Mechanical Strength of Bamboo Fibers

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***Abstract*: The indiscriminate construction of facilities contributes to rapid environmental disruption. The energy-intensive also polluting the atmosphere during its life cycle. It can measure resources and economies through the application of best available technologies such as bamboo for engineering applications. Bamboo is chosen, since it is neither a grass nor plant which is sustainable with a property of high strength and carbon sequestration. In this project an attempt is going to do for predicting the flexural behavior of bamboo reinforced concrete. Bamboo is used flexural strength and load deformation of behavior of BRC by experientially and in addition, bamboo 's strength is as strong as stainless steel and its stiffness is as strong as carbon fiber as concrete reinforcing. The findings of bending testing revealed that the strengthened cement beam in steel has the strongest bending power than others. However, in contrast with the cement framework of simple concrete bamboo reinforced concrete frames (treated and untreated). For lightweight frameworks such as a pillar and slab for the small frame, it may also be suggested to use a bamboo-reinforced concrete framework. The external frame may also be used.**

***Keywords*: Bamboo Building, Bamboo Reinforced Concrete, Flexural Behavior**

[1] INTRODUCTION

It is made up of several materials, and there are specific structural and mechanical properties of each bamboo species such as trees; teak, oak, or balsa are not alike. Additionally, depending on age and moisture of the bamboo being tested and its roots (sol, height and environment conditions) and part of the tested stem (below, center of the "forest" or the top), one bamboo form may give slightly different results for testing. Another significant explanation for the lack of knowledge is the comparatively uncommon usage of bamboo poles in Europe and North America as building material (partly because temporal bamboo is primarily manufactured in tropical countries). And over the last 30 to 35 years were the mechanical properties of bamboos checked scientifically. In the majority of countries there is no specific bamboo building code, which is hard for those who want to use this material to build. Law confusion occurs in deciding certain properties of bamboo (including fire resistance, strength, longevity etc.), so regulations and requirements are desperately required.

In laboratories around the world, bamboo strength properties have been studied and have obtained excellent performance, which are several times quite superior to traditional building materials. However, requirements for building codes not only require the material's strength properties to be recognized, but they do need to be taken account of the following specific characteristics:

- Toughness
- Fire security
- Environmental impression
- User Security
- Energy productivity

1.2 The International Organization for Standardization (ISO)

This investigation present many test findings from various sources and bamboo in this study. It is necessary to remember that not all experiments are done under ISO 22157 but provide a summary of the mechanical properties of bamboo. The technical qualities and durability of bamboo have contributed to his expertise in repairing concrete systems in emerging areas. Proposals for the broad usage of concrete frameworks of steel as a durable replacement to steel pose crucial questions for designers, developers, and experts of terms of their technical capacities, their performance and employability. This essay deals with these issues, a detailed analysis of this area of literature and a technical contrast of steel bars and bamboo bars of modern concrete frameworks. The purpose of this analysis is supposed to be restricted to the usage of whole small-scale (line) and/or broken (also called circular or rectangular strips) lines. A viable bamboo- based device, which is only briefly mentioned in this article, may reflect new innovations in bamboo products. The scope of this topic is not restricted to other uses of bamboo related substances in concrete systems (e.g. baharek, strengthened bamboo fiber and mixture of bamboo ash).

Sometimes regarded as green alternative to timber, bamboo is often considered a "steel-like," concrete substitute. It is undeniable that the main advantages of bamboo are the high productivity and regeneration of sustainable managed bamboo forests. However, a favorable comparison with steel is not effective in strength. The bamboo density is typical from 30 MPa (oak) to 50 MPa (White Oak), while it's dry, to high-quality hardwoods. Bamboo is a solid and soft, physical, and mechanical fiber of substantial profile and stem characteristics. The substance is normal and anisotropic. The bamboo density ranges in all cross sections between 500 and 800 kg / qm (from the inner stem wall to the external). In a failure condition induced by longitudinal strain, Bamboo typically displays fragility. With a range of 10% to 30%, the variation in the mechanical length of bamboo is like that of wood. In the vertical direction of the fibres, however, because of the lack of radial fibers, bamboo is particularly poor which makes it especially prone to longitudinal cutting and lateral pressure and pressure damage. In the other side, steel is a man-made commodity with a density of 7800 kg / m3 and the power of traditional stainless-steel bars from 4000 to 550 MPa. Therefore, steel is easily shaped and needs very few substances which are able to withstand charges in order to enhance their mechanical efficiency. Without much treatment and changing its nature and properties, it will be difficult to achieve this improvement with bamboo. Bamboo is often said to be "green steel" and is made of a material equivalent to low carbon steel.

1.3 Reinforced concrete

Reinforced concrete, where concrete is included in steel, these two materials work together to withstand drag. Reinforcement bars, rods or nets absorb tensile, shear, and sometimes compressed pressure in concrete structures.

Figure 1. 1 Reinforced concrete

1.3.1 Significance of Bamboo Reinforced Concrete

Demand for materials increases in most developing countries. In some cases, not enough production could be found to meet steel demand. Therefore, it is necessary to choose a more valuable alternative to steel. It has been found that bamboo is prolific and flexible, so that it can meet the needs is to an appropriate replacement for a steel as a reinforcement material. The bamboo structure gave this property its origin. Hollow tubular structure is characterized by high wind resistance in natural habitats. An innovation that addresses bamboo weaknesses and suggests bamboo as an alternative to structural steel would be a good choice.

1.3.2 Bamboo used as Reinforcement

The materials cast-off as concrete strengtheners must demonstration all the necessary characteristics for structurally active loading of the unit. For steel, we manufacture steel as required and check standard inspection core strength values.

1.3.3 Bamboo for Reinforced Concrete

Color and Age – Color and use of age clear bamboo brown. This indicates that the bamboo is at least 3 years old.

- Diameter - use long, thick legs
- Harvest - try to avoid harvesting these bamboo in the spring or summer.
- **Species –**Among the 1500 types of bamboo, the best species must be examined and tested to meet their requirements as booster material.

1.4 Material Properties of Bamboo - Reinforced Concrete

The fibers are extremely quality and the cross path is of low intensity. The cellulose fibers are oriented against the length of the composite substance of bamboo. It has dense, dense bamboo fibers, which withstand powerful winds. That is the key explanation of bamboo.

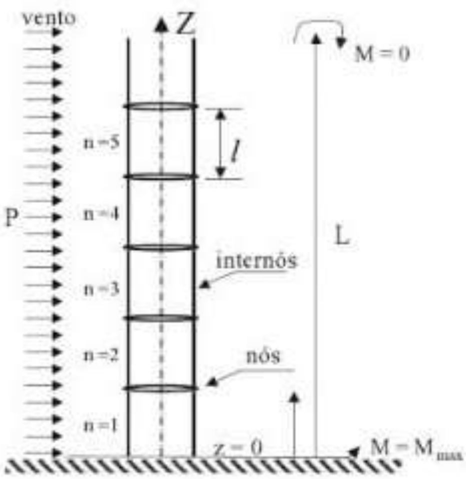

Figure 1. 2 Basic Diagram of a Bamboo

The nodes visible in bamboo are represented by n. The side load "p" it bears produces the maximum moment when supporting. It forms a cantilever structure.

1.5 Durability of Bamboo Material

As a human commodity, it becomes more vulnerable to environmental conditions and insects. The use of bamboo is one solution. The curing cycle recognizes moisture and starch, which is the principal explanation why insects are drawn. Bamboo curing may be performed in the following manner either by bamboo treatment

- On-site treatment
- The immersion procedure
- By warming
- Smoke conduction

The procedure performed when the bamboo is drained in order to leak adequately in the infiltration. The antiseptic care of bamboo take the longevity aspect into consideration and should not have an impact on chemistry. The process proceed and should not be washed in the circumstances of heavy water. This low content make the bamboo molds disappear.

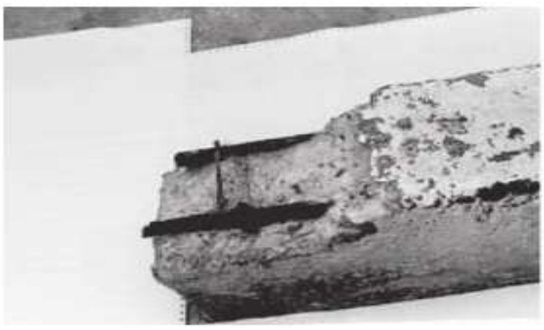

Figure 1. 3 Bamboo Reinforcement afterward 15 years

Figure 1. 4 a column steel reinforcement bars after 10 years exposed within a closer area

The resistance properties of bamboos were also very strong at the snap, but it can't be good since friction is less than stainless steel. Therefore, in the seismic environment, because bamboo is seldom affected by the highest energy absorption in the joints. Cellulose is the key bamboo part and bamboo is the principal source of bamboo mechanical properties.

Safe working pressure under stress has also been found that bamboo performs well in twisting, but because stress is less than steel, and because bamboo is not straight, the effect may not be good. In addition, it was decided that in the seismic zone, since the maximum energy absorption in the joints, bamboo is rarely damaged.

[2] REVIEW OF LITERATURE

Bhimarao & Patil (2019) published a paper concentrated mainly on bamboo improvement, double-shear, flexural resistance, friction power, low weight, earthquake protection. "Bamboo as reinforcement substitute," Bamboo is used as a steel alternative and bamboo has about the same bending power as strengthened steel material. The load strength of the Bamboo can be optimized for the participants, including parking roof floor, public toilets, sunshades, cabin of the Watchman, etc. **Sutharsan et al. (2020)** presented a paper the key fields of research were steel strengthening, bamboo, resilience and flexural, "Enhanced substance in concrete" "experimental study of bamboo." The key goal is to replace traditional items such as steel with bamboo sticks which are already usable. Bamboo is ideal for reinforcement as it has very high friction and compressive power. The bending power of the bamboo beam demonstrates greater strength that tends to enhance bamboo use. **Viswanathan et al. (2019**) This paper is designed by using basics of shearing and deflection. This paper used two types of fiber- glass fiber and basalt fiber. The benefit of the basalt fiber which is made by igneous rock is not corrosive in nature. It is good for reinforcing concrete structure which is exposed to de ionizing sari melt and also concrete exposed to marine environment. **Ghante & Shivananda (2019)** published a paper "Bamboo reinforced concrete beams experimental research on strength and resilience" primarily based on bamboo reinforced cement frames, bamboo breaks, magnesium sulfate solution, potassium chloride solution, flexural strength , tensile strength. This paper discusses the bending power of BRC beams and the resilience of bamboo as a structural strengthening. The analysis used 1.25 percent and 2.50 percent of standard bamboo and adjusted bamboo as beam reinforcement. **Mishra et al. (2019)** published an article was emphasized mainly. The emphasis of this inquiry was on the usage of bamboo as an alternate beam joint strengthening material. The comparison research is performed with and without water repellent treating bamboo-reinforced beam-column joints with steel-reinforced beam-column joints.

[3] MATERIALS METHODS & METHODOLOGY

3.1 Cement

In the building and manufacturing industry, even in addressing specific technical problems, we have a broad range of cements. These cements may have very different chemical compositions, but Portland cements manufacture the largest volumes of concrete nowadays. The manufacture of Portland cement is very easy in nature and relies on the usage of plenty of raw materials. Intimate mixture, normally of calcareous and clay, is heated to 1400 to 1600 ° C, the temperature range beyond which the two compounds chemically combine in order to form calcium silicates. High quality cements need appropriate pure and stable raw materials. Calcium carbonate (calcium carbonate) is the most common calcium oxide source, but other forms of calcium carbonate are used (usually the iron-bearing alumino-sillicates are used as a main source of silique, while clay or silts are preferred as they are already in a thinly divided state. The most important type of cement is Portland concrete known as (Ordinary Portland Cement). The OPC is graded in three grades: 33, 43, and 53 based on the 28-day intensity.

Figure 3. 1 Cement

Table 3. 1 Typical composition of OPC

Name of Compound	Formula	Abbreviated Formula	% Content
Tricalcium Silicate	$3CaO.SiO_2$	C_3S	40-55
Diacalcium Silicate	$2CaO.SiO_2$	C_2S	15-30
Tricalcium aluminate	$3CaOA12O_3$	C_3A	8-11
Tetracalciumaluminoferrite	$4CaOAl_2O3Fe2O_3$	C_4AF	13-17

Cement is the most important ingredient and act as a binding material. OPC is used for casting concrete. The cement was of uniform grey color and free from any hard lumps and was bought from a local vendor. In this research we use Ordinary Portland Cement (OPC) of 43 grade of brand Ambuja Cements form single batch through the investigation was used.

Table 3. 2 The chief chemical constituents of Portland cement

Lime (CaO)	60 to 67%
Silica (SiO2)	17 to 25%
Alumina (A12O3)	3 to 8%
Iron oxide (Fe2O3)	0.5 to 6%
Magnesia (MgO)	0.1 to 4%
Sulphur trioxide (SO3)	1 to 3%
Soda and/or Potash (Na2O+K2O)	0.5 to 1.3%

Table 3. 3 Composition and compound content of Portland cement

Portland Cement	Normal	Rapid hardening	Low heat
(a) Composition: Percent			
Lime	63.1	64.5	60
Silica	20.6	20.7	22.5
Alumina	6.3	5.2	5.2
Iron Oxide	3.6	2.9	4.6

3.2 Tests on Cement

Procedure

Smoothing it out to the top of the mold and leveling it with your fingers.

- Use a non-porous resting plate beneath the plunger to hold the test block and mold in place while you perform the test.
- Gently lower the plunger until it touches the surface of the test block, then rapidly release it to enable.
- Make different percentages conduct testing described it is established that the quantity of water required for penetration of the Vicat's plunger.

Initial and Final Setting Time
Apparatus
Vicat's apparatus with mould and non-porous plate, Initial setting time 1 sq. mm Needle, Final setting time 1 sq. mm Needle with enlarged base**,** Balance, Measuring cylinder**,** Stopwatch, Thermometer.

Samples
Cement**,** Potable water.

Procedure
- Weigh about 300 gm. of neat cement
- Starting at the moment the water is introduced, the recorded using a stopwatch.
- A put the time will be recorded every time penetrate beyond 5.0 +/- 0.5 mm
- In the next section, we will discuss initial setting time, which is defined as the time interval between the moment when water is first introduced to the cement and the time specified in (v) above.
- The needle with annular attachment will be used to determine the final setting time for the final setting timer needle.

Figure 3. 2 Vicat's Apparatus

3.3 Fineness Test of Cement
This test will be performed according to IS: 4031-15.
Apparatus
Balance capacity 500 gm., I.S. Test sieve 90 micron.
Samples
Cement
Procedure
- The sieving should be continuous for 15 minutes.
- Weigh the residue left (W2) after 15 minutes sieving and calculate percentage of residue retrained on 90 micron sieve.

Results
Fineness of cement (%) = W2/W1 x100.

Figure 3. 3 Sieve Shake

[4] METHODOLOGY & TESTS OF BAMBOO

4.1 Test Experiment for Bamboo

Tests were performed: bamboo tension pressure checks, bamboo stress tests and bending beam tests. Universal control machine (UTM) with a capacity of 2 tons, used for stress checking for bamboo. Tests conducted with hydraulic jackets for the bending power of the concrete filling system. Table 4.1 indicates the number of tests per each test form.

Table 4. 1 Type of Testing

S. No.	Type of Testing	Specimens
1	Compressive Test of Bamboo	One
2	Tensile Test of Bamboo	One
3	Beam Bending Test	M-25

4.1.1 Tensile Test

The tensile strength of bamboos is very strong and can be variable from animals to animal species, but it can be seen with an overall tensile strength 3/4 to 1⁄2, or often much higher. The carpenter's tools such as hammer, chisel, etc. split a bamboo into two wisely long parts at first. Two halves each were further divided into three pieces. For tensile check, the following requirements were taken for samples of bamboo finished without a GI spiral and the following five samples of finished bamboo with a GI spiral:

a) Certain specimens had 1 knot or more.

b) Imperfection has been removed from some type.

c) Every undulation has been decomposed.

d) Diameter at four separate positions was determined and then estimated the mean diameter. The tensile strength of bamboo is quite strong, and differs between species and species.

Figure 4. 1 Examples used for tensile challenging

4.1.2 Compressive Test

Bamboo cylinder was formed in the entire bamboo length with varying diameter.

Figure 4.2 Specimens used for Compressive test

Beam Specimen

Three types of beams, namely flat concrete pillar, double reinforced pillar and steel reinforced beam of similar dimensions are used for this work. There is no bamboo stick in the simple concrete post. Figure indicates the experimental beam size and cross section. For the therapy up to 28 days they were submerged in the warm water bath.

Figure 4.3 Actual Beam under 3 point bending.

4.1.3 Flexural Strength Test

The flexural tests were carried out on beam specimen under standard four point loading was done conforming to IS516-1959. The flexural strength determine by testing standard test specimens of 150mmx150mmx700mm under four point loading. Load vs deflections measurements are observed. The ultimate load at failure was noted.

Figure 4. 4 beam specimen

Two concentrated load at one third span were applied on beams. The flexural depends on the dimentions of the beam and manner of the supporting span that is spaced at 666.67mm center to center or on either side of beam was place perpendicular to the applied force without eccentricity. There LVDT having a least count of 0.01mm is fixed at the middle, one fourth of the span and under the load point of the set up.

4.1.4 Pullout Test

Pull out test has been performed to determine the bond strength between bamboo reinforcement and surrounding concrete. Now-a-days deformed bars are used widely for improving the bonding. On the other hand bamboo and bamboo twig have a smooth and slippery surface and therefore bonding may be a critical factor for this kind of specimen. Therefore, it was decided to investigate the bond strength of finished bamboo and bamboo twig by performing pull out test. Three samples were taken in natural condition, three samples were coated with tar and three samples were taken coated with tar and pierced nail with a length of 762 mm to 1067 mm were taken for pullout test. The following procedure was followed in preparation of bamboo specimens for pull out test

Figure 4. 5 Bamboo Sample (In Natural Condition) for Pullout Test.

Three pieces of bamboo had tar covered. Bamboo is a natural material, so once in touch with concrete water there is a risk of decomposition. Therefore, tar was used in the Fig 4.6 as a defensive.

Figure 4. 6 Bamboo Sample Coated with Tar

To increase the bond strength pierced nails were used. At first the samples were drilled by a drill machine at an interval of 1 in and the adjacent holes are right angle to one another as shown in the Fig.4.7. The samples were drilled to protect the specimen from splitting. Then the nails were hammered through the holes as shown in the Fig. 4.8. The finished sample is shown in Fig.4.9.

Figure 4. 7 Making Hole by Using Drill Machine,

Figure 4. 8 Hammering the Nails through the Holes,

Figure 4. 9 Finished Bamboo Sample (Coated with Tar and Pierced Nail)

After proper placing of the bamboo specimen in the mould, the concrete of mix ratio 1:1:2 was allowed to pour.

- The specimens were removed from the molds after 24 hrs and cured in water for 28 days

- After curing for 28 days, the specimens were tested for bond strength using pull out test machine. The specimens were placed on the lower platen of the testing machine and the upper platen was used for gripping the bamboo specimen. The edges were ringed with GI wire for proper gripping. For uniform distribution of load, a steel plate with a geo textile membrane was used at the upper portion of the specimen as shown in the Fig.4.10

Figure 4. 10 Steel Plate and Geo Textile Membrane Used for Uniform Loading

[5] RESULTS AND DISSCUSSION

5.1 Flexural strength

Bamboo beam bamboo (SRC) were tested all of flexural intensity (150x150x700 mm and and the experiments conducted on single beams (BRC). The charges of the beam and the degree of loss were measured during the experimental study. There have been reported cumulative failure loads. At the same time, the beams under load is discharged by means of the dial indicator, which was used in experimental implementation. In this load deflection curve, maximal bending moment was plotted.

The bending power flexing force according to the experimental findings for both bamboo beams. That may be because the bamboo is durable by putting a paint on its surface and because of sand binding on the back of the bamboo. This has increasing the bonding potential.

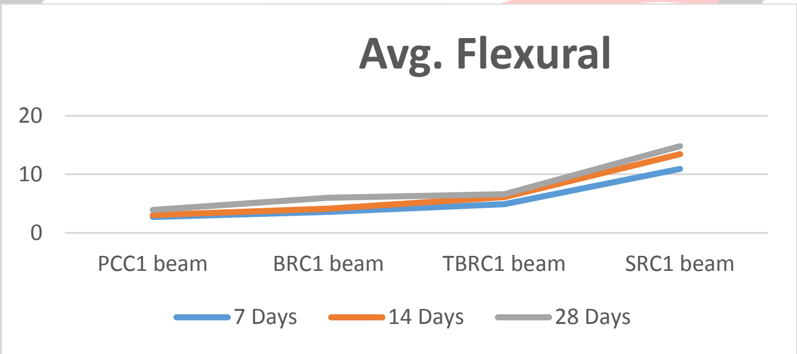

Figure 5. 1 Figure shows that the avg. flexural strength in 7 ,14 and 28 days

Fig above, the flexural strength of PCC1 beam with respect to other 14 and 28 are found 5.99 N/mm2, 6.59 N/mm2 and 14.84 N/mm2 respectively.

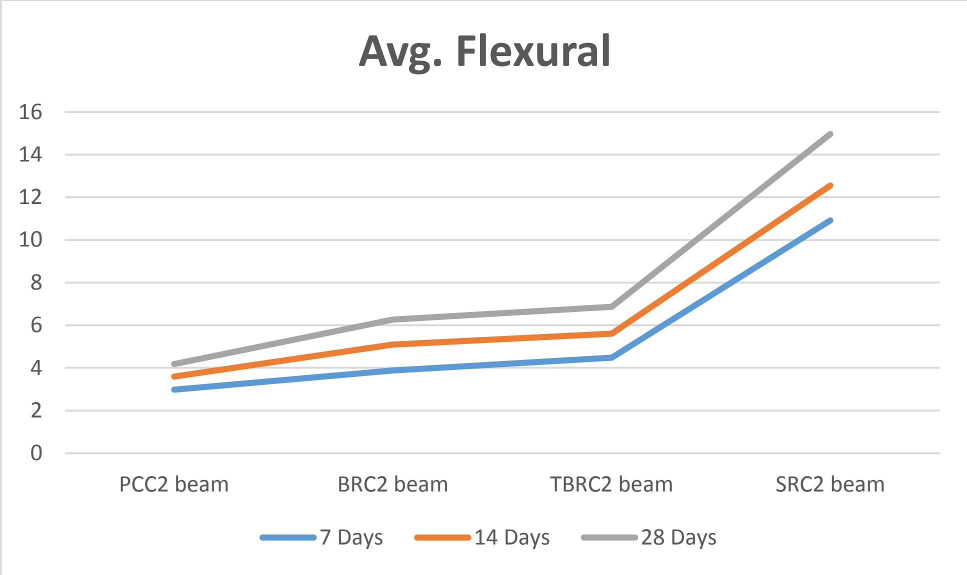

Figure 5. 2 Figure shows that the avg. flexural strength in 7 ,14 and 28 days

Fig above PCC2 14 and 28 are found 6.27 N/mm2, 6.76 N/mm2 and 14.89 N/mm2 respectively.

The study shows that the bamboo specimen's failures trend is standard division without grasp. The separation becomes similar to the grain and extends around the knot until gradually more than one position exists. It can be seen from these findings that the tensile strength is almost universal and the failure trend for specimens of bamboo where failure in grip was avoided is identical. The tensile strength of bamboo specimens with prepared ends is often greater (to resist grip failure) than the respective bamboo specimens without prepared ends (grip failure).

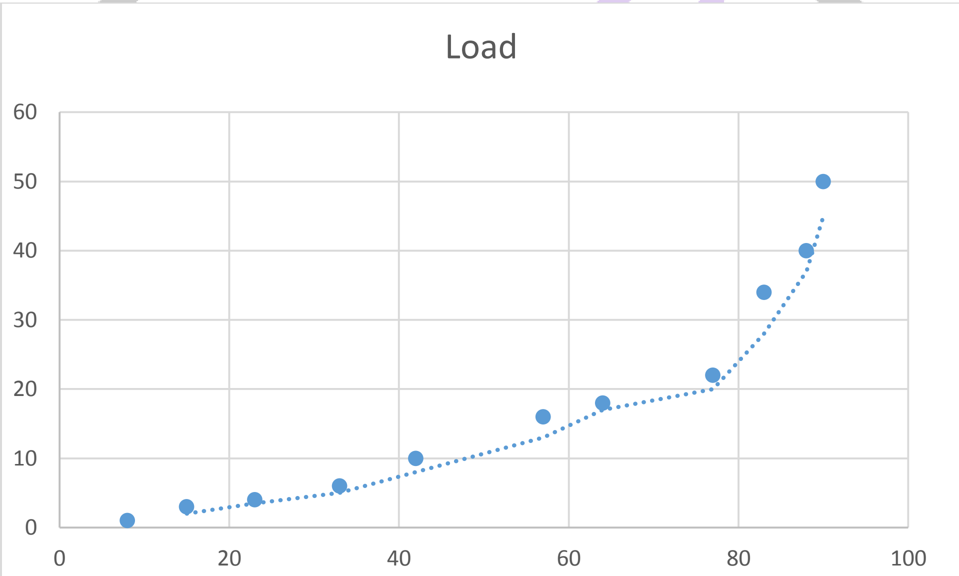

Figure 5. 3 Max Deflection (mm) vs. Load Ultimate load (kN) specimen -1

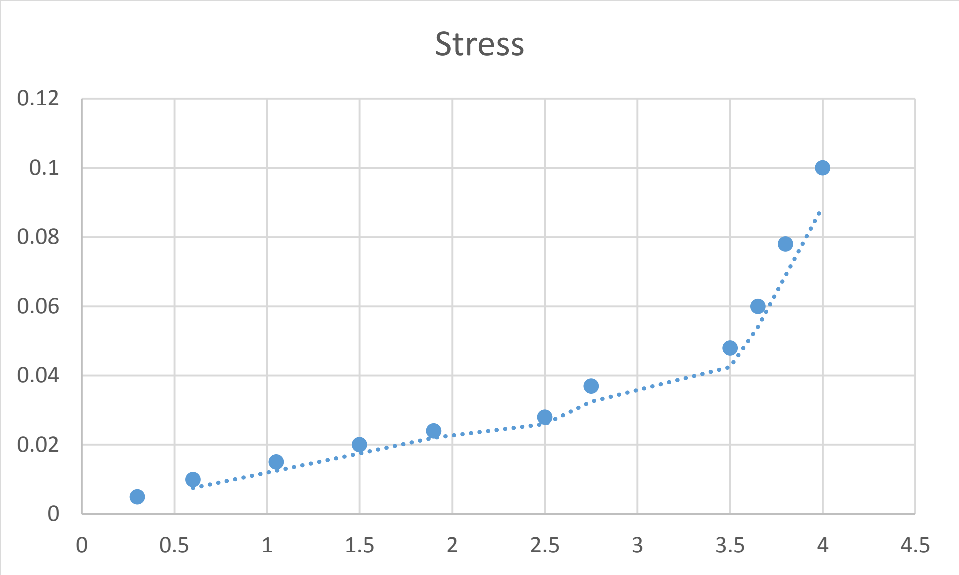

Figure 5. 4 Strain vs. Stress (specimen -1)

4.2 Experimental result for specimen -2(convention bamboo reinforced)

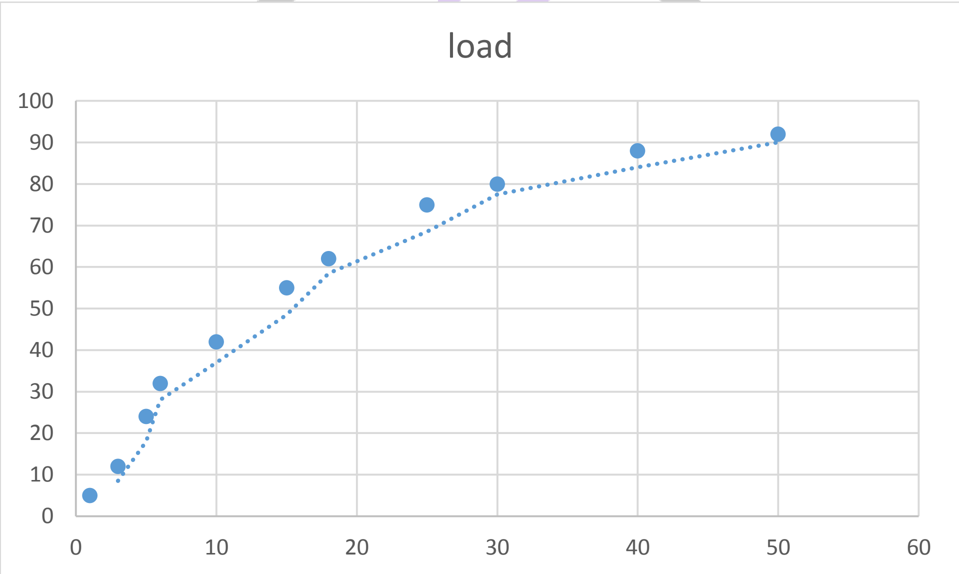

Figure 5. 5 load vs. deflection specimen -2

[6] CONCLUSION & FUTURE SCOPE

The discoveries of bowing testing uncovered that the reinforced concrete pillar in steel has the most grounded twisting force than others. In any case, interestingly with the concrete structure of basic solid bamboo fortified solid edges (treated and untreated). For lightweight systems, for example, a column and chunk for the little edge, it might likewise be recommended to utilize a bamboo-strengthened solid structure. The outer edge may likewise be utilized. Beton and steel are maybe the world's most generally delivered development items. The quality of steel comparative with concrete is extremely solid, anyway different issues exist. Any of these issues include a huge expense of yield, a solid power utilization during improvement, a non-sustainable asset, and a high level of carbon contamination. The desire not to endanger the elasticity of fortified cement has driven numerous researchers and specialists to scan for neighborhood materials to supplant customary steel reinforcing. Bamboo is, truth be told, one of the most appropriate items for the utilization of concrete as strengthening square. The appropriateness of bamboo as solid fortification was tried in the stage. Beton and steel are perhaps the world's most produced construction products. The strength of steel relative to concrete is very strong, however other issues exist. Any of these issues involve a large cost of output, a strong electricity usage during development, a non-renewable resource, and a high degree of carbon pollution. The urge not to jeopardize strength led many search for local materials to replace traditional steel strengthening. Bamboo is, in fact, one of the most suitable products for the use of concrete as reinforcing block. The suitability of bamboo as concrete reinforcement was tested in the phase. The outcome shows that the bamboo Significantly fundamentally affected the existing structure.

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