Comparative Study Between Fibre Reinforced Concrete (Glass, Jute, Steel Fibre) with Traditional Concrete

*Study of Concrete , Green Concrete

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***Abstract*— Fibre reinforced concrete is usually Portland cement concrete with either metallic or polymer fibres. The fibres are useful in providing greater resistance to plastic shrinkage cracking and service-related cracking. Fibres are not intended as primary reinforcing. The fibres are added during concrete production. They are useful in shotcrete and in thin overlays that are not sufficiently thick to accommodate reinforcing bars, and they have good resistanceto impact, vibration, and blasts. The usefulness of fibre reinforced concrete (FRC) in various civil engineering applications is indisputable. Fibre reinforced concrete has so far been successfully used in slabs on grade, architectural panels, precast products, offshore structures, structures in seismic regions, thin and thick repairs, crash barriers, footings, hydraulic structures and many other applications. Fibre Reinforced Concrete (FRC) is gaining attention as an effective way to improve the performance of concrete. Fibres are currently being specified in tunnelling, bridge decks, pavements, loading docks, thin unbonded overlays, concrete pads, and concretes slabs.**

***Keywords*—Fibre Concrete , glass fibre concrete jute fibre concrete , steel fibre concrete**

I. INTRODUCTION

As per the education pattern followed in M.H.S.S. Polytechnic, all the students are given opportunity to undergo in project as part of their syllabus.
We have selected this topic as to know the different characteristics of fibre reinforced concrete in terms of compressive strength, workability, durability, etc. And also to know whether this concrete is economical for all purposes.
Fibre reinforced concrete (FRC): When Concrete mixture is prepared by adding individual or combination of different types of fibre in it, then such formed concrete is termed as Fibre reinforced concrete .

The fibre like asbestos, glass, plastic, steel , jute can be used as reinforcement in concrete to increase various strength characteristics. Conventional Concrete: Concrete is a mixture of Cement, sand, Aggregates and Water in a certain proportion.

- USER BASED PROBLEM OF FIBREREINFORCED CONCRETE :

What are the disadvantages of fibre reinforced concrete?

- Increase in specific gravity of the concrete. This means that the concrete will be heavier than normal concrete in case of some fibres. We are looking at structural concrete so I would avoid consideringpolystyrene.
- Proportioning the exact amount of fibres in the batch of concrete. Test have shown that a slight variation in fibres creates tremendous changes in concrete strength.
- Higher cost because (production issues) as well as the cost of raw material is high.
- Corrosion of steel fibres. We use fibres to increase the tensile strength and stiffness and in order to get higher performance of concrete we want the fibres to perform well. Corrosion will reduce the performance level.

A. TYPES OF FIBREREINFORCED CONCRETE :

1. STEEL FIBRE REINFORCED CONCRETE

- Fibre reinforced concrete (FRC) is Portland cement concrete reinforced with more or less randomly distributed fibres. In FRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thusimprove concrete properties in all directions. FRC iscement- based composite material that has been developed in recent years.

- It has been successfully used in construction with its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. Fibre is a small piece of reinforcing material possessing certain characteristics properties. They can be circular, triangular or flat in cross-section.

- The fire is often described by a convenient parameter called ―aspect ratio. The aspect ratio of the fibre is the ratio of its length to its diameter. The principle reason for incorporating fibres into a cement matrix is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite. For FRC to be a viable construction material, it must be able to compete economically with existing reinforcing system.
- FRC composite properties, such as crack resistance, reinforcement and increase in toughness are dependent on the mechanical properties of the fibre, bonding properties of the fibre and matrix, as well as the quantity and distribution within the matrix of the fibres.

2. GLASS FIBRE REINFORCED CONCRETE

Concrete is most widely used construction material in the world. Nowadays the world is witnessing the construction of more and more challenging and difficult Engineering structures. So, the concrete need to possess very high strength and sufficient workability.

Researchers all over the world are developing high performance concrete by adding various fibres, admixtures in different proportions. Various fibres like glass, carbon, Poly propylene and aramid fibres provide improvement in concrete properties like tensile strength, fatigue characteristic, durability, shrinkage, impact, erosion resistance and serviceability of concrete.

Because of such characteristics Fibre Reinforced Concrete has found many applications in civil engineering field. Glass Fibre Reinforced Concrete (GFRC) is a recent introduction in the field of concrete technology. GFRC has advantage of being light weight, high compressive strength and flexural strength.

To improve the long term durability an Alkali resistance glass fibre reinforced concrete is also invented. The aim of the work is to study the properties of the effect of glass fibres as reinforcement in the concrete for different proportions from the research work which is already carried out by the researchers.

3. JUTE FIBRE REINFORCED CONCRETE

The natural jute fibre can be the effective material to reinforce concrete strength which will not only explore a way to improve the properties of concrete, it will also explore the use of jute and restrict the utilization of polymer which is environmentally detrimental. In Bangladesh, jute is locally available and, hence, less expensive.

To achieve this goal, an experimental investigation of the compressive, flexural, and tensile strengths of Jute Fibre Reinforced Concrete Composites (JFRCC) has been conducted. Cylinders, prisms, and cubes of standard dimensions have been made to introduce jute fibre varying the mix ratio of the ingredients in concrete, water-cement ratio, and length and volume of fibre to know the effect of parameters as mentioned..

SCOPE OF THE PROJECT:

- “The concrete of all the above-mentioned fibres will be made along with conventionalconcrete of M20 grade by the teammembers.”.
- The proportion of M20 grade is (1: 1.5: 3)
- {Cement, Aggregate and Sand}
- The compressive strength of the cube will be carried out at an interval of 7, 14 and 28days.

USER BASED PROBLEM OF FIBRE REINFORCED CONCRETE :

Increase in specific gravity of the concrete. This means that the concrete will be heavier than normal concrete in case of some fibres. We are looking at structural concrete so I would avoid considering polystyrene.

Proportioning the exact amount of fibres in the batch of concrete. Test have shown that a slight variation in fibres creates tremendous changes in concrete strength.

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Corrosion of steel fibres. We use fibres to increase the tensile strength and stiffness and in order to get higher performance of concrete we want the fibres to perform well. Corrosion will reduce the performance level.

EFFECT OF FIBERS IN CONCRETE:

Fibres are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They alsolower the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete. Generally fibres do not increase the flexural strength of concrete, so it can not replace moment resisting or structural steel reinforcement. Some fibres reduce the strength of concrete.

The amount of fibres added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibres) termed volume fraction (Vf). Vf typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fibre length (l) by its diameter (d). Fibres with a non-circularcross section use an equivalent diameter for the calculation ofaspect ratio.

If the modulus of elasticity of the fibre is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increase in the aspect ratio of the fibre usually segments the flexural strength and toughness of the matrix. However, fibres whichare too long tend to “ball” in the mix and create workability problems.

ADVANTAGES OF FIBER REINFORCED CONCRETE:

1. It increases the tensile strength of the concrete.
2. It reduce the air voids and water voids the inherent porosity of gel.
3. It increases the durability of the concrete.
4. Fibres such as graphite and glass have excellent resistance to creep, while the same is not true for most resins.Therefore, the orientation and volume of fibres have a significant influence on the creep performance ofrebars/tendons.
5. Reinforced concrete itself is a composite material, where the reinforcement acts as the strengthening fibre and the concrete as the matrix. It is therefore imperative that the behavior under thermal stresses for the two materials be similar so that the differential deformations of concrete and the reinforcement are minimized.
6. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties.

FACTORS AFFECTING PROPERTIES OF FIBER REINFORCED CONCRETE:

Fiber reinforced concrete is the composite material containing fibers in the cement matrix in an orderly manner or randomly distributed manner. Its properties wouldobviously, depends upon the efficient transfer of stress between matrix and the fibers. The factors are briefly discussed below:

1. Relative Fiber Matrix Stiffness

The modulus of elasticity of matrix must be much lower than that of fiber for efficient stress transfer. Low modulus offiber such as nylons and polypropylene are, therefore, unlikely to give strength improvement, but the help in the absorption of large energy and therefore, impart greater degree of toughness and resistance to impart. High modulus fibers such as steel, glass and carbon impart strength and stiffness to the composite.

Interfacial bond between the matrix and the fiber also determine the effectiveness of stress transfer, from the matrix to the fiber. A good bond is essential for improving tensile strength of the composite.

2. Volume of Fibers

The strength of the composite largely depends on the quantity of fibers used in it. Fig 1 and 2 show the effect of volume on the toughness and strength. It can see from Fig 1 that the increase in the volume of fibers, increase approximately linearly, the tensile strength and toughness ofthe composite. Use of higher percentage of fiber is likely to cause segregation and harshness of concrete and mortar.

3. Aspect Ratio of the Fiber

Another important factor which influences the properties and behavior of the composite is the aspect ratio of the fiber. It has been reported that up to aspect ratio of 75, increase on the aspect ratio increases the ultimate concrete linearly.

Beyond 75, relative strength and toughness is reduced. Table- 1 shows the effect of aspect ratio on strength and toughness.

Table-1: Aspect ratio of the fiber

Type of concrete	Aspect ratio	Relativestrength	Relative toughness
Plain concrete 0	1	1	
With	25	1.5	2.0
Randomly	50	1.6	8.0
Dispersed fibers	75	1.7	10.5

4. Orientation of Fibers

One of the differences between conventional reinforcement and fiber reinforcement is that in conventional reinforcement, bars are oriented in the direction desired whilefibers are randomly oriented. To see the effect of randomness, mortar specimens reinforced with 0.5% volume of fibers were tested. In one set specimens, fibers were aligned in the direction of the load, in another in the direction perpendicularto that of the load, and in the third randomly distributed.

It was observed that the fibers aligned parallel to the applied load offered more tensile strength and toughness than randomly distributed or perpendicular fibers.

5. Workability and Compaction of Concrete Incorporation of steel fiber decreases the workability considerably. This situation adversely affects the consolidation of fresh mix. Even prolonged external vibration fails to compact the concrete. The fiber volume at which this situation is reached depends on the length and diameter of thefiber.

Another consequence of poor workability is non-uniform distribution of the fibers. Generally, the workability and compaction standard of the mix is improved through increased water/ cement ratio or by the use of some kind of water reducing admixtures.

6. Size of Coarse Aggregate

Maximum size of the coarse aggregate should be restricted to 10mm, to avoid appreciable reduction in strength of the composite. Fibers also in effect, act as aggregate. Although they have a simple geometry, their influence on the properties of fresh concrete is complex. The inter-particle friction between fibers and between fibers and aggregates controls the orientation and distribution of the fibers and consequently the properties of the composite. Friction reducing admixtures and admixtures that improve the cohesiveness of the mix can significantly improve the mix.

7. Mixing

Mixing of fiber reinforced concrete needs careful conditions to avoid balling of fibers, segregation and in general the difficulty of mixing the materials uniformly. Increase in the aspect ratio, volume percentage and size and quantity of coarse aggregate intensify the difficulties and balling tendency. Steel fiber content in excess of 2% by volume and aspect ratio of more than 100 are difficult to mix.

It is important that the fibers are dispersed uniformly throughout the mix; this can be done by the addition of the fibers before the water is added. When mixing in a laboratory mixer, introducing the fibers through a wire mesh basket willhelp even distribution of fibers. For field use, other suitable methods must be adopted.

METHOLODGY

1) CEMENT

Ordinary Portland cement (OPC) is by far the most important type of cement. The OPC was classified into three grades namely, 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031- 1988. Ordinary Portland cement of 33 grade of ULTRATECH cement is used in this experimental work. Conforming weight of each cement bag was 50 kg.

2) FINE AGGREGATES

- It should be passed through IS Sieve 4.75 mm. It should have finess modulus 2.50-3.50 and silt contents should not be more than 4%. Coarse sand should be either river sand or pitsad; or combination of the two.In our region, fine aggregates can be found from bed of Tapi river. It confirms to IS 383- 1970 which comes under Zone I.

3) COURSE AGGREGATES

- It should be hard, strong, dense, durable and clean. It mustbe free from vein, adherent coatings and injurious amount of disintegrated pieces, alkalis, vegetable matters and other deleterious substances. It should be roughly cubical in shape. Flaky pieces should be avoided. It should confirm to IS2838(I).

4) STEEL FIBRES

- The typical diameter lies in the range of 0.25-0.75 mm hook end steel fibres are being used in this project. Length of these fibres is 30 mm and the aspect ratio of 55. Density of steel fibre is 7900 kg/cum.

5) GLASS FIBRES

Fibres lengths up to 35 mm are used in spray applications and
25 mm length premix applications. Glass fibre has high tensile strength and elastic modulus, brittle stress-strain characteristics and low creep at room temperature.

6) JUTE FIBRES

The natural jute fibre can be the effective material to reinforce concrete strength which will not only explore a way to improve the properties of concrete.

MOULDS USED FOR SAMPLING

- The mould shall be of metal, preferably steel or cast iron, and stout enough to prevent distortion. It shall be constructed in such a manner as to facilitate the removal of the moulded specimen without damage.it shall be so machined that, when it is assembled ready for use, the dimensions and internal faces shall be accurate within the following limits: 'The height of the mould and the distance between opposite faces shall be the specified size + 0·2 mm.
- The angle between adjacent internal faces and between internal faces and top and bottom planes of the mould shall be 90° +0-5°.The interior faces of the mould shall be plane surfaces with a permissible variation of 0.03 mm.
- Each mould shall he provided with a metal base plate having a plane surface. The base plate shall be of such dimensions as to support the mould during the filling withoutleakage and it shall be preferably attached to the mould by springs or screws, The parts of the mould when assembled shall be positively and rigidly held together. and suitable methods of ensuring this, both during the filling and on subsequent handling of the filled mould, shall be provided.

Procedure of casting :

1. Fill concrete into the mould in layer approximately 50 mm deep by moving the scoop around the top edge of the mould as the concrete slides form it, in order to ensure the symmetrical distribution of the concrete within the mould.
2. If compaction is done by hand tamps, the concrete with the standard rod, strokes being uniformly distributed over thecross section of the mould. For 15 mm cube, number of strokes should not be less than 35 per layer and 25 strokes for 10 cm cubes. Tamp the sides of the mould to close the voids left by tamping bars. If compaction is done by vibration then each layer is compacted by means of a suitable vibrating hammer or vibrator or vibrating table. Mode and quantum of vibration of laboratory specimen shall be near the same as those adopted in actual operation.
3. Storing the specimen in a place for 24 + 0.5 hours from time addition of water to dry ingredients. Remove the specimen from the mould and keep it immediately submerged in clean, fresh water and keep them until taken out just prior to rest. Water in which the specimen is submerged shall be renewed every 7 days.

Procedure of testing :

1. Age of test: usually testing is done after 7 days and 28 days. The days being measured from the time water is addedto the dry ingredients.
2. Test at least 3 specimens at a time.
3. Test the specimen immediately or removal

fromwater and while they are still in the wet condition. Wipe off the surface water. If the specimens are received dry, keep them inwater for 24 hours before testing.

4. Place the specimen in such a manner that the load shall be applied to opposite sides of the cube cast i.e. not to the topand the bottom.

5. Align carefully the center of the thrust of the sphericalscaled plate.

6. Apply load slowly and at the rate of 14 N/mm2. Till thecube breaks.

7. Note the maximum load and appearance of the concrete failure i.e. whether aggregates have broken or cement paste separates from the aggregates etc.

DETAILS OF DESIGN :

All the materials required for the project were procured from the stores. The physical tests was conducted for the cement and zoning of aggregate was done.

The concrete cubes of M20 grade (1:1.5:3) and three blocks of each steel fibre, glass fibre, jute fibre and conventional concrete were casted as the design and proportion mentioned below: for 1 cube :

1. Conventional Concrete: 1) Cement = 6 kg
2) Fine Aggregate= 9.00 kg
3) Coarse Aggregate = 12.00 kg
4) W/C ratio = 0.35

2. Steel Fibre Reinforced Concrete: 1) Cement = 6 kg
2) Fine Aggregate = 9.00 kg
3) Coarse Aggregate = 12.00 kg
4) Steel Fibre = 10 % of cement
5) W/C ratio = 0.35

3.Glass Fibre Reinforced Concrete: 1) Cement = 6 kg
2) Fine Aggregate = 9.00 kg
3) Coarse Aggregate = 12.00 kg
4) Glass Fibre = 10 % ofcement
5) W/C ratio = 0.35

4.Jute Fibre Reinforced Concrete: 1) Cement = 6 kg
2) Fine Aggregate = 9.00 kg
3) Coarse Aggregate = 12.00 kg
4) Jute Fibre = 10 % of cement
5) W/C ratio = 0.35

All these proportion was carried through overall project. We had casted 12 concrete cubes in a day which includes three of steel fibre, three of jute fibre, three of glass fibre and three of conventional concrete. And we continued theseproportion for all 36 cubes.

And also we had considered the wastage of concrete nearly about 54 % in our calculation part so that there is not any shortage of concrete while performing the project.

WORKING ON PROJECT :

According to the project we need to conduct compression test on all the cubes at 7, 14 and 28 day of curing. So for thatwe need to cast 12 cubes in a day which includes three of steel fibre, three of jute fibre, three of glass fibre and three of conventional concrete.

So we decided to do the casting of concrete cubes in 3 days. That means 12 cubes a day which includes three of steel fibre, three of jute fibre, three of glass fibre and three of conventional concrete. And overall we need 36 concretecubes.

We made calculations on how much the materials will be required during the overall project and procured the materials before the casting. Then after the procurement we had performed some physical tests on the material.

PROCESSES :

A. Mix Design Of Conventional Concrete:

The Design mix of M20 was prepared using IS code .

C. Batching Up Of Materials :

Appropriate quantity of materials were calculated by volume and mixed in following proportions:

Volume of cement = 06 kg

Volume of coarse aggregates = 9 kg Volume of fine aggregates = 12 kg W/C ratio : 0.35

The materials were mixed by hand mixing process and the workability of the mix was checked simultaneously by performing various workability tests such as Slump cone test and Compaction factor tests so as to ensure proper compaction, avoid bleeding of concrete and segregation of aggregate.

SLUMP CONE TEST: The test was performed on the concrete mix to guess its workability.

C. Casting Of Cubes :- three cubes of steel fibre, three cubes of jute fibre, three cubes of glass fibre and three cubeswere casted for conventional Concrete.

Dimension of cube= 15cmx15cmx15cm

The molds were filled with concrete in three layers and each layer was tamed uniformly with tamping rod to prevent the formation of voids and provide better compaction.

Procedure of casting :

1. Fill concrete into the mould in layer approximately 50mm deep by moving the scoop around the top edge of the mould as the concrete slides form it, in order to ensure the symmetrical distribution of the concrete within the mould.

2. If compaction is done by hand tamps, the concrete with the standard rod, strokes being uniformly distributed over the cross section of the mould. For 15 mm cube, number of strokes should not be less than 35 per layer and 25 strokes for 10 cm cubes. Tamp the

sides of the mould to close the voids left by tamping bars. If compaction is done by vibration then each layer is compacted by means of a suitable vibrating hammer or vibrator or vibrating table. Mode and quantum of vibrationof laboratory specimen shall be near the same as those adopted in actual operation.

3. Storing the specimen in a place for 24 + 0.5 hours fromtime addition of water to dry ingredients.

Remove the specimen from the mould and keep it immediately submergedin clean, fresh water and keep them until taken out just prior to rest. Water in which the specimen is submerged shall be renewed every 7 days.

Curing of concrete cubes :

Curing of the concrete cubes is done in a drum full of water. We had a drum so we filled it with water and fully submerged the concrete cubes in that drum containing of water. Curing of the concrete cubes is done according to its testing days. For proper identification of the cubes we had marked date of casting on the concrete.

RESULTS :

SR.NO TYPE OF FIBRE NO.OF DAYS LOAD IN (KG) COMPRESSIVE STRENGTH (N/mm2)

SR.NO	TYPE OF FIBRE	NO.OF DAYS	LOAD IN (KG)	COMPRESSIVE STRENGTH (N/mm2)
1	Steel Fibre Concrete	7	62500	27.78
2	Steel Fibre Concrete	7	61000	27.11
3	Steel Fibre Concrete	7	62000	27.50
4	Jute Fibre Concrete	7	50500	22.44
5	Jute Fibre Concrete	7	54200	24.08
6	Jute Fibre Concrete	7	53200	23.64
7	Glass Fibre Concrete	7	58000	25.78
8	Glass Fibre Concrete	7	55500	24.67
9	Glass Fibre Concrete	7	58000	25.78
10	Conventional Concrete	7	55000	24.44
11	Conventional Concrete	7	63000	28.00
12	Conventional Concrete	7	58000	25.78

Average Results After 7 days of Curing :

1. Steel Fibre Concrete : 27.48 N/mm2
2. Jute Fibre Concrete : 24.39 N/mm2
3. Glas Fibre Concrete : 25.48 N/mm2
4. Conventional Concrete : 26.07 N/mm2

SR.NO	TYPE OF FIBRE	NO. OF DAYS	LOAD IN (KG)	COMPRESSIVE STRENGTH (N/mm2)
1	Steel Fibre Concrete	14	68000	30.22
2	Steel Fibre Concrete	14	67000	29.78
3	Steel Fibre Concrete	14	65000	28.84
4	Jute Fibre Concrete	14	40000	17.78
5	Jute Fibre Concrete	14	41150	18.29
6	Jute Fibre Concrete	14	41150	18.29
7	Glass Fibre Concrete	14	60500	26.89
8	Glass Fibre Concrete	14	58000	25.78
9	Glass Fibre Concrete	14	57500	25.56
10	Conventional Concrete	14	72500	32.22
11	Conventional Concrete	14	70000	31.11
12	Conventional Concrete	14	66500	29.55

Average Results After 14 days of Curing :

1. Steel Fibre Concrete : 29.63 N/mm2

2.. Jute Fibre Concrete : 218.12 N/mm2

3. Glas Fibre Concrete : 26.07 N/mm2
4. Conventional Concrete : 30.96 N/mm2

CONCLUSION :

1. Steel fibre reinforced concrete

- A comprehensive review of literature covering papers from Journals and conferences was carried out; papers reviewed were predominantly based on fibre reinforced concrete. The literature review indicates that very few publications are available on the fibre reinforced concrete with hook tain steel fibres.

- Variables such as aspect ratio, different grades of concretes and different percentages of steel fibres are simultaneously not covered in papers reviewed. No work is reported in the development of mathematical models and their validation using own experimental values and values from other researches, considering parameters like compressive strength, Split tensile strength and Flexural Strength for Steelfibre reinforced concrete.

2. Glass fibre reinforced concrete

- Though the initial cost is high the overall cost is greatly reduced because of the good properties of fibre reinforced concrete. The glass fibre reinforced concrete showed almost 20 to 25 % increase in compressive strength, flexural and split tensile strength as compared with 28 days compressive strength of plain concrete.

- While to improve the durability from the aspect of acid attacks on concrete the use of AR glass fibres had shown good result. So, the GFRC can be used for blast resisting structures, dams, hydraulic structures.

3. Jute fibre reinforced concrete

- Concrete with jute fibre is an aspiring step towards the sustainable development in Bangladesh where the jute areabundantly cultivated.

- In the experimental investigations conducted in the study, it was found that the addition of jute fibre contributes enriched results for mechanical properties of concrete composites for a particular length and content of fibre. More specifically, compressive, flexural, and tensile strength are found to enhance significantly for volume content of 0.1 and 0.25 % and the fibre cut length of 10 and 15 mm.

- However, with larger fibre length and content, the mechanical properties were found to affect adversely. Finally, it can be stated that the maximum increment is observed for tensile strength which is 35 % with reference to the plain concrete.

So JFRCC can be developed with locally fabricated jute in Bangladesh. The least cost of jute, its being renewable resources, the reduced weight of the JFRCC, and the environmental compatibility would clearly show the socioeconomic viability of JFRCC. Based on the insights gained from the test results and analysesof the JFRCC,

The incorporation of jute fibre in making FRC composite would be one of the promising strategies to improve the performance of concrete.

FUTURE SCOPE :

The present study can be treated as platform for the new study or acting as a supporting document for a detail research in finding the different strength parameters. The following studies can be initiated so as to provide wide range of application in the field of steel fiber reinforced concrete in different sustained elevated temperatures.

1. The study can be done using different types of fibres such as polyproplyne, carbon, GI, HDPE (high density poly ethylene) fibres in ternary blended combinations when subjected to different sustained elevated temperatures.
2. The study can also be made on the effect of sustained elevated temperatures on steel fibre reinforced tertiary blended concrete with combinations like (FA+SF+GGBFS), (FA+SF+MK), (FA+SF+RHA).
3. Effect of sudden cooling, gradual cooling and intermittent cooling on the properties of steel fibre reinforced ternary blended concrete when subjected to sustained elevated temperatures.
4. Effect of grade of concrete on the properties of steel fibre reinforced ternary blended concrete when subjected to sustained elevated temperatures.
5. Effect of different aspect ratios and different volume fractions on the properties of steel fibre reinforced ternary blended concrete when subjected to sustained elevated temperatures.
6. The effect of different aggregate types on the properties of steel fibre reinforced ternary blended concrete when subjected to sustained elevated temperatures.
7. The other properties of composites such as moisture absorption, fatigue and tribological behaviour may be determined using extensive experimentation.
8. The experiments can be extended by adding other potential natural fibers, by changing the fiber orientation and fiber content and their mechanical and machining characteristics may be analysed.
9. The experiments can be extended by increasing the number of machining parameters, such as tool geometry, toolmaterials, etc.
10. The experiments can be repeated by using differenttool inserts with wider geometries.
11. The experiments can be extended to other machiningprocesses, such as milling, reaming etc.
12. The experimental data can be modelled and analyzed using other modelling techniques, such as fuzzy logic, ANFISetc.
13.

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