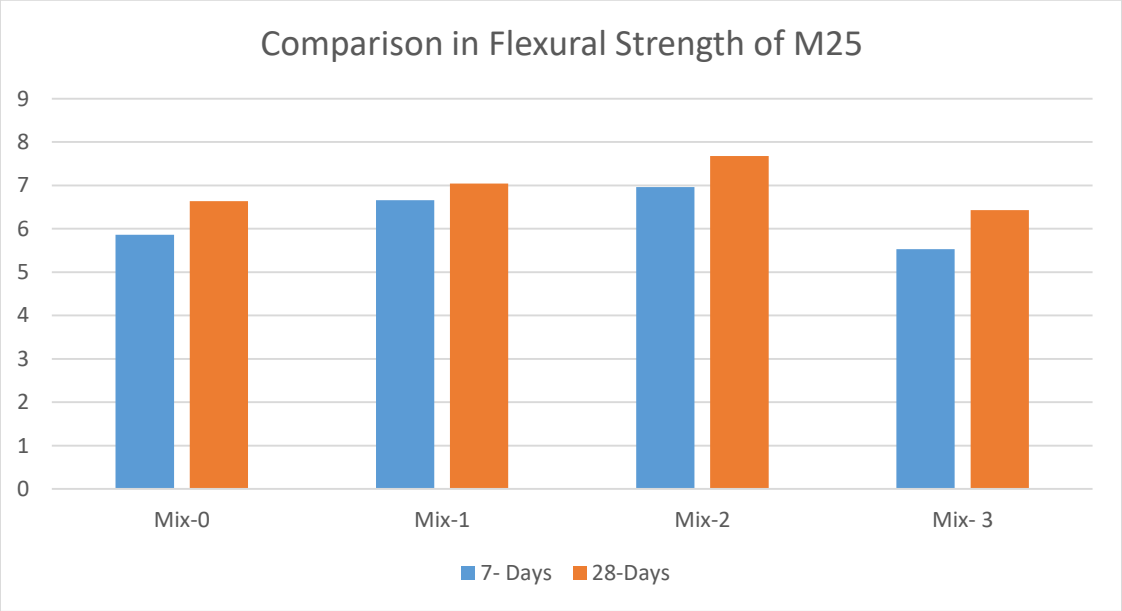
Table.4. 4: Flexural Strength Test Results (M25 grade)

Mix Designation (M25 Concrete)	**Flexural Strength [N/mm^2]**	
	7- Days	28-Days
Mix-0	5.86	6.64

Mix-1	6.66	7.04
Mix-2	6.96	7.68
Mix- 3	5.53	6.43

The Flexural strength of the concrete in the likewise manner was observed to be increased by the addition of the hair fibre percentages 1 and 2 by weight of cement. At 7 days curing period, the increment in strength is found by 13.6% at 1% hair and 18.7% at 2% amount of hair as compared to the normal concrete/zero mix concrete. Right when curing was done at 28 days the observations concluded that strength increased by 9.4% at 1% hair and 29.7% at 2% hair content as compared to the zero mix concrete.

Chart 4: Comparison in Flexural Strength of M25 grade



CONCLUSION

1) It is observed that the hair fibre provides an extraordinary increase in the concrete properties according to hair fibre percentages by the cement weight and is found to be economical with its availability in abundance.
2) Specifically, it is observed that the best increment is found in the addition of 2% hair fibre by the cement weight, in every one of the mixes.
3) The properties like Splitting Tensile Strength, Compressive Strength, toughness, Flexural Strength are found to be improved.
4) It is found to be suitable for the structures where corrosion is to be avoided and the minimizing of erosion damage in the structures where high velocity flows are encountered.
5) Reduction in the greater impact, abrasions, shatter resistances in concrete are observed.

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