A Study on the Strength Performance of Hybrid Fiber Reinforced Concrete

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***Abstract*: High performance fiber reinforced concrete is developing quickly to a modern structural material with a high potential. As for instance testified by the recent symposium on HPFRC in Kassel, Germany (April 2008) the number of structural applications increases. At this moment studies are carried out with the aim to come to an international recommendation for the design of structures with HPFRC. Hybrid fiber reinforced concrete formed by addition of fiber with different properties.in this work coir and glass fiber are added in the ratio of 0.5%,1%1.5%. Moreover, it should be consistent with existing design recommendations for structural concrete.**

***Keywords*: hybrid fiber reinforced concrete**

1. Introduction

Concrete is the most widely used construction material. It is obtained by mixing cementitious materials, water, aggregate and sometimes admixtures in required proportions. Fresh concrete is freshly mixed material which can be moulded into any shape hardens into a rock-like mass known as concrete. The hardening is because of chemical reaction between water and cement, which continues for long period leading to stronger with age. The utility and elegance as well as the durability of concrete structures, built during the first half of the last century with ordinary Portland cement (OPC) and plain round bars of mild steel, the easy availability of the constituent materials of concrete and the knowledge that virtually any combination of the constituents leads to a mass of concrete have bred contempt. Strength was emphasized without a thought on the durability of structures.

Plain concrete is weak in tension and has limited ductility and little resistance to cracking. Micro cracks are present in concrete and because of its poor tensile strength. The cracks propagate with the application of load leading to brittle fracture of concrete.

Micro cracks in concrete are formed during its hardening stage. A discontinuous heterogeneous system exits even before the application of any external load. When the load is applied, micro cracks start developing along the planes which may experience relatively low tensile strains, at about 25-35 % of the ultimate strength in compression.

During the past decades the concrete construction fields has experienced a growing interest in the advantages fibre reinforcement has to offer. Between the different fibres available, eg. Steel, synthetic, glass and natural fibres. Fibre reinforcement is mainly used in applications such as industrial floors, overlays and sprayed concrete, although other application areas exist. Some of the potential benefits of fibres in concrete are improved crack control and the possibility of designing more slender structures.

However, the extent of the crack control depends to a large extent on the type and amount of fibre added. From a durability point of view it is essential to control the cracking proceed and moreover, being able to predict crack widths and crack pattern as well as to design a structure that exhibits the desired behavior. This behavior of course, depends on a number of different factors such as structural type and size, type of concrete amount and type of reinforcement, and not at least, the casting procedure. In general, to achieve crack control, large amounts of conventional reinforcement are needed, especially in structures where only very small crack widths (0.1 mm) are allowed. Negative effects from large amounts of reinforcement are that structural dimensions often need to be larger than what is needed for load bearing capacity in order to make space for all the steel; the heavy labour placing it; and also difficulties with pouring the concrete past the tightly placed reinforcement bars of the steel cage. By using fibres in combination with or instead of the conventional reinforcement, these drawbacks may be reduced or even completely avoided.

2. Experimental Investigation

A. Cement

Cement is the most important ingredient in concrete. Some of the important factor that play a vital role in selection of cement are compressive strength at various ages, fineness, heat of hydration alkali content, tricalcium aluminate (C3A) content, tricalcium silicate (C3S) content, dicalcium silicate (C2S) content etc. It is also necessary to ensure compatibility of the chemical and mineral admixtures with cement. There are different types of cement, out of that mostly used two types are:

- Ordinary Portland cement
- Portland slag cement

Ordinary Portland cement (OPC) is the basic portland cement and is best suited for use in general concrete construction. It is of three types 33grade, 43 grade, 53 grade. One of the important benefit is the faster rate of development of strength.

Portland slag cement is obtained by mixing Portland cement clinker, gypsum and granulated blast furnace slag in suitable proportion and grinding the mixture to get a thorough and intimate mixture between the constituents. This type of cement can be used for all purposes just like OPC. It has lower heat of evolution and is more durable and can be used in mass concrete production.

Property	Values
Fineness Of Cement	7.5%
Specific gravity	3.15
Initial Setting Time	28 Minutes
Final Setting Time	600 Minutes

B. *Fine aggregate*

According to IS 383:1970 the fine aggregate is being classified into four different zone, that is Zone-I, Zone-II, Zone-III and Zone-IV. Fine aggregate are material passing through an IS sieve that is less than 4.75mm gauge beyond which they are known as coarse aggregate. Coarse aggregate form the main matrix of the concrete, whereas fine aggregate form the miller matrix between the coarse aggregate. The most important function of the fine aggregate is to provide workability and uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension.

Property	Values
Specific gravity	2.75
Fineness Modulus	2.68
Water Absorption	1 %
Bulk density (kg/m^3)	1654

C. *Coarse aggregate*

The coarse aggregate is the strongest and the least porous component in concrete. It is also chemically stable material. Presence of coarse aggregate reduces drying shrinkage and other dimensional changes occurring on account of movement of moisture. Coarse aggregate contributes to impermeability concrete provided that graded and the mix is suitably designed. Ordinary blue granite crushed stone aggregate confirming IS-383:1970 was used as a coarse aggregate in concrete. Optimum size of the coarse aggregate in most situations was about 20mm was adopted. They generally possess all the essential qualities of a good building stone showing very high crushing strength, low absorption value and least porosity.

Physical properties	Values
Specific gravity	2.86
Fineness Modulus	7.53
Water Absorption	0.75%
Bulk density (kg/m^3)	1590

D. *Water*

Water is an important ingredient of concrete as it actively participates in chemical reactions with cement to form the hydration product, calcium-silicate-hydrate (C-S-H) gel. The strength of the cement concrete depends mainly from the binding action of the hydrate cement paste gel. A higher water binder (w/b) ratio will decrease the strength, durability, water tightness and other related properties of concrete. The water used for making concrete should be from desirable salts that may react with cement. Silts and suspended particles are undesirable as they interfere with setting, hardening and bond characteristics. Algae in mixing water may cause marked reduction in strength of concrete either by combining with cement to reduce the bond or by causing large amount of air entrainment in concrete.

E. *E-glass fibre*

E-Glass or electrical grade glass was originally developed for standoff insulators for electrical wiring. It was later found to have excellent fibre forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fiberglass. Glass fibres are generally produced using melt spinning techniques. These involve melting the glass composition into a platinum crown which has small holes for the molten glass to flow.

Continuous fibres can be drawn out through the holes and wound onto spindles, while short fibres may be produced by spinning the crown, which forces molten glass out through the holes centrifugally. Fibres are cut to length using mechanical means or air jets. Fibre dimension and to some extent properties can be controlled by the process variables such as melt temperature (hence viscosity) and drawing/spinning rate. The temperature window that can be used to produce a melt of suitable viscosity is quite large, making this composition suitable for fibre forming. As fibres are being produced, they are normally treated with sizing and coupling agents.

These reduce the effects of fibre-fibre abrasion which can significantly degrade the mechanical strength of the individual fibres. Other treatments may also be used to promote wetting and adherence of the matrix material to the fibre. E-Glass is a low alkali glass with a typical nominal composition of SiO_2 54wt%, Al_2O_3 14wt%, CaO+MgO 22wt%, B_2O_3 10wt% and Na_2O+K_2O less than 2wt%. Some other materials may also be present at impurity levels.

Specification	Values
Length(mm)	12
Diameter(mm)	0.2
Aspect ratio	60
Elastic limit(Gpa)	2.75

Properties that have made E-glass so popular in fibre glass and other glass fibre reinforced composite include:

- Low cost
- High production rates
- High strength
- High stiffness
- Relatively low density
- Non-flammable
- Resistant to heat
- Good chemical resistance
- Relatively insensitive to moisture
- Able to maintain strength properties over a wide range of conditions
- Good electrical insulation.

The quality and other features of this particular type of cement. we offer the 53 Grade OPC Cement which gives even higher cement strength to match the rising demands of higher strength building material in the urban world. Property of cement details given below the table.

S.no.	Test	Value
1	Specific Gravity	3.15
2	Bulk density	1330 kg/m^3
3	Normal Consistency	34%
4	Initial Setting Time	30 Min
5	Final Setting Time	10 Hrs

F. Coir fiber

Coir is a versatile natural fibre extracted from mesocarp tissue, or husk of the coconut fruit Generally fibre is of golden color when cleaned after removing from coconut husk; and hence the name " The Golden Fibre". Coir is the fibrous husk of the coconut shell. Being tough and naturally resistant to seawater, the coir protects the fruit enough to survive months floating on ocean currents to be washed up on a sandy shore where it may sprout and grow into a tree, if it has enough fresh water, because all the other nutrients it needs have been carried along with the seed.

These characteristics make the fibers quite useful in floor and outdoor mats, aquarium filters, cordage and rope, and garden mulch. The fibrous husks are soaked in pits or in nets in a slow moving body of water to swell and soften the fibres. The long bristle fibres are separated from the shorter mattress fibres underneath the skin of the nut, a process known as wet-milling. The mattress fibres are sifted to remove dirt and other rubbish, dried and packed into bales. Some mattress fibre is allowed to retain more moisture so that it retains its elasticity for 'twisted' fibre production.

The coir fibre is elastic enough to twist without breaking and it holds a curl as though permanently waved. Twisting is done by simply making a rope of the hank of fibre and twisting it using a machine or by hand. The longer bristle fibre is washed in clean water and then dried before being tied into bundles or hunks. It may then be cleaned and 'hackled' by steel combs to straighten the fibres and remove any shorter fibre pieces. Coir bristle fibre can also be bleached and dyed to obtain hanks of different colours.

Specification	Values
Length(mm)	12
Diameter(mm)	0.12
Aspect Ratio	100
Mean elongation,%	27.2

Coir fibre Uses and applications

Brown coir is used in brushes, doormats, mattresses and sacking. A small amount is also made into twine. Pads of curled brown coir fibre, made by needle-felting (a machine technique that mats the fibres together) are shaped and cut to fill mattresses and for use in erosion control on river banks and hillsides. A major proportion of brown coir pads are sprayed with rubber latex which bonds the fibres together (rubberized coir) to be used as upholstery padding for the automobile industry in Europe. The material is also used for insulation and packaging. The major use of white coir is in rope manufacture. Mats of woven coir fibre are made from the finer grades of bristle and white fibre using hand or mechanical looms. Coir is recommended as substitute for milled peat moss because it is free of bacteria and fungal spores.

3. Effects on Mix Design

As with any traditional mix design, fibre-reinforced concrete needs to be proportioned to ensure it has good workability and finish ability in its plastic state as well as the necessary strength and durability characteristics in its hardened state to provide good field performance. Because it is well understood that fibre reinforcement has little impact on strength parameters used in concrete mix design (compressive strength, flexural strength), the major modifications that need to be made for a given mix design, if any, focus predominantly on ensuring the proper workability and finish ability of the mix. The ACI Guide for Specifying, Proportioning, Mixing, Placing, and finishing of Fibre-reinforced Concrete does recommend that for mixes containing higher dosages of steel fibre reinforcement, an increased amount of fine aggregate may be needed to maintain a desired fine-to-coarse ratio, which ensures the proper workability, finish ability, and packing of the concrete matrix.

The guide also recommends limiting the dosages of fibre reinforcement used as the maximum coarse aggregate size increases. Traditional methods for improving workability can also be used in HFRC mix design. Pozzolans can be used in HFRC to improve workability as well as durability in the same manner they are implemented in typical concrete designs. Various low- to high-range water reducers, as well as 27 air entrainments, may also be used in FRC, but the dosages necessary to produce the desired slump and air content value can vary significantly.

4. Effects on hardened concrete properties

When modern fibre reinforced concrete research began, many believed fibre reinforced concrete would be able to improve every aspect of concrete performance. Over the years, this has not been found to be true. In actuality, fibre reinforcement has been found to have little or no effect on the static properties of concrete. What fibre reinforcement does improve is the dynamic performance of concrete (fatigue, impact) and the post-cracking behaviour of concrete by improving toughness and controlling crack widths. The following sections will discuss these various hardened HFRC properties in more detail.

A. Compressive Strength

The compressive strength of hybrid fibre-reinforced concrete has been well documented, because no matter which aspect of concrete research is being conducted, the compressive strength is a parameter that is often related to the characteristics being investigated. There is a significant amount of data to show that the compressive strength of fibre-reinforced concrete will not vary significantly from the compressive strength of the same mix design without fibres. At best there may be a slight gain of ultimate compressive strength ranging from 0 to 15 percent when up to 1.5 percent by volume fibre reinforcement is used (ACI

Committee 544 1997). This slight improvement can be attributed to the hybrid fibres controlling crack propagation at the micro structural level, but there is too much variation to take advantage of any strength gains.

B. Tensile Strength

While there is a general consensus regarding the effects of fibre reinforcement on compressive strength, the effects of fibre reinforcement on tensile strength are ambiguous. Most feel that fibre reinforcement in general will only impact concrete performance once cracking has been initiated and thus will not have any impact on tensile strength in concrete. On the other hand, there has been research showing up to an 80 percent gain in tensile strength. Most likely this phenomenon can be attributed to the higher dosages (2 percent by volume) that were used, which were able to control micro-crack propagation by providing load transfer over the cracks.

C. Flexural Strength

There is no consensus regarding the effect of fibre reinforcement on flexural strength. As with tensile strength, higher dosages of fibre reinforcement will control crack widths and improve load transfer across cracks to give an apparent increase in flexural strength by redistributing stresses. Data recorded in the 1960s and 1970s showed anywhere from a 50 to 70 percent increase in flexural capacity in FRC when compared to plain concrete in 3-point flexure tests. In reality, this is an improvement in the ductile response of concrete, not flexural strength. Tests using low dosages of fibre reinforcement show that there are no significant gains in flexural strength in FRC compared to plain concrete. Other research also supports the claim that fibre reinforcement, even at higher dosages, does not actually improve the true flexural strength of plain concrete. This is why understanding the post-cracking flexural behavior of FRC in terms of flexural toughness is much more useful than attempting to determine the flexural strength performance of FRC.

D. Flexural Toughness

Flexural toughness is the primary parameter used to quantify the improvements that fibre reinforcing imparts on plain concrete. Toughness describes the post-cracking behavior of concrete in flexure through interpretation of the load-deflection plot at a prescribed mid-span deflection. There are various methodologies for interpreting the load-deflection plot to quantify toughness. Toughness is described through toughness indices (I) and residual strength factors (R). Toughness indices compare the area under the load-deflection curve at various multiples past first-crack formation to the area under the load-deflection curve up to first crack.

The residual strength factors describe the difference in toughness indices to better understand the post-crack behaviour. Toughness (T) is the area under the load-deflection plot up to prescribed mid-span deflections that are based on a certain fraction of the specimen length. This technique is dependent on specimen geometry, so toughness factors (F) were developed to better interpret toughness independent of specimen geometry. It has been well documented that all fibre types at dosage rates greater than 0.25 percent by volume will improve toughness and enable concrete to carry loads well after cracking has began. For any fibre type, toughness will be increased as the dosage is increased. At higher fibre dosages, a greater percentage of the peak load can be sustained after initial crack formation when compared to lower fibre dosages of the same type. A larger area under the load-deflection curve is obtained, which leads to higher values of calculated toughness.

The stiffness of the fibre used will also have a significant impact on the toughness of the concrete. Essential to improving toughness is improving ductility and eliminating the sudden fracture normally experienced by brittle materials. In FRC, this is achieved through a gradual pulling out of individual fibres as deformations increase until failure is eventually reached. Fracturing of individual fibres is not desired and will lead to a more brittle failure of the concrete. This is more difficult to achieve than it may seem, because if the bond between the fibres and matrix is too weak, the fibres will pull out too rapidly and the concrete will not obtain desired ductility and toughness. On the other hand, if the bond between the fibres and matrix is too great, the fibres will fracture and lead to undesirable brittle failure. Typically, as long as the fibre pulls out before critical stresses are experienced in the fibre, good ductility and toughness will be observed.

5. Effect of fibres in concrete

Fibres are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower 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 cannot 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 (V_f). V_f typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fibre length (l) by its diameter (d). If the elasticity of modulus 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 which are too long tend to “ball” in the mix and create workability problems. Some recent research indicated that using fibres in concrete has limited effect on the impact resistance of concrete materials.

6. Experimental investigation

This report presents the experimental investigation carried out on the test specimen to study the strength related properties and characteristics of concrete containing glass fibre and coir fibre.

The experimental test for strength properties of concrete are compressive strength, split tensile strength and flexural strength. Based on the test procedure given in IS 516-1959 code, tests were conducted on specimens. Then for the optimum mix, flexural tests were conducted.

A. *Design stipulation for m_{20} grade concrete*

1. Characteristic compressive strength Required in the field at 28 days = 20N/mm^2
2. Maximum size of aggregate = 20mm
3. Degree of quality control = Good
4. Type of exposure = Moderate
5. Cement used Ordinary Portland Cement of 53 grade
6. Specific gravity of cement = 3.15
7. Specific gravity of aggregate
8. Specific gravity of coarse aggregate = 2.86
9. Specific gravity of fine aggregate = 2.75

B. *Mix design*

1. Target Strength for Mix Proportioning Fck = fck + 1.65×s
   Fck = Target average compressive strength at 28 days
   fck = Characteristic compressive strength at 28 days

   S = standard deviation = 4Mpa
   Therefore, Target strength = 20+1.65×4 = 26.6Mpa
2. Selection of Water-Cement Ratio
   From table of IS 456, Maximum water-cement ratio = 0.55

3. Selection of Water Content
   From table of IS 10262-2009 maximum water content for 20mm aggregate = 186 litre (for 25 to 50mm slump range).
   Estimated water content for 186+(186×0.235) = 229.8 litres

4. Calculation of Water Content W/C ratio =0.5
   Cement content =192/0.5 = 383.0Kg/m3
   As per IS 456, minimum cement content =300kg/m^3
   469Kg/m^3>300Kg/m^3
   Hence OK.

5. Proportion of Volume Coarse Aggregate and Fine Aggregate
   From table, volume of coarse aggregate of 20mm and fine aggregate
   (zone III) = 0.64 for W/C ratio = 0.5
   volume of coarse aggregate = 0.537Kg/m^3
   volume of coarse aggregate = 1-0.537
   = 0.463Kg/m^3

6. Mix Calculation
   Volume of concrete = 1m^3
   Volume of cement = (mass/sp.gr) x(1/1000)
   = (383.16/3.15) x (1/1000)
   = 0.122 m^3
   Volume of water = (192/1) x (1/1000)
   = 0.192m^3
   Volume of all in agg = a-(b+c)
   =1-(0.122+0.192) d= 0.743m^3

Mass of coarse aggregate = d x volume of coarse aggregate x sp.gr x1000

= 0.743x0.6x2.86x1000
= 1275.39Kg

Mass of fine aggregate = d x volume of fine aggregate xsp.gr x1000

= 0.743x0.4x2.75x1000
= 639.61Kg

Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (kg)
383	639.61	1275	229.8
1	1.67	3.33	0.6

C. *Fiber content in concrete*

Three different volume fractions of fiber will added to concrete such as 0.5%, 1% and 1.5% by weight of cement.

Fiber content less than 0.5% doesn't have strength improvement and fiber content beyond 4% reduces the strength of concrete.

The mix proportion of coir and glass fibers such as follows.

% of fibre added in concrete	Mix	Glass fibers (%)	Coir fibers (%)
	CM	-	-
0.5%	G100C0	100	0
	G75C25	75	25
	G50C50	50	50

% of fiber added	Water (Kg/m^3)	Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	Coir fiber (Kg/m^3)	Glass fiber (Kg/m^3)
Control Mix	191.6	383	639.61	1275	-	-
0.5 %	191.6	383	639.61	1275	-	0.005
	191.6	383	639.61	1275	0.00125	0.00375
	191.6	383	639.61	1275	0.0025	0.0025
1.0 %	191.6	383	639.61	1275	-	0.01
	191.6	383	639.61	1275	0.0025	0.0075
	191.6	383	639.61	1275	0.005	0.005
1.5 %	191.6	383	639.61	1275	-	0.015
	191.6	383	639.61	1275	0.00375	0.01125
	191.6	383	639.61	1275	0.0075	0.0075

7. Casting and curing of test specimens

The test specimens were cast in cast iron steel moulds. The mould specimens were applied with oil in all inner surfaces for easy removal of specimens after demoulding. The raw materials used for making concrete are weighed with correct proportions. For obtaining more binding, initially cement, Glass fiber and treated coir fibers are mixed thoroughly in dry condition. Then sand is mixed thoroughly with the above mix. Then it is well mixed with the coarse aggregate. For addition of water, initially three fourth of the mix water is added to the dry mix material to mix thoroughly. After that remaining water is mixed at the frequent interval. Mixing was done up to the level of uniform workable concrete. The mixed concrete by mixer machine was placed in the moulds by three layers of equal heights which was vibrated to get a uniform concrete without any segregation. After 24 hours the specimens were de-moulded and placed into curing tank till age of testi\ng to be done.

A. *Details of test specimens*

In this study, totally four beams were cast, two control concrete beams and two hybrid fibre reinforced concrete beams of 1% fibre were added at the mix ratio of 75:25 (i.e., 75% Glass fibers and 25% Coir fibers) to the weight of concrete. The size of the beam is 1000mm x 100mm x 150mm.

B. *Reinforcement design details*

The reinforcement details were arrived by adopting IS 456 – 2000 design procedure. For main reinforcement 10mm dia. bars were used. In compression zone 8mmdia. bars were used. For shear reinforcement 6mm dia. bars were used. The reinforcement design details are given below.

Reinforcement details:
Dia. of rod at compression zone – 8mm
Dia. of rod at tension zone – 10 mm
Dia. of stirrups – 6 mm

8. Design of beam

Size of the beam = 100mm x 150mm

Grade of concrete	= M20
Grade of steel	= Fe415
B	= 100mm
D	= 150mm
Effective cover to reinforcement	= 25+10/2 = 30mm
Effective depth of beam	= 150 – 30 = 120mm

Assuming 2 nos of 10mm dia bar as main reinforcement
Ast = 2 x (π/4) x 10^2
= 157.07 mm^2

To determine the depth of neutral axis Xu/d = 0.87 fy Ast/0.36 fck bd

= 0.291

For Fe 415

Xumax/d = 0.48

Xumax/d > Xu/d

Hence the section is under reinforced Ultimate moment of resistance

Mu = 0.87 fy Ast d (1 – (fy Ast/fck bd))

= 0.87 x 415 x 157.07 x 120 (1- (415 x 157.07/20 x 100 x120))

= 6.1891 kNm

Bending moment = Wl/3

Load (W) = (6.1891 x 106 x 3)/1000 Load (W) = 18.567 kN.30 Check for shear

Total design load = 18.567 x 1.5 = 27.85 kN Nominal shear stress = 27851/ (100 x 120) = 2.321 N/mm^2

Area of tension steel Ast = 157.07 mm^2

Percentage of tension steel = 157.07 x 1000 / 100 x 120
= 1.309 %

Ʈc for 1.309% = 0.7518 N/mm2 Ʈcmax = 4.0 N/mm^2

Design of shear reinforcement

Vu = 27851

Vus = Vu – Ʈcbd

= 27851 – 0.7518 x 100 x 120

= 18829.4 N

For vertical stirrups of Fe 415

(Asv/Sv)min = Vus/(0.87 x fy x d) = 0.4345

Minimum shear reinforcement

(Asv/Sv)min = (0.4b/0.87fy) = (0.4 x 100/0.87 x 415)

= 0.11

Therefore, provide = (Asv/Sv) = 0.4345 Assume 6mm dia 2 legged stirrups

Asv = 2 x π/4 x 62 =56mm^2

Spacing Sv = 140 mm C/C

Therefore, provide 6mm dia 2 legged stirrups at 140mm C/C.

A. *Casting of beam specimens*

The beams were cast in structural engineering laboratory. The wooden beam mould of size 100mm X 150mm X 1000mm were used for casting of beam specimens. The mould surfaces are well oiled for better finishing and also for easy removal. In casting of beams, the raw materials are weighed with correct properties in weighing machine. 3 sample conventional concrete beams are casted and average results are taken. In upcoming days 3 beams of hybrid fiber reinforced concrete beams were to be examined.

9. Results

Compressive strength

Beam no.	Compressive Strength(Mpa)
1	22.34
2	23.41
3	21.90

Split tensile strength

Beam no.	Split tensile Strength(Mpa)
1	2.56
2	2.63
3	2.65

Flexural strength test

Beam no.	Flexural strength(Mpa)
1	3.86
2	3.69
3	3.75

10. Conclusion

- The sample conventional reinforced concrete beams were casted and tests are carried.
- Hybrid fiber reinforced concrete beams were to be casted and to be examined.

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