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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/mm2 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. INTRODUCTION

The general practical monetary development, efficiency, and the prosperity of a country depend vigorously on the usefulness, unwavering quality, and sturdiness of its built offices. Be that as it may, aside the natural and operational condition, the constituent materials representing the expanding instances of basic insufficiency and practical outdated nature are recorded in the constructed environment.

Weakening in solid structures is a noteworthy test looked by the framework and scaffold ventures around the world. The decay is fundamentally because of natural impacts, which incorporates consumption of steel, progressive loss of quality with maturing, rehashed high force stacking, temperature variation, solidification of defrost cycles, contact with synthetic concoctions and saline water and introduction to ultra-violet radiations. This issue, combined with amendments in basic codes expected to represent the characteristic marvels like seismic tremors or natural weakening powers, requests improvement of fruitful basic retrofit innovations. The auxiliary retrofit issue has two alternatives, repair/retrofit or devastation/remaking. Generally, the pattern inside the US development ventures has been towards the last alternative. This arrangement has turned out to be progressively unsuitable because of changing financial and social states of mind concerning existing structures. This reality prompts the need for advancement of proper auxiliary retrofit/repair frameworks.

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, bamboofibre 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.

Fiber:

Glass fiber has generally similar mechanical properties to different strands, for example, polymers and carbon fiber. Despite the fact, its 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".

Fig 1: 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 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.

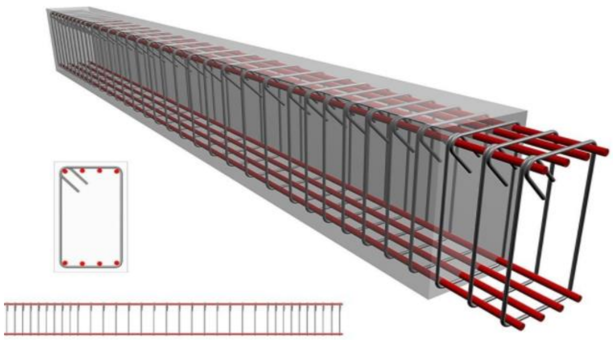

Fig 2: RC beam

Objectives

1. To determine the flexural properties of R.C.C beam using different composite materials as an replacement of main reinforcement in a beam.
2. To determine the variation in strength developed due to glass fiber, bamboo fiber as a main reinforcement in a beam.
3. To determine the cost effectiveness of these materials in an R.C.C. beam.
4. To justify the use of these waste materials in construction industry.

II. LITERATURE REVIEW

Chand et. al. (2017) Established that the Tensile quality of bamboo has been tentatively decided parallel and opposite to the fiber course. Distinctive properties are shown in two ways in bamboo because of the essential basic contrast introduce in the two bearings. Striking contrasts exist in the appropriation of cells inside one culm, both evenly and vertically. Anxiety estimations of bamboo under elastic burdens are additionally dictated by utilizing the Finite Element Method (FEM) programming ABAQUS and the disappointment stack designs have been created and analyzed. Flexural quality and redirection in bamboo decided tentatively matches intimately with the FEM produced values.

Nigarwal et. al. (2016) Arranged a relative report between the DC network conduct of bamboo fiber gathered from upper and base part of bamboo, arranged a hypothesis diagram confirmed with the exploratory outcomes.

Akinyele et. al. (2015) Discovered that the interfacial bond qualities of rattan-concrete were in the range 0.082 - 0.598 N/mm2 rely upon the species, concrete grade and other normal conditions. The trial consequences of 0.34 - 0.38 N/mm2 got by fall inside the range. Additionally, Youssef gave 0.56 - 0.68 N/mm2 for some bamboo species fortified with concrete. Every one of the discoveries fall in the vicinity of 3.94 and 28.86% of steel-solid bond quality of 2.07 N/mm2 of practically identical solid review (Neville and Brook). It was discovered that the moduli of flexibility for three types of Rattan were 3396, 516 and 11,106 N/mm2 for C. deerratus, E. macrocarpa and L. secundiflorum separately (Lucas and Dahunsi). The utilization of rattan support in lieu of traditional steel fortifications requires better comprehension under hub stacking and execution conditions. Examined the flexural conduct of two-way pieces strengthened with rattan and regular fortifications under pivotal stacking.

Andonian et. al. (2015) Various examinations have been done on normal strengthening materials, for example, wood jute bamboo raffia palmand palm stalk. Consideration is bit by bit been centered around the utilization of bamboo (Bambusa vulgaris), rattan (Calamusdeerratus) and other characteristic fiber fortifying materials as elective fortifications in concrete particularly for minimal effort lodging for rustic networks. In provincial networks of Ghana, babadua is utilized as a part of covering and its stems are integrated with structure of houses before smearing with mud (Schreckenbach and Abenkwa).

III. METHODOLOGY

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 are 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 involves 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 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.

Table 1 : Cement Properties

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

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:-

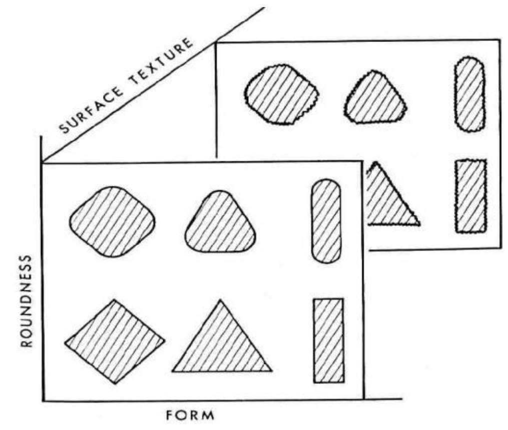

Figure 3 Represent the shape of aggregate

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.

Sample Preparation

Samples are prepared in a test laboratory, where all materials are mixed in a proper proportion. After wards beams are casted in a 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.

Figure 4 .Sample mixing and casting

IV. 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 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.

Experimental Results

Test results: for 7 days

Table 3. Failure loads for beam

Beam	First crack load, Fc (KN)	Ultimate load failure, Fu (KN)	Fc/Fu	Flexural Strength (N/mm^2)
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	.73	5.45

Table 4 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	6.10

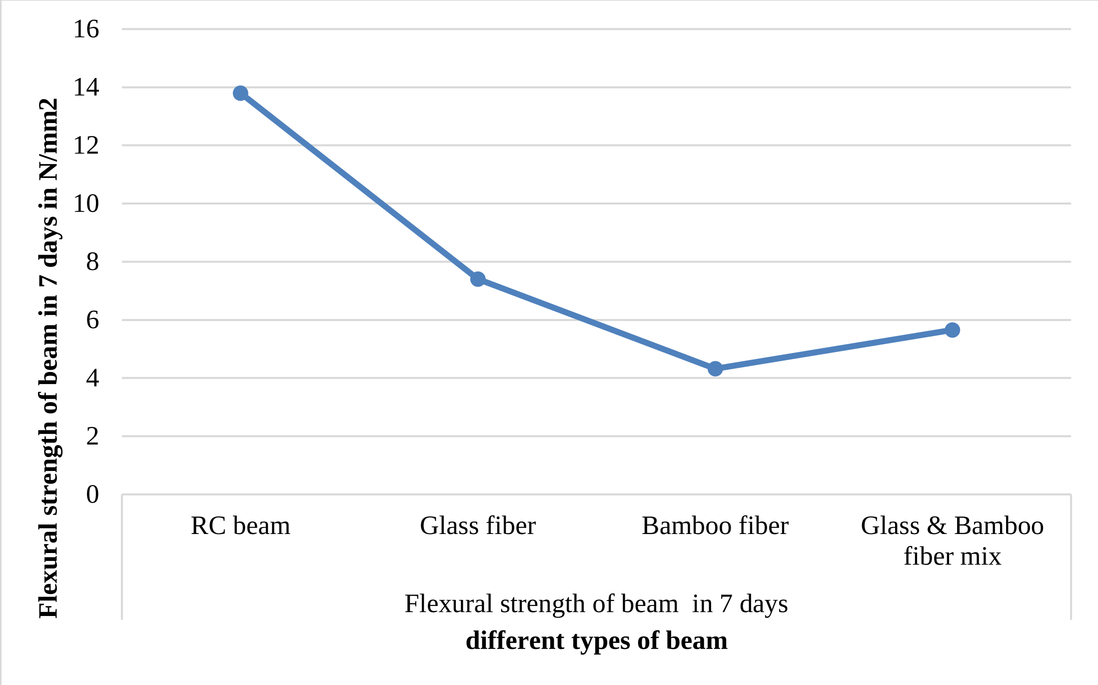

Figure 5. Flexural strength 7 days

Test results: for 14 days

Table 5. 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	20.5	33.8	0.606	12.6
glass fiber beam	13.2	18.7	0.705	6.8
bamboo beam	7.6	8	0.95	3.89
Glass & Bamboo fiber mix	10.7	13.6	0.82	5.4

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

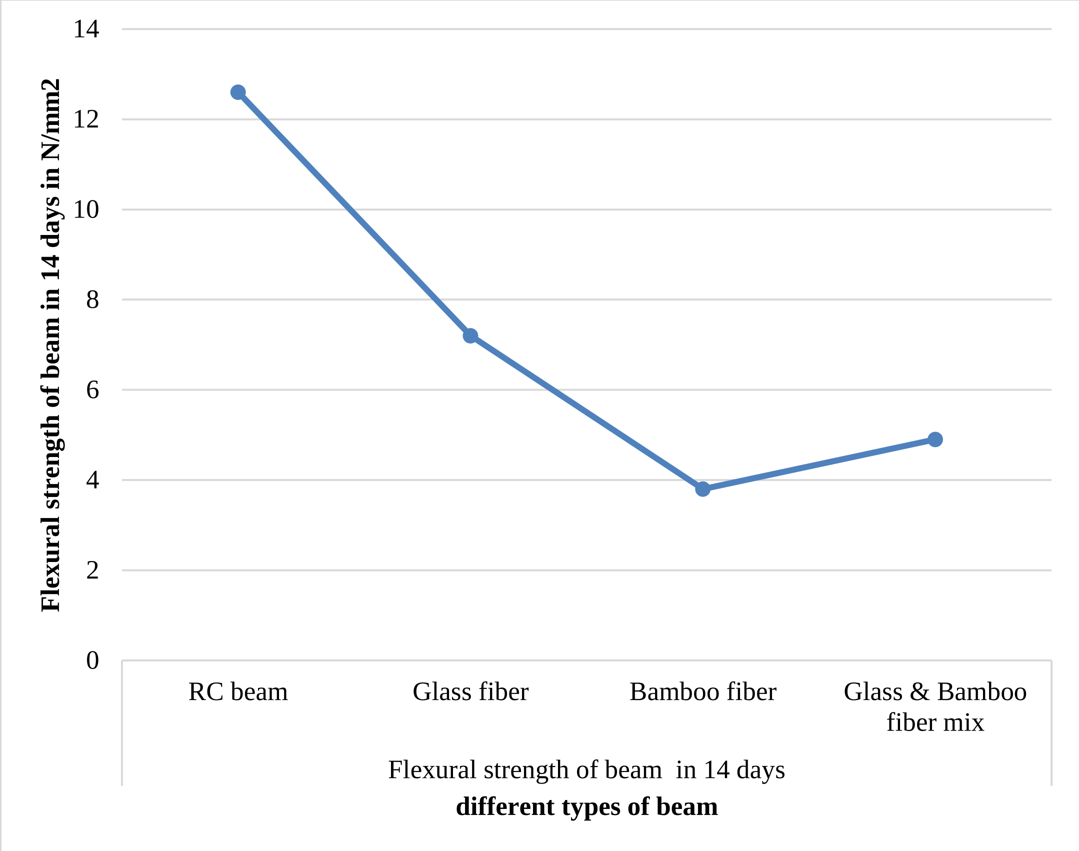

Figure 6. Flexural strength 14 days

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/mm²)
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

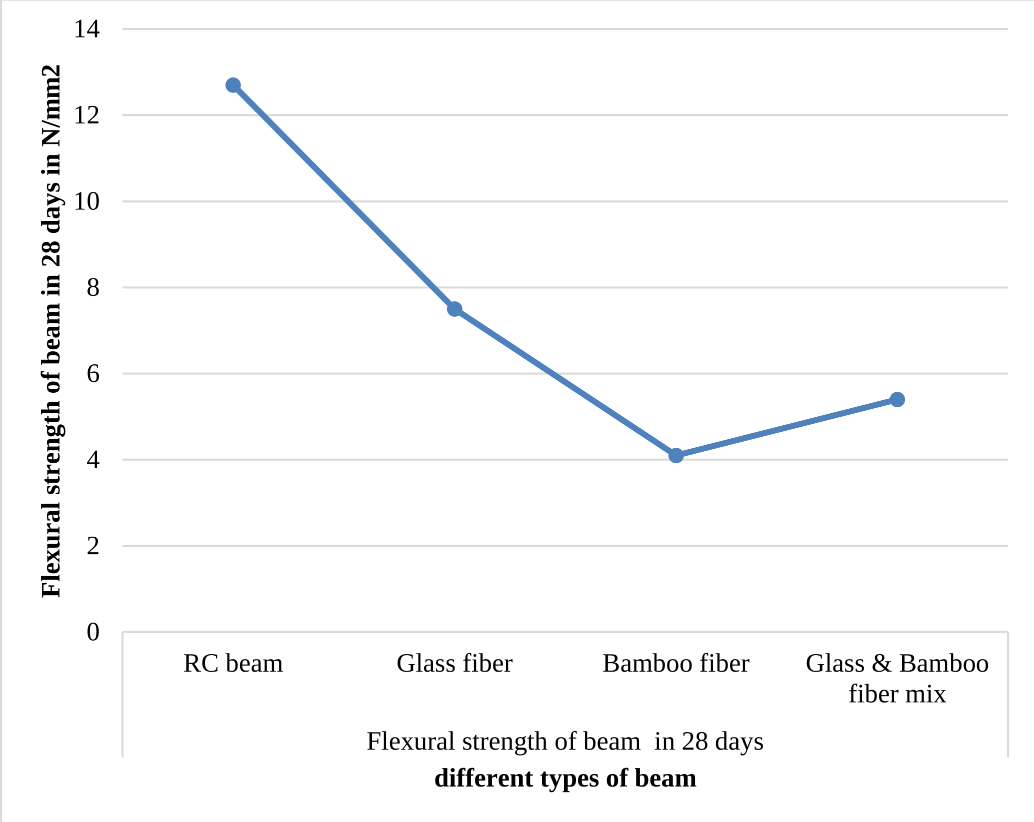

Figure 7. Flexural strength 28 days

Impact test results

Table 9. Impact test values

Aggregate size (mm)	Weight of sample before testing(kg)	Weight of sample after testing(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. This is suitable.

Flakiness index test

Table 10. Flakiness and elongation index

Size of Aggregate in mm		Corresponding Thickness Gauge	Weight of Aggregate Passing through Thickness Gauge gm	Weight of aggregates passing through thickness gauge gm	Corresponding length gauge size mm
Passing Through IS Sieve	Retained on IS sieve				
1	2	3	4	5	6

			Determination	Determination	
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%

Flakiness index = $\frac{\textbf{Total of percentage of retained on thickness gauge}\ (\%)}{\textbf{100}}$

Flakiness index= $\frac{36.34}{100}$ **=0.3634**

Elongation index =$\frac{\textbf{Total of percentage of retained on length gauge}\ (\%)}{\textbf{100}}$

Flakiness index = $\frac{15}{100}$**= 0.15**

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)	9.0 %	
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 - while placing the test block in the narrow mould and ease off on the non – porous plate, under the rod bearing the niddle (c), gently lowering the niddle in order to make it in contact with the surface of the test block and release it at the earliest, permitting it to invade inside the test block.

1. Rehash this system until the needle, when acquired contact with the test square and discharged as portrayed above, neglects to puncture the square past 5.0 ± 0.5 mm estimated from the base of the shape should be the underlying setting time.
2. Determination of Final Setting Time - Replace the needle (C) of the Vicat mechanical assembly by the needle with an annular connection (F).

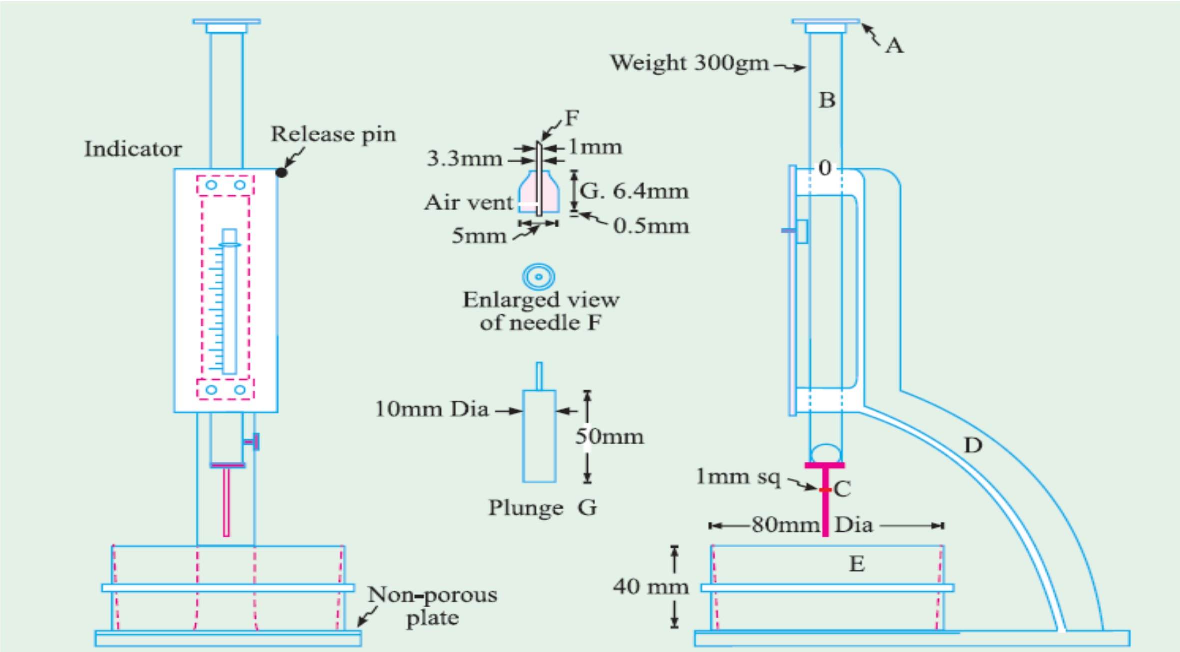

Table 8. Vicat apparatus

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

Initial setting time:-

In this project the ordinary Portland cement to be used the initial setting time of this cement paste 30 minute or 1800 second the needle of vicat's apparatus penetrate 4.7 mm from bottom of the mould in 30 min. according to code provision the penetration should be beyond 5.0 ± 0.5 mm

Final setting time

The annular collar of vicat apparatus lef impression on test block at 10 hrs than the final setting time of this cement is 10hrs.

V. 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.
3) Bamboo and glass fibre can only be used for lightweight RC structures. The flexural stiffness of bamboo and glass fibre 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 fibre RC beams were 31% and 55% respectively of the conventional steel RC beams. The experimental ultimate failure loads of bamboo and glass fibre 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 fibre 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).

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