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Comparative Study of Steel, Bamboo and Glass Fiber as Reinforcing material in Concrete beams

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ABSTRACT Concrete is the most principally utilized material in the development field took after by steel as reinforcements. The present-day situation is seeing a quick change in the building material industry and step by step new innovations are supplanting the ordinarily utilized materials. Scientists everywhere throughout the world are endeavoring to enhance concrete by the utilization of fibers, pozzolanas and different admixtures. Steel is given in the pressure side fundamentally in order to balance the powerless zone of concrete that is Tension. In spite of the fact that it is thought to be the best for this work yet at the same time it gets eroded by the activity of the nature in this way, emerges the point of searching for an option. A standout amongst the most well-known choices is Fiber strengthened polymer rebars (FRP's). In the present trial examination supplanting of Ordinary Concrete with Glass fiber and bamboo fiber Reinforced Concrete along these lines considered on the progressions of Compressive Strength and Ultimate Crushing loads.

This study comparatively evaluated the flexural performance and deformation characteristics of concrete elements reinforced with bamboo (*Bambusa vulgaris*), Glass fiber and the twisted steel rebars. The yield strength (YS), ultimate tensile strength (UTS) and the elongation of 9 specimens of the three materials were determined using a universal testing machine. These beams of concrete strength 25 N/mm^2 at age 7, 14 and 28 days were separately reinforced with bamboo, glass fiber and steel bars of same percentage, while the stirrups were essentially mild steel bars. It is Determined that out of three which material sample is suitable rebars for non-load bearing and lightweight RC flexural structures also bonding and load-carrying capacity.

Keywords: Flexural, UTM, Tensile strength, Bamboo, Fiber, loading, flexural strength.

I.BACKGROUND

Reinforced Concrete (RC) structures represent dominant part of the developed infrastructures universally and their execution is significantly impacted by the properties of the fortifying bars. The exchange of stress from cement to steel is made conceivable through competent bond amongst concrete and the fortification.

Past investigations on the substance, physical and quality attributes of steel fortifying materials uncovered the risks of boosting benefit to the detriment of value, a circumstance that represent a noteworthy test to the basic dependability and strength of structures and common framework. Albeit broad examinations have been completed on manufactured and characteristic non-ferrous fortifying materials in the previous decades, common support still remains a dynamic field of further examination.

In this thesis work R-C beam main support bar is supplanted with some reusing rigidity producing materials like strengthened with Glass fiber, bamboo fiber and a mix of both, preparing a correlation with fortified shaft. The physical and rigidity properties of glass fiber, bamboo fibre and rebar were first decided and the flexural limits of solid pillars strengthened with the individual materials bars were assessed. The breaking points of utilization of bamboo and glass fiber bars as fortification were built up regarding the Rebar RC shafts.

II.BEAM STRENGTHENING

Early endeavors for understanding the reaction of plain cement subjected to unadulterated torsion uncovered that the material bombs in pressure instead of shear. Structured members curved in design, members from a space outline, capriciously stacked bars, bended box braces in spans, spandrel shafts in structures, and winding stair-cases are average cases of the auxiliary components subjected to torsion minutes and torsion can't be disregarded while planning such individuals. Auxiliary individuals subjected to torsion are of various shapes, for example, T- shape, transformed L– shape, twofold T-shapes and box segments. These distinctive arrangements make the comprehension of torsion in RC individuals from complex errand. Moreover, torsion is typically connected with bending moments and shearing forces, and the communication among these forces is imperative. In this way, the conduct of solid components in torsion is principally administered by the ductile reaction of the material, especially its

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pliable breaking

qualities. Spandrel pillars, situated at the edge of structures, convey loads from pieces, joists, and shafts from one side of the part as it were. This stacking component produces torsional powers that are exchanged from the spandrel pillars to the segments. Fortified cement (RC) bars have been observed to be lacking in torsional limit and needing reinforcing. These lacks happen for a few reasons, for example, deficient stirrups coming about because of development blunders or insufficient outline, diminishment in the powerful steel zone because of consumption, or expanded request because of an adjustment in inhabitance. Likethe flexure and shear reinforcing, the FRP texture is attached to the strain surface ofthe RC individuals for torsion fortifying. On account of torsion, all sides of the part are subjected to slanting pressure and in this way the FRP sheets ought to be connected to every one of the characteristics of the part cross segment. Be that as it may, it isn't generally conceivable to give outside support to every one of the surfaces of the part cross segment. In instances of distant sides of the cross segment, extra methods for fortifying must be given to set up the sufficient component required to oppose the torsion. The viability of different wrappingsetups demonstrated that the completely wrapped shafts performed superior toutilizing FRP in strips.

Glass Fiber:

Glass fiber has generally similar mechanical properties to different strands, for example, polymers and carbon fiber. Despite the fact, it's not as solid or as unbending as carbon fiber, it is considerably less expensive and fundamentally less weak when utilized as a part of composites. Glass strands are consequently utilized as a strengthening specialist for some polymer items; to shape an exceptionally solid and generally lightweight fiber-fortified polymer (FRP) composite material called glass-strengthened plastic (GRP), additionally prominently known as "fiberglass".

Glass fiber properties

1. Glass fibers are most commonly used fibers. They come in two forms: –
2. Continuous fibers
3. Discontinuous fibers

- **Principal advantages: –**

1. Low-cost
2. High strength
3. Impact resistance
4. Moisture resistance
5. Good chemical resistance
6. High thermal expansion
7. High bonding strength
8. Readily processed by thermoplastic

Fig:1 Glass fiber

Bamboo fiber:

BAMBOO is one of the most seasoned building materials utilized by humanity.The bamboo culm, or stem, has been made into an expanded decent variety of items extending from residential family unit items to mechanical applications. In Asia, bamboo is very basic for extensions, platform and lodging, yet it is generally an impermanent outside basic material. In numerous excessively populated districts of the tropics, certain bamboos supply the one appropriate material that is adequately shabby and abundant to meet the broad requirement for conservative lodging, a report by. With the headway of science and innovation and the great supply of

timber, new strategies are required for the preparing of bamboo to make it sturdier and more usable as far as building materials.

Fig:2 Bamboo fiber

RC- Beam:

(RC) is a composite material in which concrete moderately low rigidity and flexibility are balanced by the consideration of fortification having higher elasticity or

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pliability. The support is as a rule, however not really, steel fortifying bars (rebar) and is generally implanted inactively in the solid before the solid sets.

It ought to be fit for opposing expected tractable, compressive, bowing and shearforces.

It ought not demonstrate exorbitant redirection and ruin usefulness necessity.

There ought to be appropriate cover to the fortification, with the goal that theerosion is anticipated.

The hair breaks created ought to be inside as far as possible.

It is a decent heat proof material.

When it is new, it can be formed to any coveted shape and size.

Durability is very good.

R.C.C. structure can be intended to take any heap

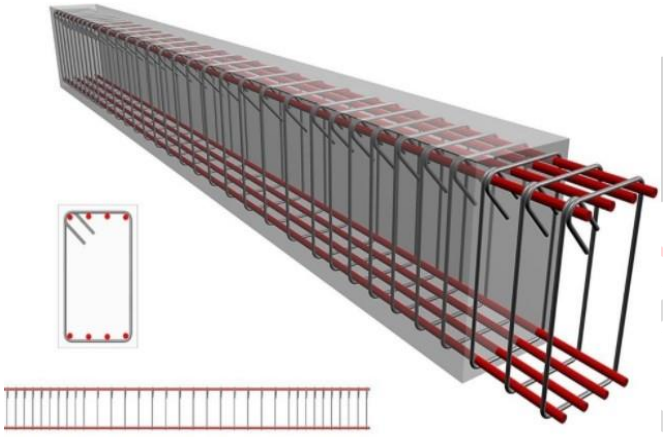

Fig:3 R-C-C Beam

Stresses in Beam:

loads acting transversely to the longitudinal pivot the heaps make shear powers and bowing minutes, stresses and strains because of V and M are examined in this section horizontal burdens following up on a bar make the pillar twist, along these lines misshaping the hub of the bar into bend line, this is known as the diversion bend of the bar the shafts are thought to be symmetric about x-y plane, i.e. y-hub is a hub of symmetric of the cross segment, all heaps are accepted to act in the x-y plane, at that point the bowing redirection happens in a similar plane, it is known as the plane of twisting the avoidance of the bar is the relocation of that point from its unique position, estimated in y direction

III.METHODOLOGY & MATERIAL SELECTION

General

The agenda behind the present research work is to consider the impact of fiber strengthened pillar on the shear limit of the RC shafts under static stacking conditions. In this test program a sum of four quantities of bars is thrown and tried. The pillars are gathered by its material as a support.

The physical and rigidity properties of steel, bamboo and blend of glass and bamboo fiber were resolved tentatively utilizing a 600 kN limit widespread testing machine (UTM)

Ordinary Portland concrete was utilized. The totals which involve waterway sand and pulverized stone of 20 mm most extreme ostensible size was utilized.

Mixed at a water-concrete proportion of 0.45.

Twelve 150 × 150 × 900 mm solid shaft examples were delivered and assembled into three.

In rebar case 10φ4 bars and stirrups were 10φ8 mm steel bars separated at 100 mm focus and the ostensible cover was 25 mm.

In Glass fiber case Glass fiber is utilized as much A.s.t is required and stirrups were 10φ8 mm steel bars separated at 100 mm focus and the ostensible cover was 25 mm.

In Bamboo fiber case Bamboo fiber is utilized as much A.s.t is required and stirrups were 10φ8 mm steel bars separated at 100 mm focus and the ostensible cover was 25 mm.

In instance of blend test of both half of every material is taken according to required Ast%.

Material used in the study:

CEMENT: Cement is a fastener material that sets and solidifies and can tie extra material commonly .in this task we apply conventional Portland concrete grade of concrete is 43. Portland bond is by away the most widely recognized sort of concrete all in all utilization around the globe. This concrete is made by warming limestone (calcium carbonate) with other material argillaceous stone e.i. earth to around 15000c in the turning furnace, in a procedure known as calcination. The subsequent item is known as bond clinker when is as little balls or pellets of shifting size. The clinkers are cooled in a revolving cooler and pummeled together with 2-3% gypsum in crushing machine. The subsequent powder is called Portland concrete which is filled in hermetically sealed packs to reject dampness.

SETTING AND HARDENING OF CEMENT-

At the point when concrete is blended with water, different hydrations and hydrolyses responses of constituent mixes occur. The compound of the products results in charge of setting and steady solidification.

The process of solidification of cement consists of focusing three steps :-

1. INITIAL SETTING
2. FINAL SSETTING

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3. HARDENING

The chemical composition of cement is as below: -

S.NO.	NAME OF CONSTIUENTS	CHEMICAL FORMULA	ȣBREVIATION
1.	Di calcium Silicate	$2CaO.SiO_2$	C_2S
2.	Tri calcium Silicate	$3CaO.SiO_2$	C_2S
3.	Tri calcium Aluminates	$3CaO.Al_2O_3$	C_3A
4.	Tetra Aluminous ferrite	$4CaO.Al_2O_3.Fe_2O_3$	C_4AF

Table:1 cement property

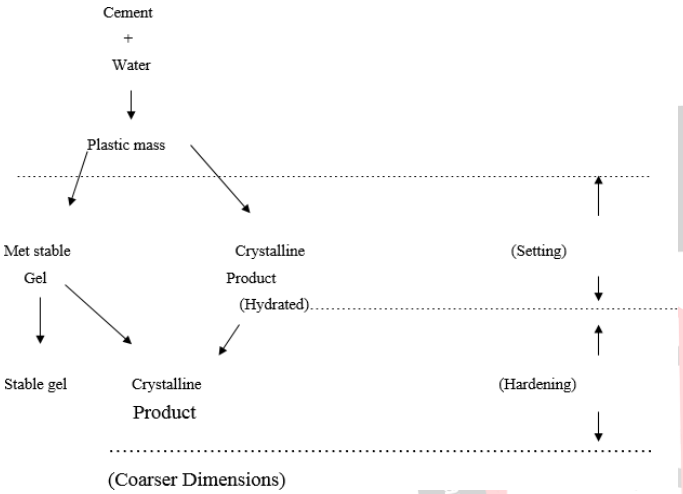

Fig:4 representing flow diagram of setting and hardening

COARSE AGGREGATES

Coarse aggregates are the very most important construction material which is used to making concrete mixture. coarse aggregates are the produced by crushing the stone at stone quarry .in this project we have taken easily available coarse aggregate the size of aggregates are the 20mm which has angular shape and size. coarse aggregates are bind together with other material properly to making higher strength.

Types of aggregates-according to their shapes: -

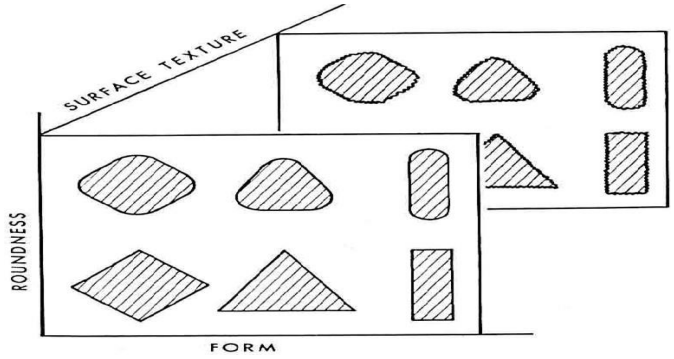

Fig:5 Represent the shape of aggregate

ROUNDED-Fully harmed or totally formed by disintegration. cases waterway or ocean shore rock desert, ocean shore and windblown sands.

IRREGULAR - normally uneven or somewhat molded by whittling down, having adjusted edges. illustration pit sands and rock, land or burrowed stones, cuboid shake.

ANGULAR-having unmistakable edges molded at the crossing point of generally planar countenances. illustrations pulverized rocks of numerous types

FLAKY-material generally precise of which the thickness is little with respect to the width and length-case – covered rocks

SAND

Sand is the general term for the broken-down granules of stone. Sand is very smaller than gravel, but larger than silt or clay. Sand is the key ingredient in all good for construction. Fine aggregate or sand: Aggregates passing No.4 (4.75 mm) sieve and predominately retained on the No. 200 (75 μm) sieve.

Sand Types: -

Natural Sand: Natural sand has eroded from mountain rock and is mined from somewhere it was deposited. The host rock determines the accurate mineral composition, however most sand is composed of silica, from wrecked down quartz crystals. This type of sand is tremendously resistant to weathering and breakdown due to its chemical hardness. These hard sand particles have been transported and tumbled with water, and the time spent tumbling determines an angular or encircling grain shape.

Artificial Sand: Shake quarries pound shake into different sizes, and the insignificant particles are known as "fines" and sold as fake Sand, Man-made Sand, Crusher Fines, or Stone Dust. These particles assortment from 5 mm to fine powder, are sharp and will solidly minimized if utilized alone. The mineral pieces would variety be able to broadly, and these particles are not the strong "existing" quartz grains of tumbling waterway activity, so they might be gentler and separate to clean, sooner.

Glass fiber:

This type of glass fiber is especially reasonable for high quality, low weight covers. Consistent fiber glass is favored in these applications by virtue of it's more prominent quality and low mass factor. The fabric woven from ceaseless fiber yarn extends in thickness from 0.002-0.02 inches. All in all directional properties of overlays rely upon the kind of weave and component setting utilized.The case of texture fortified plastic is aircraft radar. In this application, a material is required which will permit the radar beams to abandon twisting from the beams sending hardware out of the objective and after that back to the radar getting gear on the plane. It should likewise stand the gaseous tension strain of a sonic or supersonic speed. Blend of glass texture and low-weight plastic pitch gives a

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magnificent response to these prerequisites.

Mix of glass textures and insulated polyester pitch are additionally utilized for making high quality level and formed covers for flying machine segments, for example, a ducting, boards, nose, wings tips, rudder parts, covers, dash-loads up, racks, floors

This material is additionally utilized for empty angling poles, where unidirectional texture fits twisting cycle a strong mandrel, for body protective layer and for the fabricate of extensive article, for example, pontoons by the low weight procedure and for some different items.

Bamboo fiber

Bamboo fiber is a recouped cellulosic fiber made from bamboo. Flat crush is conveyed from bamboo stems and leaves through a system of soluble hydrolysis and multi-arrange blurring. Propel concoction techniques convey bamboo fiber.

Rehashed innovative examination has demonstrated that this sort of fiber has a slenderness degree and whiteness degree near typical finely faded thick and has a solid strength, security and relentlessness. Bamboo fiber texture is made of 100% bamboo mash fiber. It is portrayed by its great hygroscopicity, astounding penetrability, delicate feel, effectiveness to rectify and color and astonishing shading impact of pigmentation.

Concrete: -

Preparation of concrete starts with mixing of organic material namely cements with water along with either dust of stones or sand along with standard stones in any form whether uncrushed or crushed. The reaction occurs when cement is added to the water resulting in formation of artificial plastic stone or a solid mass.

Standard Mix design of concrete

Mix design is a process by which find out the mixture of ingredients which is mix mutually to make the concrete such that we get properties of concrete or presentation of concrete according to certain specifications

Is 456-2000 has designated the concrete mixes keen on a number of grades of concrete as M10, M15, M20, M25, M30, M35 and M40. In that assignment the letter M alludes to the blend and number to be determined 28 days 3D square quality to blend in N/mm2.the blends of evaluations M10, M15, M20 and M25 stay in contact going to the blend extents (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) separately.

Compressive Strength

It is one of the most critical properties of concrete and impacts numerous other describable of the toughened concrete. The normal compressive quality basic at a particular age, by and large 28 days, finishes up the ostensible water bond proportion of the blend. The extra factor influencing the quality of concrete at a known age and cured at a recommended temperature is the measure of compaction. As indicated by Abraham's law the quality of totally packed concrete is contrarily relative to the water concrete proportion.

Workability

The level of workability fundamental relies upon three elements. These are size of the area to be cemented, the measure of support, and technique for compaction to be utilized. for the thin and troublesome segment with a few corners or in available parts, the solid have a high workability so that possessed compaction can be accomplished with a sensible measure of exertion. this likewise apply toward the settled steel areas. The coveted workability relies upon compacting accessible at the site.

Durability

The durability of concrete is its confrontation to aggressive environmental situation. high strength concrete is generally more durable than concrete of low strength. in the situations when the high strength is not essential but the conditions of exposure are such that high strength is vital, the durability requirement will establish the water cement ratio to be used.

Quality Control

The degree of control can be predictable statically by the differences in test result. The in-strength results from the differences in the properties of the mixing gradients and be short of control of exactness in batching, mixing, placing, curing and testing. The lower the dissimilarity between the signify and minimum strengths of the mix lesser will be the cement content necessary. The factor scheming this difference is termed as quality control.

EXPERIMENTAL WORK

Sample Preparation

Samples are prepared in a test laboratory, where all materials are mixed in a proper proportion. After wards beams are casted in 150 × 150 × 900 mm specimens considering stirrups of mild steel fe250 whereas main reinforcement is selected as glass fiber, bamboo fiber, rebar and a composite of glass and bamboo fiber.

EXPERIMENTAL WORK (table for percentage of material added) Table 2: Percentage of fiber replacing cement

Percentage of composite material added			
S.no.	Material	% (by weight)	Replacing
1	Glass fiber	5 %	Cement
2	Bamboo fiber	5 %	Cement
3	Glass fiber + Bamboo fiber	2.5% both	Cement

Universal Testing Machine:

The pliable test is led on UTM. It is using pressurized water works a pump, oil in oil sump, stack dial marker and focal

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catches. The left has upper, center and lower cross heads i.e; example holds (or jaws). Sit still cross head can be climbed and down for alteration. The channels interfacing the lift and right parts are oil pipes through which the drew oil under strain streams on left parts to progressively the cross-heads.

TEST PROCEDURE STEPS: -

The heap pointer is set at zero by altering the underlying setting handle.

The dial gauge is settled and the example for estimating lengthening of little sums.

Estimating the distance across of the test piece by vernier caliper at any rate at three places and decide the mean esteem likewise check the measure length.

Presently the example is grasped amongst upper and center cross head jaws of the m/c.

Set the programmed diagram recording framework.

Begin the m/c and take the perusing.

The example is stacked bit by bit and the prolongation is noted until the point that theexample breaks.

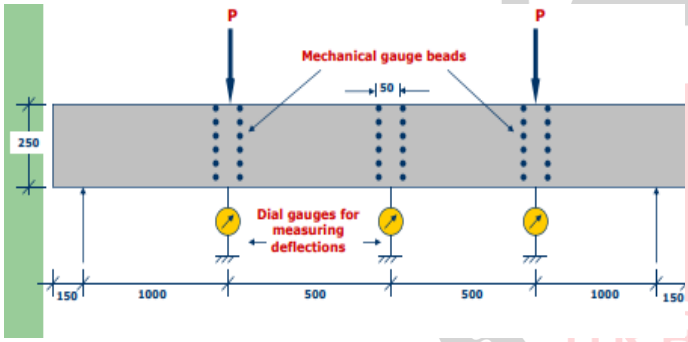

Fig:6 UTM setup

Fig:7 Arrangement of test

IMPACT TEST ON COARSE AGGREGATES BY IMPACT TESTINGMACHINE

Firstly, collect the sample of locally available coarse aggregate of size 20mm.

This aggregate passed from 12.5mm IS sieve and retained by 10mm IS sieve. the weight of material which is passed by 12.5mm sieve and retained 10mm sieve is W_1 350gm i.e. W_1

The cup of impact testing machine fixed in lower end properly.

the cup is filled with this aggregate in three layers by proper tamping with tampingrod.

After placing sample 25 strokes should be applying.

The sample is passed by IS sieve of 2.36mm.

The sieved material weighed the weight of material is123gm. i.e. W_2

RESULTS & DISCUSSION

TEST RESULTS: FOR 7 DAYS

Table3: Failure loads for beam

Beam	First crack load, Fc (KN)	Ultimate load failure, Fu (KN)	Fc/Fu	Flexural Strength (N/mm2)
R/f beam	19	33	0.57	12.1
glass fiber beam	12	18	0.67	6.4
bamboo beam	7	7.5	0.933	3.21
Glass & Bamboo fiber mix	9.8	12	0.73	5.45

Table4: Failure mode and crack characteristics

Beam no.	mode of failure	type of crack at failure	experimental min. crack width
R/f beam	Shear	Diagonal	9.1
glass fiber beam	Flexural	Vertical	6.4
bamboo beam	Shear	Vertical	7.2
Glass & Bamboo fiber mix	Shear	Diagonal	6.1

TEST RESULTS: FOR 14 DAYS

Table 5: Failure loads for beam:

Beam no.	ack load,Fc (KN)	Ultimate load failure,Fu (KN)	Fc/Fu	Flexural Strength (N/mm^2)
R/f beam	20.5	33.8	0.606	12.6
glass fiberbeam	13.2	18.7	0.705	6.8
bamboobeam	7.6	8	0.95	3.89
Glass & Bamboo fibermix	10.7	13.6	0.82	5.4

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Table 6: Failure mode and crack characteristics

Beam no.	mode of failure	type of crack at failure	experimental min. crack width
R/f beam	Shear	Diagonal	8.7
glass fiber beam	flexural	Vertical	6.3
bamboo beam	Shear	Vertical	6.9
Glass & Bamboo fiber mix	Shear	Diagonal	6.10

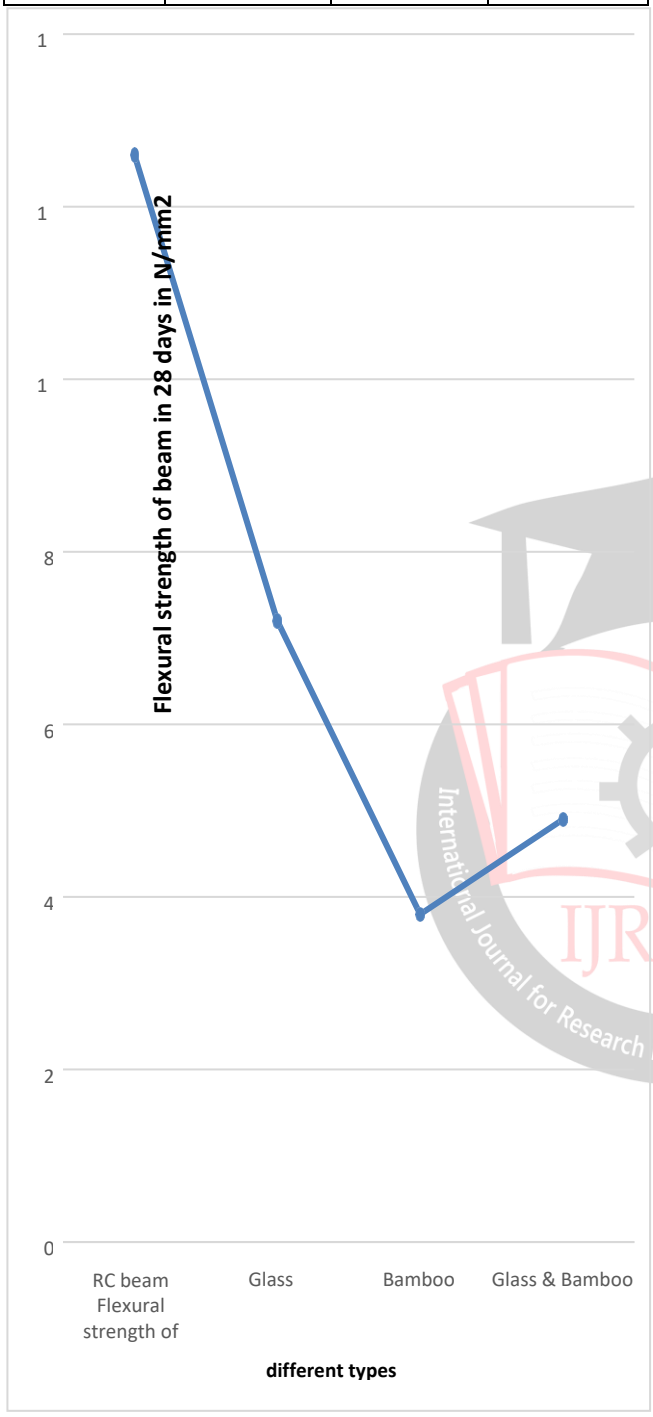

Fig: 9: Flexural strength 14 days

TEST RESULTS: FOR 28 DAYS

Table 7: Failure loads for beam:

Beam no.	First crack load, Fc (KN)	Ultimate load failure, Fu (KN)	Fc/Fu	Flexural Strength (N/mm^2)
R/f beam	22.4	33.8	0.662	13.8
glass fiber beam	14.3	18.7	0.764	7.4
bamboo beam	8.4	8	1.05	4.32
Glass & Bamboo fiber mix	11.5	14.65	0.86	5.65

Table 8: Failure mode and crack characteristics

Beam no.	mode of failure	type of crack at failure	experimental min. crack width
R/f beam	Shear	Diagonal	8.5
glass fiber beam	Flexural	Vertical	6.15
bamboo beam	Shear	Vertical	6.8
Glass & Bamboo fiber mix	Shear	Diagonal	6.35

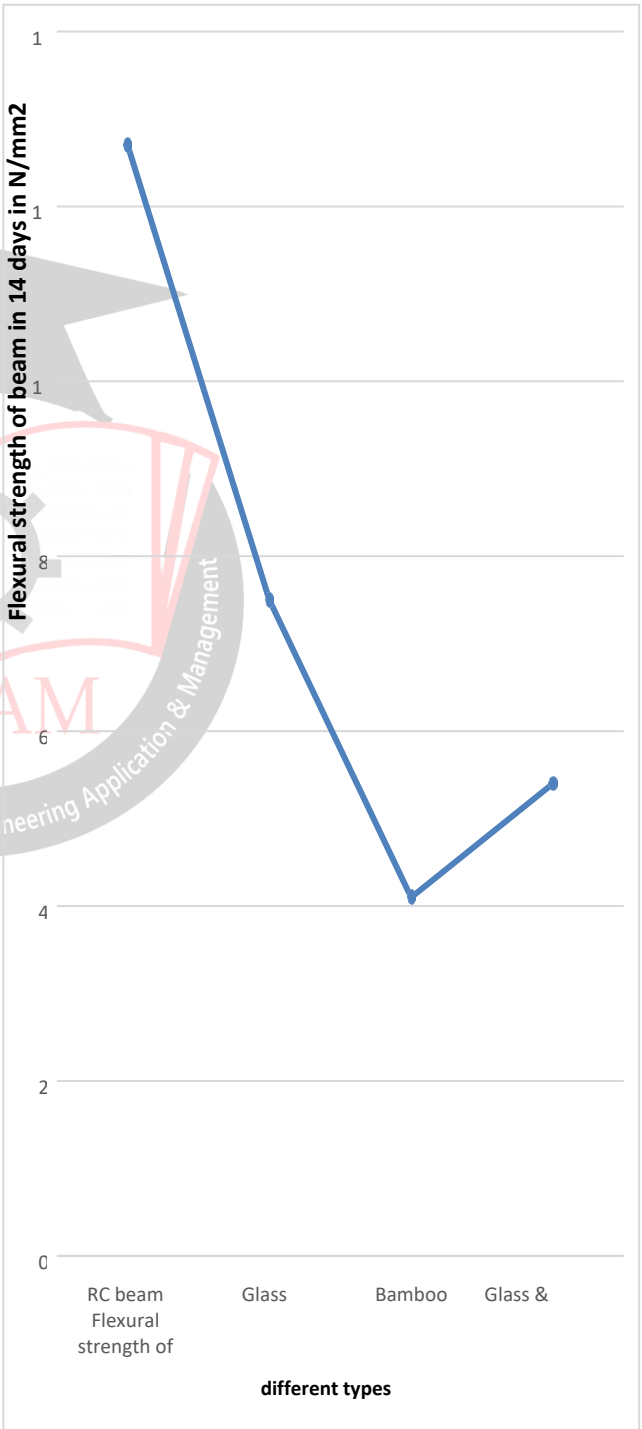

Fig: 10: Flexural strength 28 days

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IMPACT TEST RESULTS

Table 9: Impact test values

Aggregate size (mm)	Weight of sample beforetesting(kg)	Weight of sample aftertesting(kg)	Loss in weight (kg)
In between 10mm to 12.mm	3.50	1.23	2.27

In this experiment the sample of aggregate is taken of 3.50kg after placing in impact testing mould and testing the sample weight reduces to 1.23kg and the loss of weight is taking place 2.27 kg from calculation the value of impact in percentage is 35. Thisis suitable.

FLAKINESS INDEX TEST

Table 10: Flakiness and elongation index

egate inmm					
Passing ThroughIS Sieve	Retained on IS sieve	Corresponding Thickness Gauge	Weight of Aggregate Passing through Thickness Gauge gm	Weight of aggregates passing through thickness gauge gm	Corresponding length gauge size mm
1	2	3	4 Determination	5 Determination	6
20mm	16mm	10.8mm	68	50	32.4
16mm	12.5mm	8.55mm	242	35	25.6
12.5mm	10mm	6.75mm	80	60	20.2
10mm	6.5mm	4.89mm	28	30	14.4
Average total of col. 4 and 5			418	175	

Percentage of retained flaky material=36.34% Percentage of retained elongated material=15%

EXPERIMENT ON CEMENT

Ordinary Portland cement (Grade-43) BIRLA GOLD was used and conforms to IS 8112-1989.Its physical properties are as given in Table-

Table 11: Properties of Cement

S. No.	Physical property	Results obtained	IS: 8112-1989 Specification
1	Fineness (retained on 90-pm sieve)	9.00%	
2	Normal Consistency	30%	
3	Vicat initial setting time	90 Min.	30 Min.(Minimum)
4	Vicat final setting time	300 Min.	600 Min.
5	Compressive Strength 3-days (MPa)	22 MPa	22 MPa
6	Compressive Strength 7-days (MPa)	35 MPa	33 MPa
7	Compressive Strength 28-days (MPa)	43 MPa	43 MPa
8	Specific Gravity	3.14	

Determination of Initial Setting time -

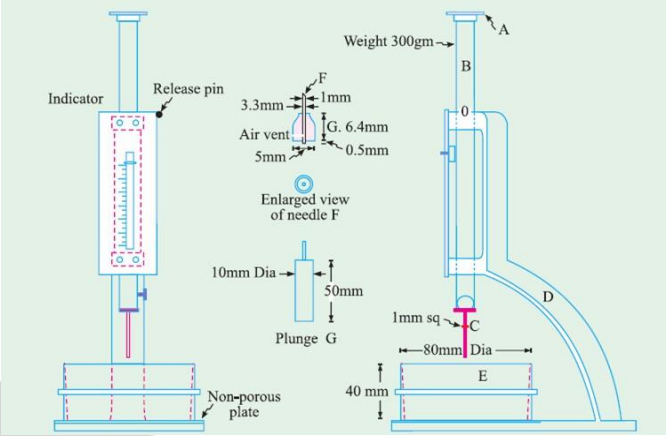

Fig. 11: Vicat apparatus

Determination of initial setting time

Table 12: Represent the values of initial setting time

Sr. No.	Setting Time(Sec)	Penetration(mm)
1.	300	0
2.	600	1
3	900	2.3
4	1200	3.3
5	1500	3.8
6	1800	4.6

III. CONCLUSIONS

The following observation we did in laboratory and prepared a comparative study, and concluded that R.C.C. beam is comparatively more stable in load resisting but in comparison we can also prefer glass fiber or Glass fiber and bamboo fiber mix one as depends on load resisting requirements, following are the conclusions mentions below as per results find out in 7-day, 14 day and 28 days sample:

1. The tensile properties of the three reinforcing materials are normally distributed and their stress ratios satisfied the minimum requirement value of 1.08. The strength of Glass fiber and bamboo represented 45% and 17% of that of steel reinforcing bars respectively.
2. The elongation of bamboo did not meet the ductility requirements of 12%, glass fiber marginally satisfied this, but steel rebars fully met the requirements.

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3. Bamboo and glass fiber can only be used for lightweight RC structures. The flexural stiffness of bamboo and glass fiber RC beams was about 13.5% and 33% respectively of the conventional steel bars RC beams.
4. The first cracking loads of bamboo and glass fiber RC beams were 31% and 55% respectively of the conventional steel RC beams. The experimental ultimate failure loads of bamboo and glass fiber RC beams were 21% and 48% respectively of the conventional steel RC beams.
5. Bamboo and steel RC beams had 40% residual capacity after the first crack, while glass fiber RC beams had exhausted 75% of its load-carrying capacity after the first crack.
6. The mode of failure for bamboo and steel RC beams was shear, indicated by diagonal cracks because of the short-span specimen adopted and the relatively higher tensile strength than the glass fiber RC beams which failed by flexure(vertical cracks).

Future Scope

a. In this study bamboo and glass fiber is taken in future other recycling materialscan be selected.

b. In future we can consider finite element analysis of these beams using analysistools.

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