Study On Addition Of The Natural Fibers Into Concrete

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Abstract: The current manuscript deals with subject of addition of natural fibers to concrete in order to study the strength properties and also to observe if there is reduction in propagation of shrinkage crack problems. Basically natural fibers are of two types. Natural inorganic fibers such as Basalt, Asbestos…etc and the other are the natural organic fibers such as coconut , palm, kenaf, jute, sisal, banana, pine, sugarcane, bamboo…etc. The natural fibers are investigated by different researchers as construction materials that can be used in cement paste/mortar/concrete. This study may include the fiber properties, characteristics and compatibility between themselves. Also the comparisons and conclusion to be studied for different fiber-cement proportions. However all properties of concrete may not improve for the same proportions of different fibers. Some properties may be improved and same may be reduced, since each fiber has its own different properties. Totally the study deals with comparisons and differences between the different natural fibers

Keywords: Natural inorganic fibers, Natural organic fibers, Fiber-cement ratio, Cube compressive strength, Cylinder compressive strength, Stress-strain curve, Workability, Young's modulus

1. INTRODUCTION:

The Portland cement concrete is a brittle material. It possess a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are present in concrete and its poor tensile strength is due to propagation of such micro cracks leading to brittle fraction of concrete. In plain concrete and similar brittle materials, structural cracks develop even before loading due to drying shrinkage and other causes. When load is applied the internal cracks propagate and open up due to stress and additional cracks are formed. The development of this cracks is the cause of inelastic deformation in concrete. The addition of small closely spaced and uniformly dispersed fibers to concrete can act as a crack arrester and improves its static and dynamic properties. This is known as fiber reinforced concrete, which can also be defined as the concrete containing fibrous materials which increases its structural performance. It contains short discrete particles [fibers] that are uniformly distributed and randomly oriented.

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The fibers are of same order of magnitude as aggregate inclusions. Addition of fibers can increase strength and also reduce plastic shrinkage and drying shrinkage by arresting the propagation of crack. The development of steel reinforcement has overcome the problem of poor tensile strength. But it doesn't completely solve the problem of micro cracks due to drying and plastic shrinkage owing to weathering conditions. This let to study on research of various methods to adopt fibers as reinforcement with different fibers. Addition of steel reduced the micro cracks but over a long period, steel gets corroded due to various actions. This made the need for enlightenment of usage of various organic and inorganic fibers which are eco friendly and economic. According to study of natural fibers, compared to natural inorganic fibers, vegetable fibers (natural organic) are very much renewable , eco-friendly, economical and production cost is also very low. Hence study on vegetable fibers with respect to natural inorganic fiber is been carried out in this project The mixes for addition of different proportions of fiber-cement ratio of natural organic(vegetable) fibers are being compared with one of the natural inorganic fibers in concrete with respect to plain concrete for their properties.

2. MATERIALS AND METHOD:

2.1 Materials:

The Ordinary Portland Cement of 53 grade which is readily available in the market is used in the project. The better coarse aggregates of 20mm and 12mm from the near by quarry and the fine aggregate of zone II are used in the project.SNF based super plasticizer is used.

2.1.1. Fibers:

Natural Inorganic fiber:

1. Basalt rock fiber

The composition of basalt rock fiber which is most eco-friendly and inert natural material

TABLE 1

composition	Percentage(%)
SiO_2	49.58
TiO_2	2.08
Al_2O_3	14.48
Fe_2O_3	4.42
FeO	9.43
K_2O	1.89
Na_2O	2.10
MgO	5.10
CaO	8.5

Natural Organic fibers:

1. Jute
2. Sisal
3. Hemp
4. Banana
5. Pine apple

2.2. Method:

The work on M30 grade of concrete as per IS:456-2000 for fiber-cement ratios 0.5%,1%,1.5% are carried out with fiber length of 6mm-10mm chopped.

2.2.1.Mixing:

The particular ingredients are weighed and mixed dry in electric concrete miller for 2 minutes and then the fibers are spread into the miller while mixing and after 2 more minutes, the particular water is added and mixed thoroughly for 3 minutes. the perfect mixture is now quickly tested for slump and poured into the moulds which are readily placed on electric vibrator in three layers. After few seconds of vibration the surface is properly leveled before it is hardened. Let the moulds dry for 24 hours. Then remove the moulds and place it in curing

2.2.2. Workability:

The slump for all the mixes is carried out in a standard slump apparatus

2.2.3. Cube compressive strength:

The standard cube moulds of 150*150*150mm which are thoroughly fitted and oiled are used. They are set for 28 days curing and then tested in a universal testing machine

2.2.4. Cylinder compressive strength:

The standard cylinder mould of diameter 150mm and height 300mm which are thoroughly fitted and oiled are used. They are set for 28 days curing and then tested in a universal testing machine along with the stress strain curve which is obtained from a dial with a circular gauge fit at the top and bottom of the cylinder. The compression which leads to bulging gives the deformation value in dial gauge.

3. RESULTS AND DISCUSSIONS:

3.1. Slump:

While mixing as the fiber-cement ratio is increasing, the slump is going on decreasing due to water absorption of fibers. Based on their absorbency different fibers possess a different change in slump values where the slump of M30 grade plain concrete is *92mm* is shown in the table 2.

TABLE 2

Type of the fiber	Slump in mm for fiber-cement ratio of percentage		
	0.5	**1**	**1.5**
Basalt rock fiber	78	62	60
Jute	70	45	50
Sisal	72	55	60
Hemp	75	52	65
Banana	72	50	58
Pine apple	74	65	56

3.2.Cube compressive strength:

The compressive strength of any fiber depends upon its own compositions. Also Similar fibers may show a variation in strengths when subjected to loading may be due to varied slumps also. Here are the test results for 28 days in table 3

TABLE 3

Cube compressive strength for 28 days

Plain concrete = 40.76N/mm2			
Type of the fiber	Cube compressive strength in N/mm2		
	Fiber-cement ratio		
	0.5%	1%	1.5%
Basalt rock fiber	44.71	42.53	36.44
Jute	47.24	45.64	44.44
Sisal	42.22	46.49	40
Hemp	40.89	38.67	32
Banana	43.56	40.44	36
Pine apple	40	38.22	31.11

3.3. Cylinder compressive strength and young's modulus:

The compression of a cylinder shows a bulging property while loading which gives the stress–strain values. A dial is

fixed around cylinder top and bottom to get the stress-strain curve along with load as shown in fig1. The young's modulus is given in table 4 and the ultimate cylinder compression strength values for 28 days is given in table 5

Fig 1: dail gauge set up to obtain stress-strain deformations

TABLE 4

Young's modulus for 28 days

Plain concrete = 30 KN/mm2			
Type of the fiber	Young's modulus in KN/mm2		
	Fiber-cement ratio		
	0.5%	1%	1.5%
Basalt rock fiber	34.1	32.6	30.9
Jute	34.8	33.9	31.8
Sisal	30.6	34.4	31.9
Hemp	42.6	35.7	32.9
Banana	44.5	35.1	33.7
Pine apple	38.9	40.3	30.3

TABLE 5

Cylinder compressive strength for 28 days

Plain concrete = 33.74N/mm2			
Type of the fiber	Cube compressive strength in N/mm2		
	Fiber-cement ratio		
	0.5%	1%	1.5%
Basalt rock fiber	38.5	37.37	29.44
Jute	38.5	36.23	32.84
Sisal	35.50	36.23	32.9
Hemp	37.20	35.90	25.31
Banana	36.63	33.97	32.84
Pine apple	36.63	31.71	27.18

3.4. Stress-strain curves:

The consecutive stress-strain curves for all the fibers with respect to plain concrete for 28 days

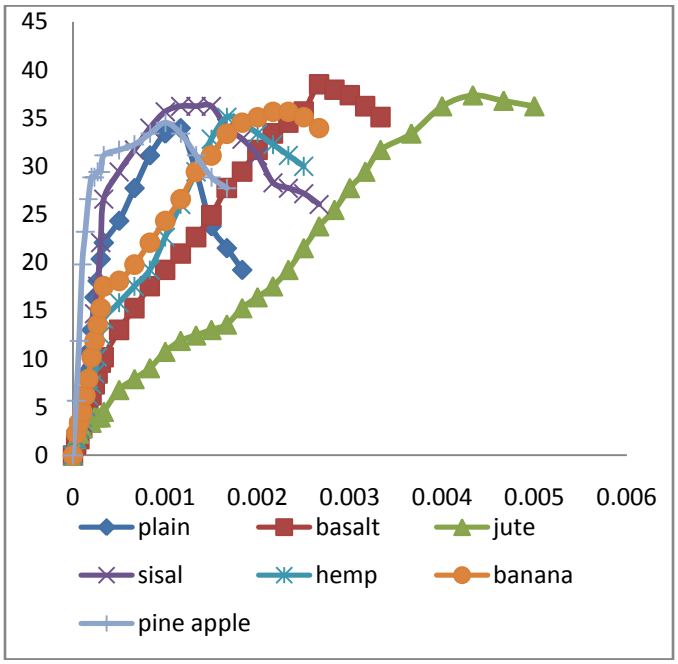

Fig 2:Graph between fibers for fiber-cement ratio 0.5%

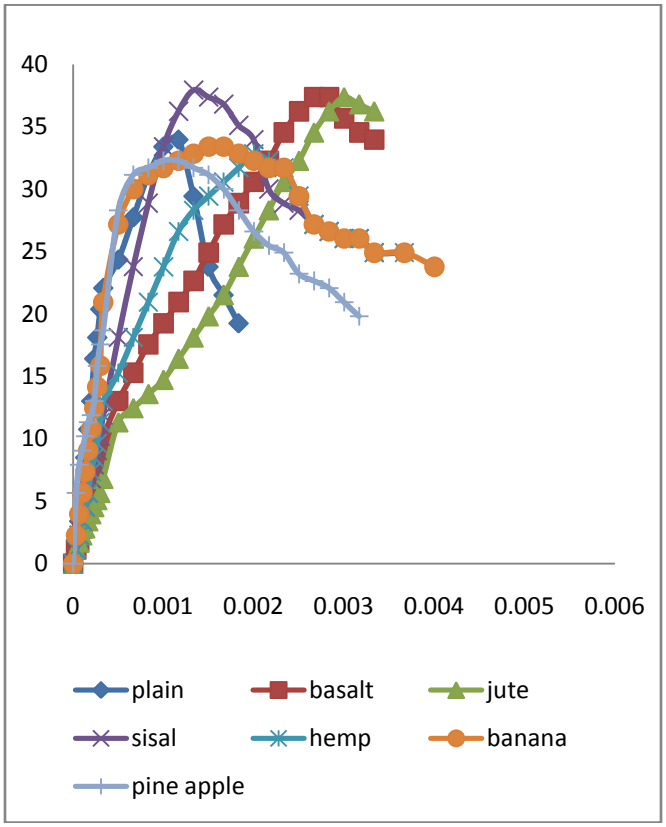

Fig 3:graph between fibers for fiber-cement ratio 1%

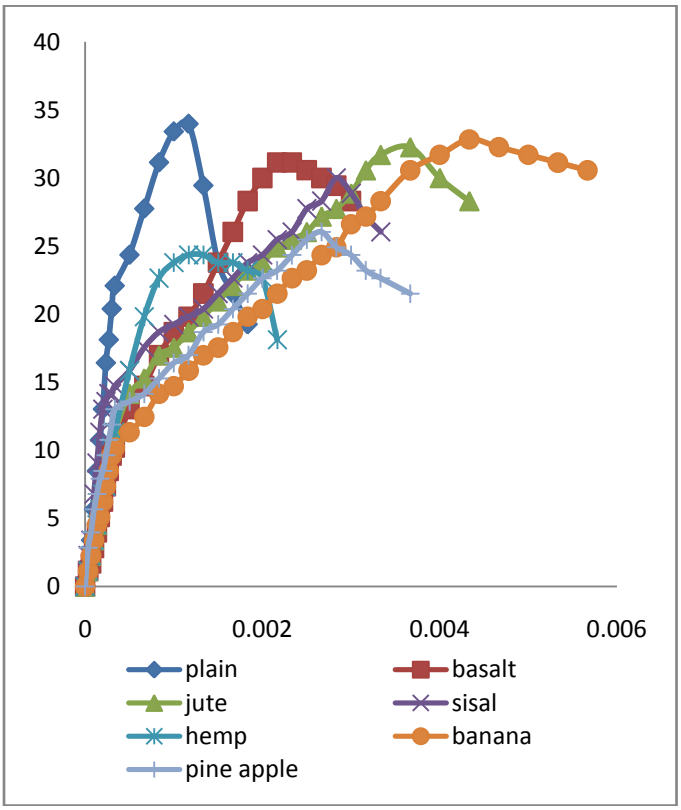

Fig 4: graph between fibers for fiber-cement ratio 1.5%

4. OBSERVATIONS:

4.1. Plain concrete:

While loading, since the plain concrete is brittle, it has shown a sudden and brittle failure as shown in fig 5 and fig6

Fig 5: cylinder failure in M30 plain concrete

Fig 6: cube failure pattern in M30 plain concrete

4.2. Concrete with fibers:

It is observed that there is more bulging in concrete with added fibers than in plain concrete. Also the failure is not sudden and with increase in fiber-cement ratio, the cracks at failure load are observed to be very less. This can be clearly glanced in fig 7,fig 8 and fig 9

Fig 7: bulging in concrete with fibers

Fig 8: Cube resistance to cracking due to binding of fibers

Fig 9: Cylinder resistance to cracking due to fibers

4.3. Strength variations:

All the fibers has shown much better increase in strength than plain concrete for 0.5% fiber-cement ratio and little increase than plain concrete for 1% fiber-cement ratio and with further increase of fiber-cement ratio to 1.5% the strength is decreased than plain concrete but sudden failure is resisted. It is expected that the decrease of strength may be due to decrease in slump and increase of fibers in concrete leads to voids as shown in fig 10 and fig 11

Fig 10: Voids in cylinder for 1.5% fiber-cement ratio though properly compacted

Fig 11: Voids in cube for 1.5% fiber-cement ratio though properly compacted

5. CONCLUSIONS:

- Slump is decreasing with the addition of fibers. More the fiber-cement ratio, more is the decrease in slump due to absorbency of water by fibers. Hence the use of proper super plasticizer which does not effect other properties except workability is recommended for higher fiber-cement ratios

- The addition of fibers increased compressive strength with 0.5% fiber-cement ratio and little increase for 1% of fiber-cement ratio compared to plain concrete. But at 1.5% of fiber-cement ratio, though plasticizer is added, the compressive strength is decreasing compared to plain concrete
- As the percentage of fibers is increased, the sudden and brittle failure of sample is resisted.
- Increase in fiber-cement ratio is tending to voids in concrete though thoroughly compacted because of improper bonding of materials in concrete with increase in fibers.

6. ACKNOWLEDGEMENT:

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