MECHANICAL STRENGTH OF BAMBOO REINFORCED BEAM

Submitted in partial fulfillment of the requirements of the award of the degree of

Master of Technology

In

Civil Engineering

by

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CERTIFICATE

This is to certify that the project work entitled "**MECHANICAL STRENTH OF BAMBOO REINFORCED BEAM.**" submitted by **Mayank bhati (18SOCE2010019)** to the School of Civil Engineering, Galgotias University, Greater Noida, for the award of the degree of **Master of Technology in Civil Engineering** is a bonafide work carried out by him under my supervision and guidance. The present work, in my opinion, has reached the requisite standard, fulfilling the requirements for the said degree.

The results contained in this report have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

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Assistant Professor
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Dean,

School of Civil Engineering

External Examiner

DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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18SOCE2010019

ABSTRACT

The indiscriminate construction of facilities contributes to rapid environmental disruption. The energy-intensive steel, cement, synthetic polymers and metal alloys used in building activities are 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 picked, since it is neither a grass nor plant which is sustainable with a property of high quality and carbon sequestration. In this task an endeavor will accomplish for foreseeing the flexural conduct of bamboo reinforced. Bamboo is utilized as fortification in concrete by deciding the different physical and mechanical properties of bamboo. The examinations led for the tried kinds of bamboo are assessed utilizing the equivalent acknowledge rules as that of steel. This examination researches the flexural quality and burden distortion of conduct 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 used.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

It is made up of a number of 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 similar to 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

The demand for steel as reinforcing 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.

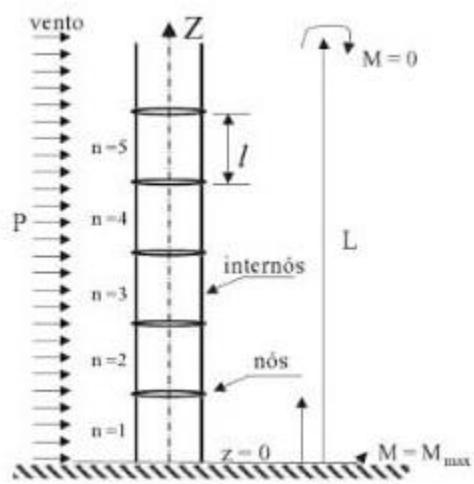

Figure 1. 2 Basic Diagram of a Bamboo

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.

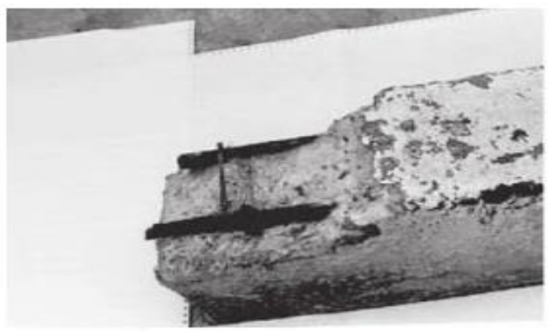

Figure 1. 3 Bamboo Reinforcement afterward 15 years

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. There are some common characteristics of bamboo:

Specific gravity -0.58 to 0.66

Average weight is 0.625 kg / m

Rupture factor - 600 to 1610 kg / cm2

Modulus of elasticity - 1.45 to 2.0 x 105 kg / cm2

Final nervous pressure from 795 to 865 kg / cm2

Safe working pressure at -106 kg / cm2

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.

1.6 Compressive Strength Bamboo Material

Curiously, the ISO 22157 standard only describes a test method parallel to the compression strength of the grain, and does not provide a method perpendicular to the pressure strength of the grain. Because of the natural form of the bamboo "forest," it is important to check three separate sections of the stem: bottom, middle, and top. This is important because of the fact that the bamboo leg has no continuous cross section and the structural characteristics vary between the lower section with the greater diameter and the top section with a smaller diameter.

Test cannot have nodes and the findings of such experiments are not identical since the nodes in the bamboo stem are the strongest regions. The segment between the two (inner) nodes must then be taken for the test sample, since it is the weakest portion of the bamboo electrode.

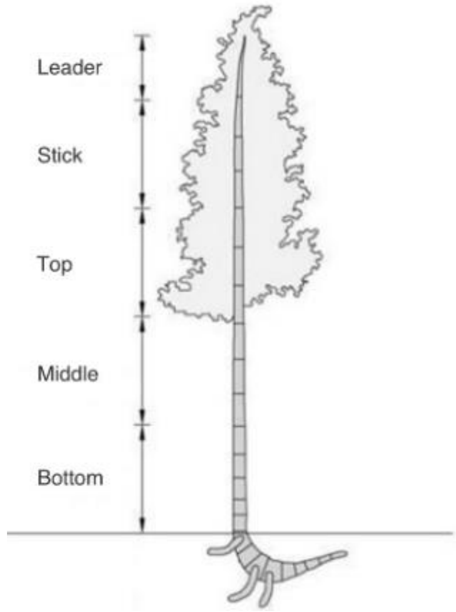

Figure 1. 5 Stem of Bamboo

The foundation, center, and top may be used as columns or beams only for building purposes. Because of its limited diameter, 'leading' sections and 'sticky' bamboo poles are not useful in construction.

1.7 Tensile Strength

Checking fibers (bamboo legs) rather than on a whole propensity sample defines the overall tensile strength of the bamboo. Three strokes from the lower, upper, and top portions of the whole bamboo stem have been used to measure the tensile strength of the bamboo. The band width of each unit differs from 10 to 20 mm, the bamboo column thickness and 100 mm of length. For each study, moisture content should be calculated and a knot should be used in the study. Because the path of the Node fibers is counter to the path of the Node fibers, the Node is perceived to be the weakest point of the Node stem (the reverse is valid if the compression force is tested).

1.8 Shear Strength

Maximum shear stress is an essential consideration for the production of effective carpentry systems and links in bamboo. There are two potential forms of shear tension, parallel to the grain and perpendicular to the grain. Similarly, only parallel grain shear stress is given for by ISO 22157. The bamboo stem has been checked with three samples of the lower, middle and high sections. The distinction is that one node should be included in the half of the study, while one node in the other half should not be included. Before testing, measure each sample carefully. The height of the test piece and the thickness of the rod are measured in four areas where shear will occur.

1.9 Bending Strength

The bending strength directly affects the performance of the structure, so it is to be expected that the deviation of each element in the structure before building the structure. The most common way to determine the deviation of a beam or column is a four-point bending assessment.

1.10 Application of bamboo as reinforcing material

While bamboo reinforced concrete is not approved for use in large structural parts, it could be feasible to adapt such applications if the longevity, dimensional flexibility, and bonding between bamboo and concrete described in this study are addressed. Once bamboo is used for at least 3 percent, cane or plate should be used to avoid cracks instead of a floor lab (thinned floorboard). These panels are supposed to be unbroken and / or have controlled ties such that a managed split may only be permitted.

Panels of LCBF, called baharek houses, compose of lightweight bamboos. LCBF construction is a modern technique that uses a bamboo or metal slice matrix consisting of a composite shear plate, placed onto a bamboo structure device and added to a cement or lime mortar. This cycle operates because the wall matrix pressure is too low. It was suggested to use small bars or bamboo plywood as a reinforcing material for construction. Because of the role of building reinforcement (as opposed to reinforcing concrete), some researchers believe that strengthening of bamboo is suitable for strengthening hollow bricks in non-seismic environments.

1.11 Methodology

In order to determine the viability of the bamboo as a beam bending feature, the experiment was performed. The concrete blend definition was introduced with the Indian standard for concrete power. The approach included the basic material processing, casting of beams, curing and checking and analysis of tests in order to achieve the objectives. Bending strengths were applied to strengthened concrete beams to investigate the possible use of bamboos as a building material in reinforced concrete structures, replacing all bars of bamboo, including central rebars and strips.

CHAPTER 2
REVIEW OF LITERATURE

1. 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. They study of the comparison of cost, double shear, flexural strength & tensile strength of bamboo reinforcement with regularly used steel reinforcement. Recently Global warming is the major issue on which we want to focus. Generally in construction steel reinforcement is used but they know that the production of steel is very harmful for nature. The construction industry is mainly depending on cost of project. The cost of project is mainly depends upon factors such as labor cost and material cost. So for reducing the cost of project we can replace the material such as they can use bamboo as reinforcement.

2. 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.

Inferred from stress-stream curves, this analysis demonstrates bamboo's viability as a reinforcement medium in concrete and thus, relative to the bamboo's steel, it does not avoid the corrosion of the concrete under the ultimate setting. Compression in the top layer reveals the bamboo is concentrated at the top edge, 32.2% more than in other stages of compression. The tensile strength of the bamboo indicates a further improvement because of its weak elastic modulus.

3. Viswanathan et al. (2019) published a paper **"Experimental study on bamboo reinforcement concrete beam by using fibers",** they emphasized mainly on Bamboo reinforcement, Bamboo, Glass fiber, Basalt fiber, and Resin. This paper think about the quality between steel reinforcement and bamboo reinforcement. The quality of the bamboo reinforcement is improved by wrapping fibres. The supplanting of steel fortified with bamboo strengthened is a significant factor as it improves conservative perspective also environmental advantages. To investigations the quality of the bamboo support shaft in the size of 700 x 150 x 150 mm . This paper is designed by using basics of shearing and deflection. This paper used two types of fiber-glass fiber and basalt fiber. Glass fiber is used in the concrete beam to increase the strength and durability of concrete. Glass fiber increases the compressive strength, tensile strength, split strength of the concrete. The strength of the beam is increased by wrapping glass fiber an around the beam and strength is calculated. 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. This exploratory test shows the increasing strength and ductile of concrete beam. At long last the result of the venture is examined by compacting ordinary steel and bamboo reinforcement beam over the bamboo reinforcement beam with the test . The exploratory examination shows that solid wrapped with the strands increment the quality of the solid. The beam is tried by flexural quality test. By wraping the fibres over the bamboo strengthened beam invigorates high strength and durability. It is observed that e-glass fiber and basalt fiber wrapped around the bamboo reinforced beam gives high strength. When compared to basalt fiber, e-glass fiber gives more strength.

4. 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.

5. 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. The bamboo-reinforced beam-column joints had the overall load-bearing capability considerably higher than that of joints without waterproof care.

6. Karthik et al. (2017) published a paper “Strength properties of bamboo and steel reinforced concrete containing manufactured sand and mineral admixtures” Mainly based on, steel strengthening, bending power, GGBS, fly ash and energy. In this analysis, bamboo strips were used to strengthen concrete, made of additional cement materials and partial removal of the river sand (M-sand). Cement has been partly supplemented by 25% of the mixture of fly-ash and ground-granulated blast-furnace-slag (GGBS). Concrete samples were developed and evaluated for defined times in accordance with normal specifications such as cubes, cylinders and beams. The bamboo study was conducted using SEM and FTIR and also calculated its tensile power. Bamboo is a solid, ductile material, the effects of the micro and tensile strength studies. The work indicates that mixing fly ash, GGBS and m-sand, which are used as substitute construction components, increases tensile strength and fractionally. Under flexon packing, BRC production produced with substitute materials (fly ash, GGBS and m-sand) was considerably decreased compared with BRC containing traditional materials. Compared with BRC containing traditional materials. Furthermore, BRC formed flexurity with traditional compounds more than the SRC, with a difference of 6.5%.

The research based on the qualities of the sand and mineral admixtures of the bamboo and steel reinforced concrete. The findings of the inquiry is as follows:

A). It has been established that bamboo is a ductile reinforcing material with considerable tensile force that renders it a suitable replacement for steel by the morphological characteristics (FTIR and SEM) of the bamboo dust. Bamboo can be an ideal medium for compact and rotating members because of its closely bound fibers.

B). The partial substitution of cement in concrete, completely sanded, with fly ash and GGBS as a fine aggregate provided a strong compression strength. However, their values relative to the reference concrete are low, but for some structural applications it may shape a strong material. Yet in terms of broken tensile power, the formulations are stronger than the comparison concrete.

C). Unlike the BRC with reference materials, its efficiency was substantially poor under flexural handling, relative to the BRC with alternate materials (fly ash, GGBS and m-sand). Perhaps a weak combining of bamboo with substitute materials like concrete may be a cause, since bamboo itself is solid and ductile. Furthermore, the BRC provided more bending power with reference materials than the SRC, which reflects a 6.5 percent strength improvement.

7. Dewi & Nuralinah (2017) published a paper “Strength properties of bamboo and steel reinforced concrete containing manufactured sand and mineral admixtures”, they focused mainly bamboo reinforced. The usage, more easily applied and added benefit in cost and environmental protection of bamboo for environmentally-friendly building materials is very important to research further. The application of the pins along the beam will improve the potential for tensile load bearing. Additional strengthening raises the successful tension from 45 MPa to 90 MPa. A strong radiation-column relation would be possible with the use of fittings for reinforcement including hooks on steel reinforcement. For the next test, another form of pins was important. For precast buildings and earthquake-resistant systems the usage of lightweight materials is very beneficial. In spite of the socially sustainable application of building and manufacturing waste. The Ministry of Engineering Development and Higher Education of Indonesia has performed and funded this work.

8. Siddique et al. (2017) they focused mainly Bamboo reinforcement, Flexure test, and Composite beam. This paper emphasis of behavior of a Composite material that is Bamboo as a Replacement for Reinforcement in concrete. Mechanical properties of Bamboo are studied and basic testing like Water Absorption tests using two different coating, Compression test of bamboo are carried out. The technique for fractional substitution of steel, the bamboo culms is put in beneath the fortification in request to diminish the amount of steel support in a beam component. A correlation is done between the Analytical Results acquired by Analysis of Bamboo Reinforced bars in ANSYS programming to the exploratory outcomes. The level of water ingestion in bamboo covering with polyester pitch was 8.09%. By the Comparison of Ultimate Compressive Strength

(N/mm^2) of Bamboo without Knots and of Bamboo with Knots, we infer that bamboo without hitches have more extreme compressive quality than contrasted with bamboo with ties.

By the Comparison of Ultimate Compressive Strength (N/mm^2) of Bamboo without Knots and of Bamboo with Knots, we infer that bamboo without knots have more extreme compressive quality than contrasted with bamboo with knots. From the graph pressure versus strain of bamboo, it was seen that bamboo shows low modulus of flexibility than steel. So it doesn't turn away splits created in concrete underneath definite burden. Use of polyester tar on to the bamboo culms with reagent and impetus with fine covering of sand brings about diminishing of the water retention in bamboo culms. The modulus of elasticity of steel is a lot higher than concrete. Subsequently, steel will take all the stresses incited because of loading. In any case, in the event of bamboo strengthened solid bar the modulus of elasticity of bamboo is lesser than that of concrete. Consequently, concrete will take all the stresses. This is the purpose behind the beam to fail because of shear. The maximum failure load of the beam is 219KN for 8mm bamboo reinforced beam than compared to other beams.38MPa is the strength in flexure for bamboo reinforced concrete beam with 8mm reinforcement. Maximum deflection of 8mm partially bamboo reinforced beam 2 element at failure is 26.94mm. All the bamboo reinforced specimens failed due to shear Final cracking load of the bamboo reinforced beam element in ANSYS software is 26KN

9. Adom-Asamoah et al. (2017) they focused mainly bamboo, ductility, flexure, RC beams, self-compacting concrete**.** This research aims to analyze the bamboo-reinforced SCC beams' flexural efficiency with ample cross reinforcement. The key construction parameters were the shear span-to-depth ratio, the longitudinal strengthening percentage and the total scale of the field aggregate. Curves of load-deflection, serviceability and final degradation properties, cracking conduct and ductility behavior have been analyzed between the measured frames. The findings suggested that their structural efficiency at operation and ultimate loss should be sufficient if BS 8110 construction code used a content reduction factor of three. The longitudinal strengthening degree will however be about 2.6–3.1 percent in order to achieve optimum ductility. In fact, an improvement in gross size would have a direct effect on the degree of ductility.

10. **Dey & Chetia (2018)** published a paper **"**Experimental study of Bamboo Reinforced Concrete beams having various frictional properties", Flexural power, alliance, columns, low cost housing became their key area of concern. In this research, trials for the use of simple, efficient and economic bamboo reinforced concrete beams were performed. This is a bamboo reinforced concrete beam reference analysis of specific frictional characteristics. The Web content primarily consists of steel rods that withstand the shear of bamboo beams constructed of reinforced concrete. In 4-point bend experiments eighteen these beams were tested to fail. For comparative purposes, the flexural intensity 28, 45 and 60 days are taken into account. If this loss happens, beams with a higher curing duration and a larger strengthening scale were found to work stronger than beaming with a lower curing time and smaller strengthening scale. In fact, higher bond tension for G.I rolling bamboo beams has been achieved.

In recent decades, environmental and natural resources issues have grown. It has been recognized that an inappropriate or insufficient usage of natural capital is simply an environmental violation. In recent years, there have been major shifts in better perception of the viability of housing. Prior focus was paid mainly to technological problems surrounding infrastructure systems, but social development became increasingly apparent as non-technical concerns including the environment advanced. In the environmental growth of civil engineering building, Bamboo reinforced concrete stands as a successful option. In this area many studies were undertaken that help us appreciate the broad nature of the usage of bamboo in reinforced concrete. Bamboos have a high voltage intensity of 250 N / mm2 or greater, which is currently based on crop location, plant size, cross-sectional distance, can be inferred from experimental research. The improvement of bamboo bars in the amount of days of curing time and the change in scale have shown an increased bending efficiency of BRC plate.

11. Eldin & El-Tahan (2016) published a paper **"Experimental study of Bamboo Reinforced Concrete beams having various frictional properties",** they focused mainly on Bamboo, Reinforcement, and concrete. The key purpose of this paper is to cover the absence of knowledge regarding the bamboo: its technical properties, its relations with the ground, its power and its longevity. In contrast to other bamboo strengthened boards, this alternative is explored by experimental studies. This probability is explored. The test findings have been checked and extended with the FE kit ANSYS. Bamboo has been used without care or stirrups in this study. Untreated bamboo has been shown not to be used in concrete beam construction, although its mechanical properties can be seen as equivalent to steel.

12. Awoyera & Babalola (2015) published a paper called "Influence on the mechanical properties of high-strength materials on plate steel, bamboo and high-strength concrete, bending power, compressive strength, tensile strength," which concentrated primarily on steel. This paper was released. This paper examined the effect on high strength concrete of steel and bamboo fibres. Compression, stretching and breaking of tensile strength checks respectively were conducted on prototype concrete blocks, beams and cylinders casted with different amounts of steel and bamboo fiber. Concerns reveal that the 1, 0% bamboo fiber containing concrete has the greatest impact on bending power (81% power increase), as well as splitting strength (101% increase). Bamboo fiber, however, has been shown to have little to no impact on high power concrete's compressive strength. In general, steel fiber-reinforced concrete improved compressive, twisting and separating tensile strength substantially over bamboo fiber-reinforced concreted concrete.

The mechanical properties of designed high solid cement have been investigated for the influence of bamboo and steel fibers. The report found that bamboo fiber had little to no effect on the friction ability of high strength concrete • the findings of the test demonstrated. However, hardened steel fiber allowed a major intensity compressive. This finding has demonstrated that stainless steel fiber strengthens concrete properties. Compressive strength may be concluded that decreased by growing the amount of bamboo fiber. For all sample categories checked, thus, pure concrete produced compressive strength as bamboo fiber reinforced concrete.

• High quality concrete flexural and fracturing tensile properties were significantly improved by incorporating bamboo fiber. Betray comprising 1.0% bamboo fiber recorded the largest bending force impact (81% strong increase). The same fiber quality of bamboo produced the greatest impact on tensile force division (101% increase). The result of this is that bamboo fiber cannot be used in high-fistfight concrete since it does not increase the compressive capacity of the concrete.

• The finding suggests, however, that this fibres, which play a significant part in reducing the spread of cracks in the concrete and in preventing the final breakdown of the concrete, may be ideal for strengthening tensile reinforced concrete.

13. Dewi & Wijaya (2017) have published a paper entitled 'Use of bamboo fiber to reduce cracks in reinforced concrete beams' which examines the use of bamboo fiber for improving the efficiency of reinforced bamboo concrete in the tension cracking zone. A number of experiments have been carried out to accomplish this aim. The beam-size structure is 15 cm x 20 cm x 160 cm, with aggregate bamboo reinforcement and pumice pulp. Sand was painted to become rough on the surface for reinforcing the bamboo. Bamboo fibers will minimize cracking and concrete fluctuation as well as improve the beam load carrying ability after cracking. The findings were shown. Fiber quantity influences workability and concrete consistency. However, the development and propagation of cracks can be stopped with bamboo fiber.

The aim of this research is to investigate the introduction of bamboo fibres. The experimental test was carried out to monitor the performance. The experimental results show that further fibers reduce the cracks in cement width and the load carrying capacity of the concrete after cracking. However, fiber increases will decrease depression or workability and concrete efficiency. 40 grams is the ideal fiber volume to be used in this analysis as a blended aggregate. Introduction of fiber can improve the initial crack load potential and can decrease the crack width of the beam of reinforced cement, avoid the introduction of fibres, and thereby minimize crack development and spread.

14. Dewi M. Dewi A report entitled 'Bamboo reinforced concrete beams with a hose clamp flexural models' (2019) was released concentrating specifically on the concepts of flexural behavior. Although the bamboo surface was slick, the bamboo reinforced cement beam (BRC) did not snap out of cracks, resulting in slip failures between a strip of bamboo and concrete. The research is done using a basic double-pin mirror. The test results indicate that the bending behavior of the BRC rails is distinct from that of the SRC.

The installation of tubular spanners, waterproof coverings and sandblasting on the reinforcing of BRC beams will improve the ability of bamboo reinforcement and concrete, but also have a much lower rigidity than the SRC beam stiffness. The reinforcement of the BRC beams for studying the load deflection relation of BRC beams it is necessary to minimize elastic constants in each blocking sheet. The study reveals how similar to the experimental findings the load-deflection measurement pattern is. The region surrounding the crack is likely to be circular up to the crack point (sustainability).

CHAPTER 3

MATERIALS METHODS & METHODOLOGY

3.1 Cement

Cement is a material, for the most part in powder from, that can be made into a glue ordinarily by expansion of water and, when poured, set into a strong mass. Various natural mixes utilized for following, or affixing materials, are called Cement . Cement, when blended in with coarse total, fine total and water it made concrete. The capacity of Cement is above all else to bind the sand and stone together and second to top off the voids in the middle of sand and stone particles to frame a smaller mass. In the structure and assembling industry, even in tending to explicit specialized issues, we have a wide scope of Cement. 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 widely used cement is Portland cement. Portland cement is manufactured by grinding together calcareous (limestone, chalk, marl, etc.) and argillaceous (shale or clay) materials in approximate proportion of 2:1 and other silica, alumina or iron oxide bearing materials. 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	$3CaOAl2O_3$	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 (Al2O3)	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

Apparatus

Vicat's apparatus with mould, Plunger, Balance, Measuring cylinder, Non-porous plate.

Procedure

A paste of weighed cement content must be prepared for a weighted quantity of drinking water (measuring time not lower than 3 minutes and not higher than 5 minutes). Note the time to measure when water is added to dry cement until the mold is filled. Fill the Vicat'smould with the paste, smoothen and level it to the top of the mould.

- Place the test block and the mould together with a non-porous resting plate under the plunger
- Lower the plunger gently to contact the outside of test specimen and rapidly discharge, permitting it to sink into the paste.
- Prepare trial pastes with various % of water and carry out tests as above until the amount of water necessary for penetration of the Vicat's plunger to 5mm to 7mm from the bottom is determined.

Results

Express the amount of water as % by weight of dry cement.

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
- Time will be recorded with stopwatch from the time the water is added.
- Standard needle will be placed on the test block and time will be observed when the needle fails to pierce the block beyond 5.0 +/- 0.5 mm (measured from the bottom of the mould)
- The time difference between the starting time when water is added to cement to the time mentioned in (v) above will be noted as initial setting time.
- The needle with annular attachment will be used for determining final setting time.
- The cement will be considered as at long last set when after applying the needle tenderly to the outside of the square, the needle establishes a connection subsequently, while the connection neglects to do as such.

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

- Weigh accurately 300 gm. of cement (W1) and place it on a standard IS sieve 90 microns.
- Break down any air set lumps in the sample with finger. But do not rub on the sieve.
- Continuously sieve the sample by holding the sieve in both hands and giving a delicate wrist movement.
- The sieving should nonstop 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

Table 3. 4 Physical Properties of Cement after Testing

Name of the tests	Tested value
Standard consistency test	33 %
Initial setting time	35 min
Final setting time	315mm
Soundness of Cement (Le chatelier expansion)	2.98mm
Fineness of Cement (%age retained on 90 micron IS sieve)	4.6 %
Specific gravity of Cement	2.92
Tensile strength (after 7 days)	2.55 N/mm2
Compressive strength at 3 days 7 days 28 days	 27.6 MPa 32.3 MPa 46.7 MPa

3.4 Fine Aggregates

The sand was first dried, passed through a 5mm sieve to remove any particles greater than 5mm including roots and debris.

3.4.1 Properties of Fine Aggregates

Aggregate is prime constituent of concrete as it provides volume to the concrete. It a chemically inert material, it provides strength and durability to the concrete. For fine aggregate we use locally available sand which pass through 4.75mm sieve. And for coarse aggregate we use aggregate of size 10mm and 20mm conforming to IS: 383-1970.

3.5 Coarse Aggregates

Locally available coarse aggregates having maximum size of 19mm were used in this work. Particle size distribution of the coarse aggregate was also obtained using Malest Auto sieve shaker.

3.6 Tests on Aggregates

3.6.1 Sieve Analysis of Fine Aggregates

To determine the gradation of fine aggregates

Apparatus

Sieves of the sieve 10mm, 4.75mm, 2.36mm, 1.18mm, and 600micron 300 micron 150 micron and 75 micron, Balance and standard weights, Oven.

Sample

Fine aggregate

Procedure

- Take about 500 gm. of sand.
- Air-dry the sample either at room temperature or by heating it in an oven at temperature of 100 degree C to 110deg C. The air-dry sample shall be weighed and sieved successively on appropriate sieves.
- Each sieve shall be shaken separately over a clean tray for not less than 2 minutes Light brushing may be used on the 150 & 75 micron sieves to prevent blinding of apertures.
  - Cumulative proportion of cumulative sample weight moving to the closest total amount each of the sieves.
  - The weight percentage of the main seven study, held to a minimal 0.1% by the next smaller seven •
- Grading zone is ascertained by checking against permissible limits of Table-4 of IS-383 1972

- Fineness Modulus is calculated by Sum of cumulative % retained divided by 100.

Results

Fineness Modulus = (Sum of cumulative % retained)/100.

3.6.2 Sieve Analysis of Coarse Aggregates

To regulate the gradation of coarse aggregates

Apparatus

Sieves of sizes 25mm, 20mm, 10mm, 4.75mm & 2.36mm, Balance, Oven

Samples

Coarse Aggregates

Procedure

- Weight before the quartering / division of the complete sample coarse aggregate and tray shall be 25 kg. For through study in the grade of 20 mm, the required sample weight is 2.0 Kg.

- Before measuring and sieving, the sample must be air-dry. Either drying at temperature in rooms or heating at 1000 C to 1100 C. may be accomplished. This is finished.

- Weigh and extreme air dry tests on the fitting sieves, beginning with the larger one, successively. Be vigilant to insure that the sieves are clean prior to using.

- Each sieve must be shaked on a clean tray independently for a duration of no longer than two minutes before no longer than one trace passes.

- Shaking shall be done with a variety of motions, back and forth, left to right, circular in clockwise and counter-clockwise, and frequently jarring, so that the material moves frequently over the sieve surface.
- Content must not be pushed by the hand pressure via the sieve, although it is permissible for particle putting on sieves that are coarser than 20 mm.

- Delicate materials may be cut with the finger on the side of the sieve by gentle pressure when current.

3.7 Impact Test

This test was performed according to IS: 2366 (Part IV) - 1963. The aggregate impact value test gives relative measure of the resistance of an aggregate to sudden shock or impact.

Apparatus

Impact testing machine (metal base),A cylindrical steel cup of internal dimensions: dia. – 102 mm & depth – 50 mm, A metal hammer balancing 13.5 to 14 k, Means for raising the hammer and allowing it to freely fall between the vertical guides from a height of 380 + 5 mm, IS sieves of sizes 12.5, 10 & 2.36 mm, A cylindrical metal measure, of sufficient rigidity to retain its form under rough usage, A straight metal stamping rod of circular cross-section 10mm in dia. and 230mm long, rounded at one end. Balance of capacity not less than 500gmsreadable and accurate to 0.1gm. A suitable oven thermostatically controlled to maintain a temperature of 1000 C to 1100 C.

Samples:

Coarse Aggregate 100 to 200 gms.

Procedure

- The impact machine shall rest without wedging or packing upon the level plate.
- The hammer shall be elevated until the bottom side is 380 mm over the top of the cup and may land on the mixture freely.

Figure 3. 4 Impact Apparatus

Table 3. 5 Test results of coarse aggregate & Fine aggregates

S. No	Properties	Experimental Values	
		Coarse Aggregate	Fine Aggregate
1	Water Absorption	0.65%	0.50%
2	Specific gravity	2.68	2.64
3	Crushing Value	18.22%	-
4	Impact Value	12.90%	-
5	Fineness Modulus	6.19	2.67
6	Bulking Of Sand	-	30.21%

Water: Generally water that is satisfactory for drinking is also suitable for use in concrete. In this work portable water suitable for human consumption was employed in the experimental procedures.

Concrete: Concrete of grade M25 was used in the research and W/C ratio of 0.5 was used. The cement content used in the mix design is 380 kg/m3. The mix proportion of 1:1.8:3.08 (where 1is for cement 1.8 for fine aggregate and 3.08 for coarse aggregate of size 10mm to 20mm).

3.8 Slump Test

The workability of all concrete mixture was determined through slump test. The slump tests were performed according to IS 1199-1959.

Apparatus

Frustum of a cone, tamping rod.

Procedure

• Washing and removal of moisture and any collection of concrete from the inner surface of the mold prior to processing.

• A flat, rectangular, solid and non-absorbent surface shall be put in the mold such as a precisely planed metal plate, which should be held strong throughout the filling.

• Approximately one fifth of a mold heighten shall be lined with four layers of the mold.

• The rounded end of the rod is tamped with 25 strokes each sheet.

• The stroke shall be distributed over the mold cross-section in a standardized fashion and penetrated into the underlying layer for the second and corresponding parts.

• The cement must be hit down with a trowel or tamping handle, until the top layer has been flattened, so that the mold is filled precisely • any mortar that may be leaked between the mould and the base plate is withdrawn. •

• The mold shall be automatically lifted off the concrete by moving it in the vertical direction gradually and carefully.

• This helps the concrete to fall and the slump is weighed at once to determine the gap between the mold height and the maximum level of the test specimen.

Figure 3. 5 Slump Cone

Table 3. 6 Workability, Slump of Concrete with 20mm or 40 mm maximum size of aggregates

Degree of Workability	**Slump (mm)**
Very Low	-
Low	35-75
Medium	65-115
High	115-150

Mix proportions (Concrete mix proportion)

To design M25 grade concrete

Characteristic strength = 25 N/mm2

Quality control degree= good

Maximum size (aggregate) = 20 mm

Specific gravity-

Coarse aggregate = 2.68

Fine aggregate = 2.64

Cement = 2.92

Type of exposure = Moderate

Weight -

Water = 197 kg/m3

Cement = 450 kg/m3

Fine aggregate = 704.89 kg/m3

Coarse aggregate = 1529.1 kg/m3

The variations have been assigned according to the mix template system IS 10262-2009. The M 25 mixing measurements were modeled on the basis of the tests. Prepared was the concrete blend with a 0.47 w / c ratio. The specifications of the 1 m3 concrete blended proportions are seen in the Table.

Table 3. 7 Material required for 1m3 of Concrete (Kg/m3)

Grade	Cement (kg)	FA (kg)	CA (kg)	Water (lit)
M25	420	790	1010	197

Is the IS mix design approach used in the preparation of the mix design for bamboo enhanced specimens, using standard steel reinforced concrete? But concrete slumps are low as workability allows excess water to be minimized, which leads to bamboo swelling.

3.9 Properties of using Bamboo

Owing to its identical chemical composition bamboo physical structure is generally related to wood products. Bamboo differentiates from the forest the internal form. Wood has anisotropic properties and includes grains that are aligned across the whole system in the same direction. Branches grow on the outside edge of each branch, forming different types of herbal structures. Bamboo includes parallel fibers reinforced around the Culm axis.

Bamboo, like timber, shifts its proportions as it gets moisture or loses. The moisture content in bamboos differs in height, position and seasoning time, which is a key determinant of existence for the bamboo. This skill allows it possible to use Bamboo as a replacement for building strengthening. The immense elasticity of bamboo renders it a very good construction tool for vulnerable parts of the earthquake. Bamboo also has a small weight advantage. It can be easily transported and operated, thereby making it impossible to use cranes and other massive machines.

CHAPTER 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 Specimens used for tensile testing

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

Test The assurance of flexural quality is basic to gauge the load at which the concrete member may crack. The flexural tests were completed on shaft example under standard four point loading was finished adjusting to IS516-1959. The flexural quality decide by testing standard test examples of 150mmx150mmx700mm under four point stacking. Load vs deflections estimations are watched. A definitive burden at disappointment was noted.

Figure 4. 4 beam specimen

Two concentrated load at one third span were applied on beam. The flexural relies upon the dimensions of the beam and way of the supporting range that is dispersed at 666.67mm to focus to fixate or on either side of bar was place opposite to the applied power without eccentricity. There LVDT having a least check of 0.01mm is fixed at the center, one fourth of the range and under the load purpose of the set upToward the finish of each load addition,observation and measurement were recorded for load point avoidance,deflection and crack development and propagation on the beam surfaces. The load at first crack, ultimate load, type of failure etc., were carefully observed and recorded. The specimens were loaded continuously at a constant rate till failure

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

Bamboo specimen preparation:

- The length of specimens is between 762 and 1067 mm.
- Any form of weak and decayed portions was avoided.
- The diameter of each specimen was measured at three locations using Slide Calipers and
- The average values were calculated.
- Three samples were taken in natural condition as shown in the Fig.4.5

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.

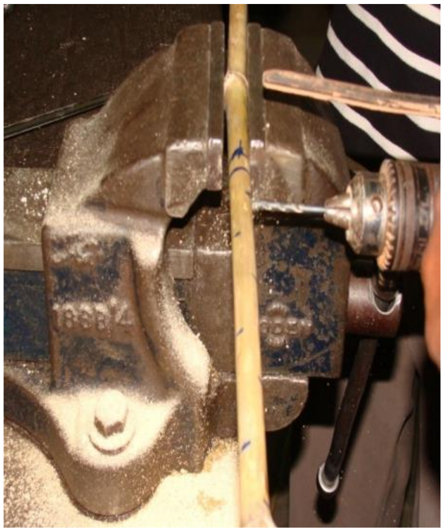

Figure 4. 7 Making Hole by Using Drill Machine,

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

4.2 Preparation of Beams

4.2.1 Types of beam and their Design

The goal of that investigation is to recognize the viability of using bamboos as concrete reinforcement, i.e. the conventional reinforcement, and measure their actions against steel. Two beams have been chosen for this build. Steel reinforced reinforcing Reference beams in all sizes have been chosen with a Fe 415 type reinforcement panel. Below is a table demonstrating the configuration of the beam of steel reinforced concrete (SRC).

Table 4. 2 Design of steel reinforced concrete (SRC) beam

Type of beam	SRC1 beam	SRC2 beam
size of beam	150 x 150 x 700 mm	150 x 200 x 700 mm
Grade of concrete	M25	M25
Grade of steel	Fe-415	Fe-415
Design constants a) Limiting value of percentage reinforcement , Pt,lim b) Limiting value of depth of neutral axis, xu,lim	Pt,lim = 1.19 % xu, lim = 0.48d	Pt,lim = 1.19 % xu,lim = 0.48d
Percentage reinforcement provided, Pt	1.20 %	0.86 %
Reinforcement provided	2 no. 12mm diameter bars	2 no. 12mm diameter bars
Type of section	Balanced (as Pt = Pt,lim)	Under-reinforced (as Pt<Pt,lim)
Cover	25 mm	25 mm
Stirrups	8 mm diameter 2 legged Stirrups	8 mm diameter 2 legged Stirrups
Spacing of Stirrups	180 mm C/C	180 mm C/C
No of Compression Bar	2	2

4.2.2 Bamboo reinforced concrete (BRC) beam

Clear construction requirements are not valid for BRC & TBRC beams. The reinforcement area given in BRC and TBRC beams was then retained the same as the reinforcement area given in the SRC beam for both sizes.

Table 4. 3 bamboo's Design reinforced concrete (BRC) beam

Type of beam	BRC1 beam	BRC2 beam
size of beam	150 x 150 x 700 mm	150 x 200 x 700 mm
Grade of concrete	M25	M25
Type of reinforcement bars	Bamboo sticks	Bamboo sticks
Percentage reinforcement provided	1.20 %	0.86 %
Reinforcement provided	2 bamboo sticks of about 12 mm diameter	2 bamboo sticks of about 12 mm diameter
Cover	25mm	25mm
Stirrups	8 mm diameter 2 legged Stirrups	8 mm diameter 2 legged Stirrups
Spacing of Stirrups	180 mm C/C	180 mm C/C
No of Compression Bar	2	2

4.2.3 Treated bamboo reinforced concrete (TBRC) beam

Bamboo sticks have been selected and sawn for three weeks in this form of board. The bamboo bags have then been roughened with a knife and a thin coal tar coat has been spread on the floor. The sand was poured onto the coat of paint shortly afterwards. The sand was applied to the paint sheet and would then enhance the linking motion in the TBRC beams between bamboo sticks and concrete. The bamboo bags were then allowed to cure the paint for 48 hours, then these handled bamboo bags were used to cast both-size TBRC beams.

Table 4. 4 Treated bamboo reinforced concrete (TBRC) beam's Design

Type of beam	TBRC1 beam	TBRC2 beam
size of beam	150 x 150 x 700 mm	150 x 200 x 700 mm
Grade of concrete	M25	M25
Type of reinforcement bars	Treated bamboo sticks	Treated bamboo sticks
Percentage reinforcement provided	1.20 %	0.86 %
Reinforcement provided	2 treated bamboo sticks of about 12 mm diameter	2 treated bamboo sticks of about 12 mm diameter
Cover	25mm	25mm
Stirrups	8 mm diameter 2 legged Stirrups	8 mm diameter 2 legged Stirrups
Spacing of Stirrups	180 mm C/C	180 mm C/C
No of Compression Bar	2	2

4.3 Experimental setup of flexural strength test

This research was carried out on beams 150 x 150 x 700 mm & 150 x 200 x 700 mm afterward 7 ,14 to 28 days of curing under bending-check system in compliance with IS: 516-1959.

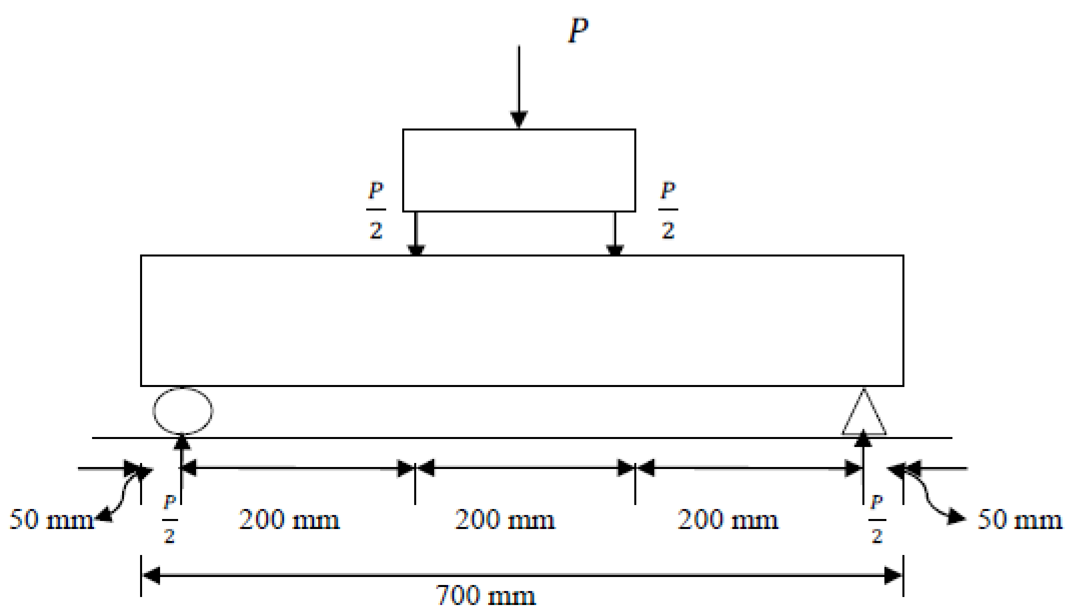

Figure 4. 11 A flexural strength and arrangement

Flexural strength (N/mm^2), $f = \frac{PL}{bd^2}$ and Bending moment, $M = \frac{PL}{6}$

Where, P = maximum load
L = Span of beam (600mm)
b = Width of the beam,
d = Depth of beam

Failure outline of behavior of beams are exposed in fig. 4.12.

(a) **(b)**

(c) **(d)**

Figure 4. 12 Failure of beam, Plain cement concrete, bamboo reinforced concrete beam , steel reinforced concrete beam

CHAPTER 5

RESULTS AND DISSCUSSION

5.1 Flexural strength

Bamboo beams (BRC), treated beam reinforced bamboo (TBRC) and steel reinforced concrete (SRC) beams were tested for all sizes of flexural intensity (150x150x700 mm and **150 x 200 x 700 mm**), and the experiments were conducted on single concrete beams (PCC) (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 of TBRC was greater than the flexing force of BRC, 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.

Table 5. 1 Flexure test results of PCC1, BRC1, TBRC1 and SRC1 beams at 7, 14 & 28 days

Beam designation	Avg. Flexural	Percentage variation in	Avg. Flexural	Percentage variation in	Avg. Flexural	Percentage variation in
for beam of size	strength at 7	flexural strength with respect to PCC1 beam	strength at 14	flexural strength with respect to PCC1 beam	strength at 28	flexural strength with respect to PCC1 beam
150 x 150 x 700	days (N/mm2		days (N/mm2		days (N/mm2)	
mm						
PCC1 beam	2.68	0%	3.01	0.00%	3.88	0%
BRC1 beam	3.57	38.88%	4.10	36.32%	5.99	57.23%
TBRC1 beam	4.89	56.33%	6.10	48.80%	6.59	69.73%
SRC1 beam	10.9	293.91%	13.46	221.65%	14.84	278.80%

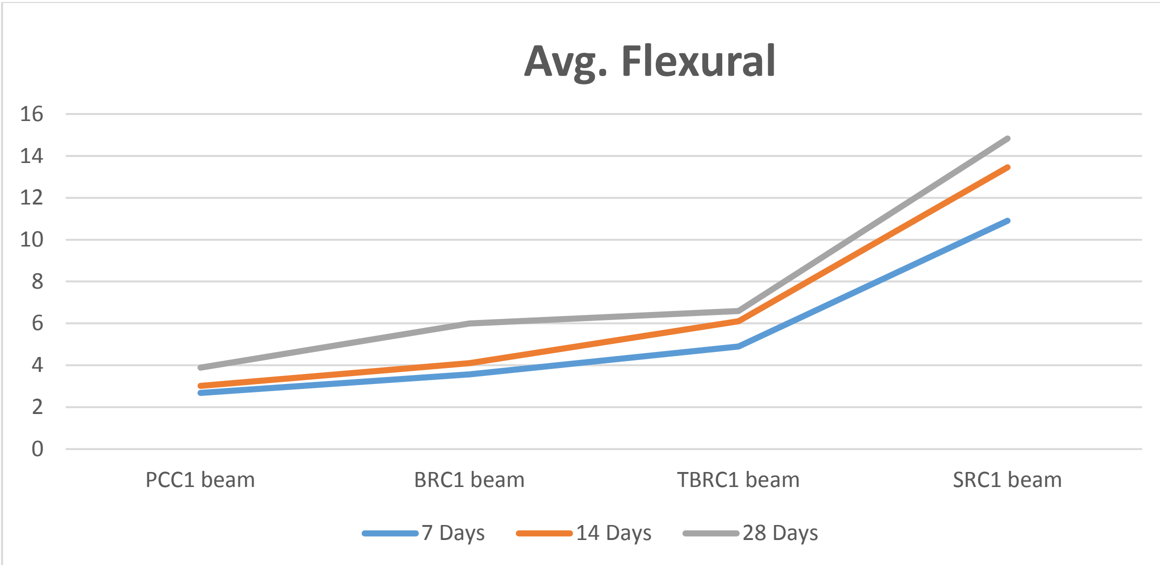

Figure 5. 1 Figure shows that the avg. flexural strength in 7 ,14 and 28 days

Fig above, the flexural strength of PCC1 beam with respect to other BRC1, TBRC1 and SRC1 beams at 7, 14 and 28 days are found 5.99 N/mm2, 6.59 N/mm2 and 14.84 N/mm2 respectively.

Table 5. 2 Flexure test results of PCC2, BRC2, TBRC2 and SRC2 beams at 7 & 28 days

Beam designation	Avg. Flexural	Percentage variation in	Avg. Flexural	Percentage variation in	Avg. Flexural	Percentage variation in
for beam of size 150 x 200 x 700 mm	strength at 7	flexural strength with	strength at 28	flexural strength with	strength at 28	flexural strength with
	days (N/mm2	respect to PCC2 beam	days (N/mm2	respect to PCC2 beam	days (N/mm2)	respect to PCC2 beam
PCC2 beam	2.98	0%	3.59	0%	4.18	0%
BRC2 beam	3.88	30.20%	5.09	41.00%	6.27	50%
TBRC2 beam	4.48	50.34%	5.60	55.98%	6.76	64.12%
SRC2 beam	10.92	266.44%	12.55	249.58%	14.89	258.13%

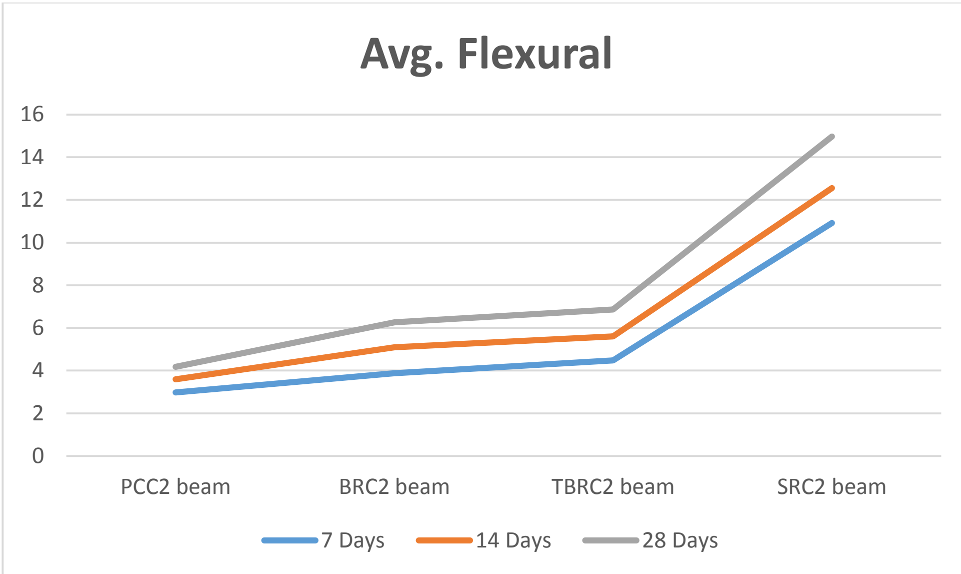

Figure 5. 2 Figure shows that the avg. flexural strength in 7 ,14 and 28 days

Fig above the flexural strength of PCC2 beam with respect to other BRC2, TBRC2 and SRC2 beams at 7, 14 and 28 days are found 6.27 N/mm2, 6.76 N/mm2 and 14.89 N/mm2 respectively.

Table 5. 3 Tension Test for Bamboo Reinforcement

Specimen No.	Avg. Area (mm2)	Failure Load (kN)	Stress at Failure (MPa)	Failure type
1	195	17.9	85.9	Splitting and failure at grip
2	183	19.5	107.6	Failure at node
3	150	24.5	154.5	Splitting and failure at grip

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).

Table 5. 4 Max Deflection (mm) and Ultimate load (kN) (Specimen-1)

Max Deflection (mm)	Ultimate load (kN)
8	1
15	3
23	4
33	6
42	10
57	16
64	18
77	22
83	34
88	40
90	50

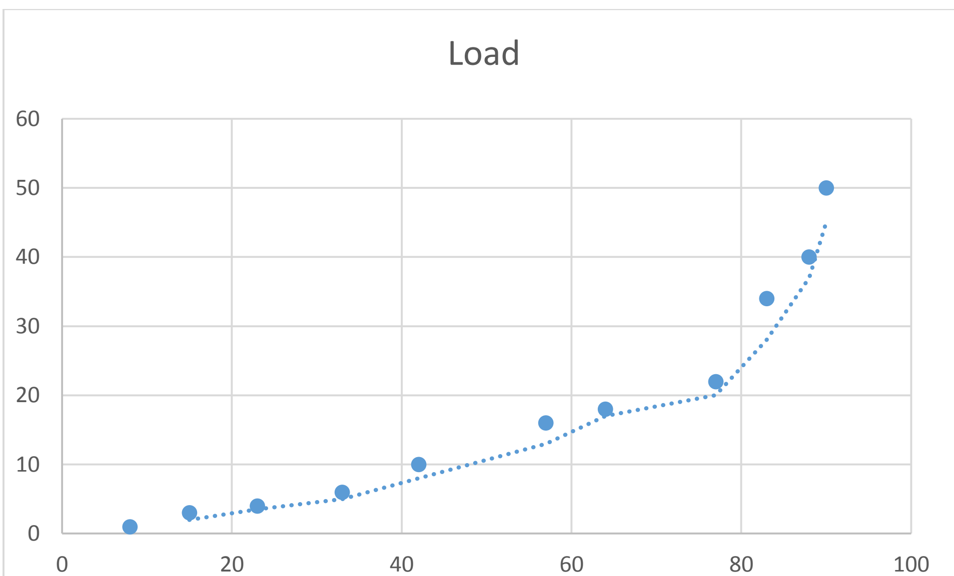

Figure 5. 3 Max Deflection (mm) vs. Load Ultimate load (kN) specimen -1

Table 5. 5 Strain and Stress (N/mm) (Specimen-1)

Strain	**Stress (N/mm)**
0.3	0.005
0.6	0.01
1.05	0.015
1.5	0.02
1.90	0.024
2.50	0.028
2.75	0.037
3.5	0.048
3.65	0.06
3.80	0.78
4.0	0.1

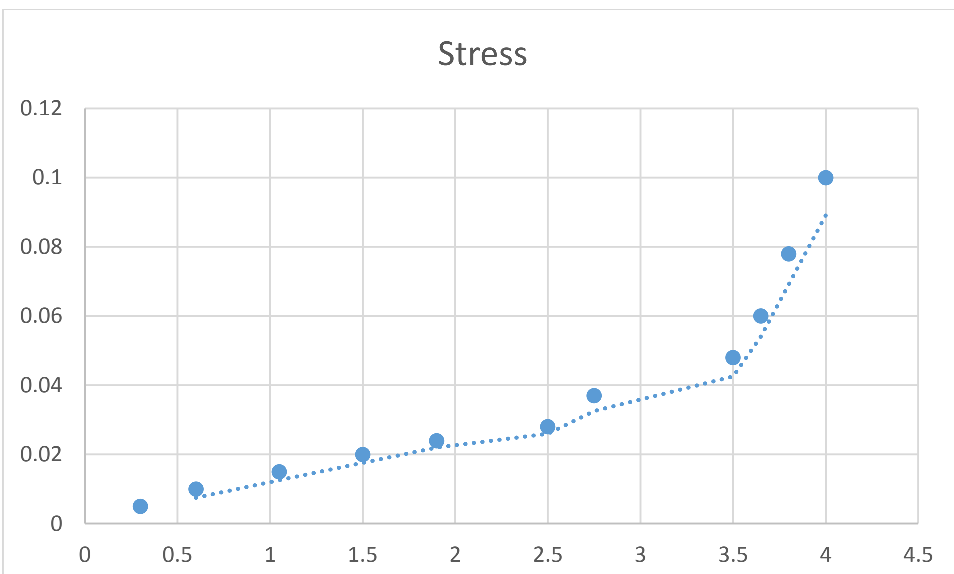

Figure 5. 4 Strain vs. Stress (specimen -1)

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

Table 5. 6 Max Deflection (mm) and Ultimate load (KN) (Specimen-2)

Max Deflection (mm)	Ultimate load (kN)
1	5
3	12
5	24
6	32
10	42
15	55
18	62
25	75
30	80
40	88
50	92

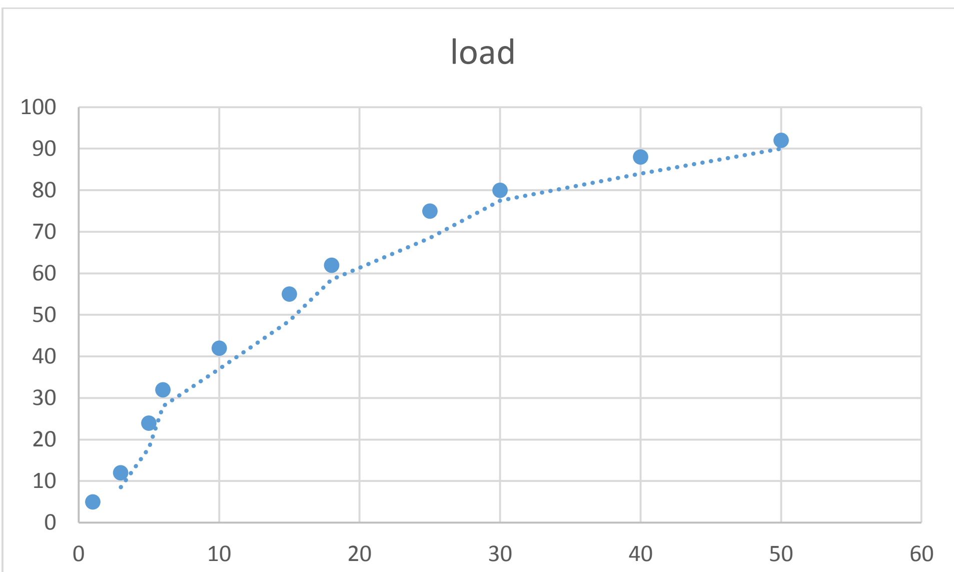

Figure 5. 5 load vs. deflection specimen -2

Graph (stress vs. strain)

Table 5. 7 Strain and Stress (N/mm) (Specimen-2)

Strain	Stress (N/mm)
0.005	0.1
0.015	0.5
0.02	1
0.021	1.5
0.025	1.9
0.03	2.5
0.04	2.75
0.048	3.3
0.06	3.7
0.08	3.9
0.1	4

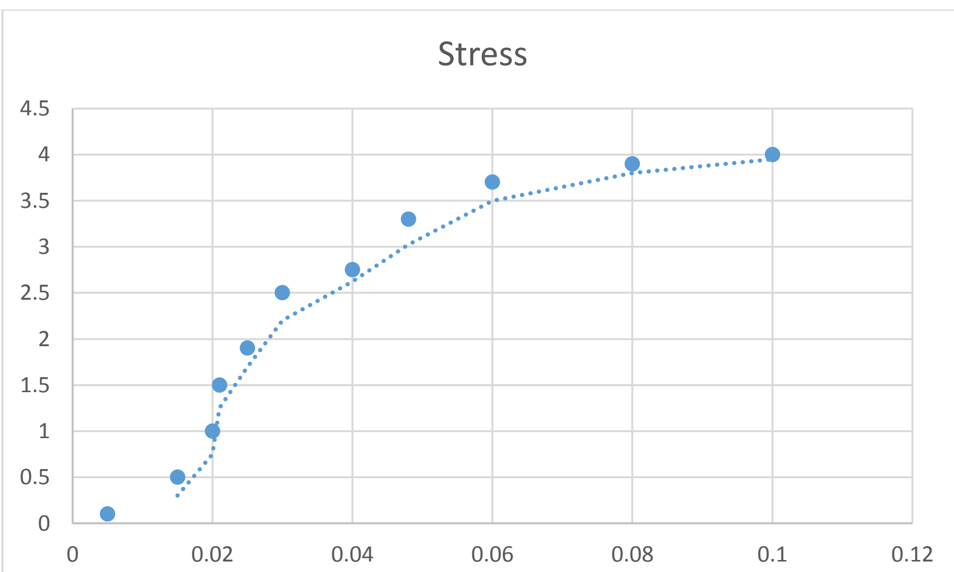

Figure 5. 6 stress vs. strain specimen -2

Graph (load vs. deflection)

Table 5. 8 Max Deflection (mm) and Ultimate load (KN) (Specimen-3)

Max Deflection (mm)	**Ultimate load (kN)**
0	0
0.5	2.5
0.6	5
1	6
2	7.5
4	10
9	15
12	16
20	22
30	25
40	27
50	28
60	28

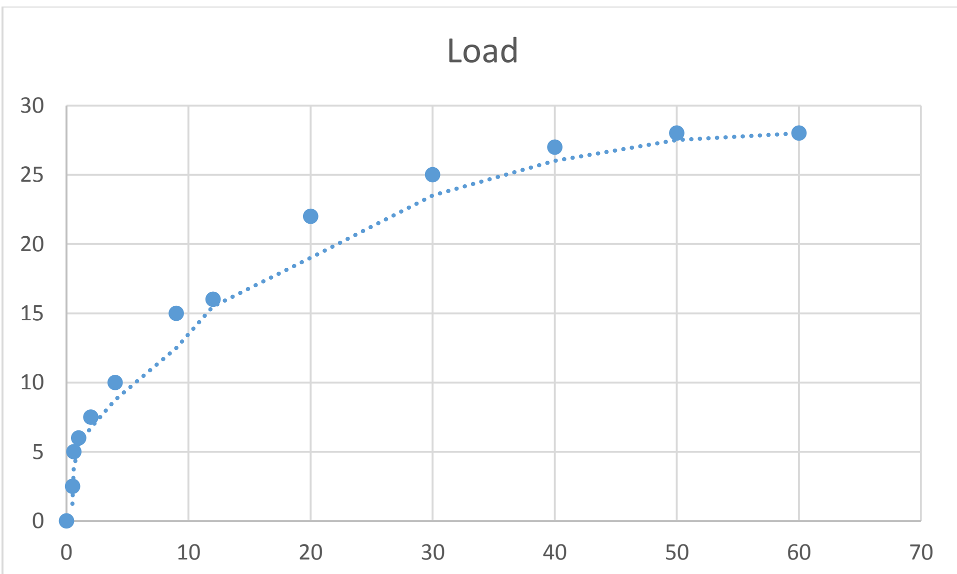

Figure 5. 7 load vs. deflection specimen -3

Graph (stress vs. strain)

Table 5. 9 Strain and Stress (N/mm) (Specimen-3)

Strain	Stress (N/mm)
0	0
1000	0.005
1100	0.01
3000	0.02
8000	0.03
10000	0.031
15000	0.035
20000	0.04
25000	0.048
30000	0.05
40000	0.52
50000	0.55
60000	0.54
70000	0.54

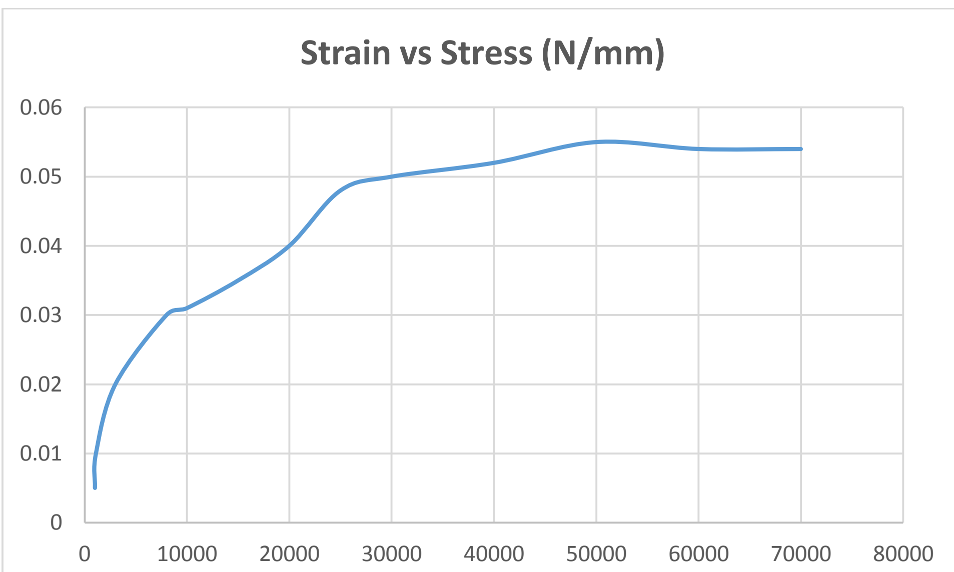

Figure 5. 8 stress vs. strain specimen -3

CHAPTER 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 commonly 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 the tensile strength of reinforced concrete has led many scientists and engineers to 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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