“EXPERIMENTAL STUDY OF BAMBOO REINFORCED CONCRETE BEAMS”

Submitted By

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Department of Civil Engineering

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Certification

The thesis titled "**Experimental Study of Bamboo Reinforced Concrete Beams**" Submitted by has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Civil Engineering on May 2023. To the best of our knowledge, Except for properly cited external sources, this thesis consists of original research and does not rely on the work of others.

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We hereby attest that we are the sole author of this thesis and that no part of it, nor the entire thesis, has been submitted to any other university or institution for a degree. We certify that this project report, **Experimental Study of Bamboo Reinforced Concrete Beams** is done by Department of Civil Engineering, Daffodil International University. We are announcing that this project is our unique work, we additionally proclaim that this undertaking works are unique and have never been submitted in its entirety for any degree or diploma at this university.

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Dedicated to

We dedicate this work to Almighty Allah, also thankful to our Parents, and our respected Teachers who have always supported us.

Abstract

This thesis presents an experimental study focused on investigating the structural behavior of bamboo-reinforced concrete beams. Bamboo, as a sustainable and renewable resource, has gained significant attention in recent years as a potential alternative to conventional steel reinforcement in structural elements. The research aims to evaluate the flexural performance and load-carrying capacity of bamboo-reinforced concrete beams by conducting a series of laboratory tests. The experimental program includes the fabrication and testing of multiple beam specimens with varying bamboo reinforcement configurations, such as different bamboo types, lengths, and orientations. The parameters investigated include ultimate strength, deflection characteristics, crack propagation, and failure modes. The test results are compared with control beams reinforced with conventional steel bars to assess the feasibility and effectiveness of bamboo reinforcement. In this experiment, if 25% bamboo is used then there is a crushing moment near the reinforced beam. The findings from this study provide valuable insights into the potential utilization of bamboo as an eco-friendly alternative of reinforcement material in civil engineering structures. The outcomes also contribute to sustainable development by promoting the use of renewable resources in the construction industry.

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List of Abbreviation

BRC	Bamboo Reinforced Concrete
BRB	Bamboo Reinforced Beam
BCS	Bamboo Concrete System
BAC	Bamboo and concrete composite
BCC	Bamboo-cement composite
BDC	Bamboo-dowel composite
BLC	Bamboo-leaf composite

CHAPTER ONE
INTRODUCTION

1.1 Introduction

Bamboo is a fast-growing, renewable plant that has been used for centuries as a building material in various parts of the world. Its unique combination of strength, flexibility, and sustainability makes it a promising alternative to traditional building materials like steel and timber. In recent years, bamboo has been gaining increasing attention as a potential reinforcement material in concrete, a widely used construction material. The resulting material, known as bamboo reinforced concrete (BRC), offers several advantages over traditional reinforced concrete, including improved strength, durability, and sustainability [1]. BRC has become increasingly popular due to its eco-friendliness, as bamboo is a low-carbon material with a high strength-to- weight ratio. This makes it a promising alternative to steel reinforcement, which has a high carbon footprint and requires significant energy inputs during production. Bamboo, on the other hand, is a highly renewable and sustainable resource that can be grown and harvested without causing significant damage to the environment. The use of bamboo as a reinforcement in concrete has been researched and experimented with for several decades [2]. The earliest known instance of BRC being used in a construction project was in the 1950s, when it was used as a substitute for steel in some small-scale construction projects in Japan. However, it was not until the 1990s that the use of BRC gained significant attention, with a number of research studies being conducted on the properties and performance of the material. BRC offers several advantages over traditional reinforced concrete. One of the main advantages is its strength. Bamboo is a highly fibrous material, and when used as reinforcement in concrete, it can provide a significant increase in tensile strength. This means that BRC can withstand greater forces and is less likely to crack or fail under load. BRC also offers a higher strength-to-weight ratio than traditional reinforced concrete, making it a more efficient use of materials and reducing the overall weight of the structure [4].

In addition to its strength, BRC also offers improved durability over traditional reinforced concrete. Bamboo has a natural resistance to pests and rot, which means that it is less likely to be damaged by insects or fungi over time. This makes it a good choice for construction projects in humid or tropical climates, where traditional reinforcement materials like steel can be prone to corrosion and deterioration. Another advantage of BRC is its eco-friendliness. Bamboo is a low-carbon material that can be grown and harvested sustainably, making it a more environmentally friendly choice than steel or other traditional reinforcement materials. Using bamboo in construction can help to reduce the overall carbon footprint of a project, which is becoming

increasingly important as the construction industry seeks to become more sustainable. Despite its many advantages, BRC also has some challenges and limitations that must be considered. One of the main challenges is the lack of standardization and regulation in the use of bamboo as a reinforcement material. Unlike steel, which has well-established standards and guidelines for its use in construction, the use of bamboo in BRC is still in the experimental stages [5]. This means that there is a lack of consistent testing and quality control measures in place, which can make it difficult to ensure the reliability and safety of BRC structures.

Another challenge of BRC is the potential for moisture absorption, which can cause the bamboo to swell and weaken over time. This can be particularly problematic in humid or wet environments, where the moisture content of the concrete can be high. To address this issue, researchers are exploring the use of treatments and coatings to protect the bamboo from moisture and improve its durability over time. Bamboo reinforced concrete is a promising and innovative material that offers a range of benefits over

1.2 Background of the study

The background of the study on bamboo reinforced concrete (BRC) involves the growing interest in finding sustainable building materials that reduce environmental impact and provide cost-effective solutions for construction projects. Traditional reinforcement materials, such as steel, have been widely used in the construction industry for many years, but they are associated with a high carbon footprint and significant energy inputs during production. The use of bamboo in BRC offers an eco- friendly and renewable alternative to traditional reinforcement materials, while providing similar or even better performance in terms of strength, durability, and cost- effectiveness. Bamboo is a highly renewable resource that has been used for centuries as a building material in various parts of the world. However, its potential as a reinforcement material in concrete has only recently been explored in more detail. In the 1990s, a number of research studies were conducted on the properties and performance of BRC, with promising results. Since then, the use of BRC has gained increasing attention, particularly in developing countries where bamboo is abundant and affordable. BRC offers several advantages over traditional reinforced concrete, including improved strength, durability, and sustainability. Bamboo is a highly fibrous material that provides a significant increase in tensile strength when used as reinforcement in concrete, making it a more efficient use of materials and reducing the overall weight of the structure.

In addition, bamboo has a natural resistance to pests and rot, which makes it a good choice for construction projects in humid or tropical climates.

However, the use of bamboo in BRC also presents some challenges and limitations that must be considered. The lack of standardization and regulation in the use of bamboo as a reinforcement material can make it difficult to ensure the reliability and safety of BRC structures. In addition, the potential for moisture absorption in bamboo can weaken the material over time, which requires further research and development to improve its durability.

In summary, the background of the study on BRC involves the growing interest in finding sustainable building materials that reduce environmental impact and provide cost-effective solutions for construction projects. The use of bamboo in BRC offers an eco-friendly and renewable alternative to traditional reinforcement materials, while providing similar or even better performance in terms of strength, durability,and cost- effectiveness. The study aims to explore the properties and performance of BRC,as well as identify ways to improve its reliability and durability over time.

1.3 Scope of the study

The scope of the study on bamboo reinforced concrete (BRC) involves the investigation of the properties, performance, and potential applications of BRC as a sustainable and cost-effective alternative to traditional reinforcement materials. The study will focus on the following areas:

Materials: The study will investigate the physical and mechanical properties of bamboo as a reinforcement material, as well as the properties of concrete when reinforced with bamboo. The study will also explore the effect of different processing and treatment methods on the performance of BRC.

Performance: The study will evaluate the structural performance of BRC through experimental testing, including tensile, compressive, and flexural strength, as well as durability and resistance to environmental factors such as moisture and corrosion.

Applications: The study will explore the potential applications of BRC in various construction projects, including buildings, bridges, and other infrastructure. The study will also consider the economic feasibility and cost-effectiveness of using BRC in comparison to traditional reinforcement materials.

Future research: The study will identify areas where further research is needed to improve the performance and durability of BRC, as well as explore the potential for combining bamboo with other sustainable materials to further enhance the eco-Friendliness of the construction industry.

The study aims to contribute to the growing body of research on sustainable building materials and provide valuable insights into the potential of bamboo reinforced concrete as a viable alternative to traditional reinforcement materials.

1.4 Objective

The objectives of the study on bamboo reinforced concrete (BRC) are as follows:

- ❖ To investigate the physical and mechanical properties of bamboo as a reinforcement material, including tensile, compressive, and flexural strength.
- ❖ To evaluate the structural performance of BRC through experimental testing, including tensile, compressive, and flexural strength.
- ❖ To compare the performance of BRC to traditional reinforcement materials, such as steel, in terms of strength.

The objectives of the study aim to provide valuable insights into the properties, performance, and potential applications of bamboo-reinforced concrete as a sustainable and cost-effective alternative to traditional reinforcement materials. The study also aims to identify areas where further research and standardization are needed to ensure the safety and reliability of BRC structures, as well as explore the potential for further innovation in sustainable building materials.

1.5 Research Outline

The thesis consists of six chapters and an accompanying annex. In the first chapter, you will find an overview of the problem, a declaration of the study's purpose and scope, and a brief statement of your overall thesis. An examination of precedents studies, as well as the most salient data drawn from the cited sources, is presented in

Chapter 2. The study provides a thorough description of, and incorporation of, the various researches that have been conducted in specific parts of the overall study region.

Chapter 3. Primarily, this chapter introduces the reader to the necessary resources and testing protocol for this thesis.

Chapter 4, we get a high-level overview of the research methods used. Everything from how the study was conducted to what instruments were used to collect the data is detailed here. This chapter also provides a succinct summary of the approach that will be employed to achieve the study's goals.

Chapter 5 discusses the findings and the related debates. Findings and recommendations are discussed in the last, sixth chapter.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Bamboo reinforced concrete (BRC) is a relatively new area of research that has the potential to revolutionize the construction industry. Previous research has shown that the addition of bamboo fibers to concrete can improve the mechanical properties and durability of the concrete, including increasing the flexural strength and toughness, reducing shrinkage and cracking, and improving the resistance to environmental factors such as moisture, temperature, and corrosion. Additionally, bamboo has high tensile strength, toughness, and ductility, which make it a promising reinforcement material for concrete. However, further research is needed to fully understand the properties and behavior of BRC and to develop standards and regulations for its use in construction. Bamboo has been used as a construction material for thousands of years in many parts of the world, especially in Asia, South America, and Africa. Its properties, such as its high strength-to-weight ratio, fast-growing and renewable nature, and sustainability, have made it a popular choice for various construction applications. With the increasing demand for sustainable and eco-friendly building materials, bamboo reinforced concrete has emerged as a potential alternative to traditional reinforcement materials in concrete construction. The current literature on BRC has demonstrated that it has numerous benefits, including improved mechanical properties and durability, reduced environmental impact, and potentially lower costs. The use of BRC has also gained traction in recent years in developing countries due to the availability of bamboo and the potential to reduce the carbon footprint of construction. Despite the promising results, more research is needed to fully explore the potential of BRC, including investigating its long-term durability and behavior under various conditions, and to establish industry standards and regulations to ensure its safe and effective use in construction.

2.2 Overview of the use of bamboo in construction

Bamboo has been used as a construction material for thousands of years in many parts of the world, especially in Asia, South America, and Africa. Bamboo is a fast-growing, renewable, and sustainable material with high strength-to-weight ratio, and it has been used in various applications, such as scaffolding, flooring, wall panels, and even as a structural element in buildings and bridges. Bamboo can be used in a variety of construction applications, such as scaffolding, flooring, walls, roofs, and even as a substitute for steel and concrete reinforcement.

2.3 Previous research on bamboo reinforced concrete

Several studies have been conducted on the use of bamboo as a reinforcement material in concrete. For example, a study by Jiang et al. (2016) investigated the mechanical properties of bamboo reinforced concrete, and found that the addition of bamboo fibers increased the flexural strength and toughness of the concrete. Another study examined the durability of bamboo reinforced concrete in aggressive environments, and found that bamboo fibers improved the resistance to chloride ion penetration and reduced the risk of corrosion [3].

Previous research on bamboo reinforced concrete (BRC) has demonstrated its potential as a promising alternative to traditional reinforcement materials in concrete construction [4]. Studies have shown that the addition of bamboo fibers or strips can significantly improve the mechanical properties and durability of concrete. Research has found that BRC exhibits improved flexural strength, toughness, and ductility, as well as reduced shrinkage and cracking compared to traditional concrete [5].

BRC has also been found to have better resistance to environmental factors such as moisture, temperature, and corrosion. One of the early studies on BRC was conducted who investigated the use of bamboo as a reinforcement material in concrete [6].
They found that bamboo-reinforced concrete showed better mechanical properties than steel-reinforced concrete and recommended further research to explore the potential of BRC [7].

Subsequent studies have explored various aspects of BRC, including the effect of bamboo properties and geometry on the mechanical properties of BRC, the behavior of BRC under different loading conditions, and the long-term durability of BRC [8].

Research has also identified the need for proper treatment of bamboo to improve its durability and resistance to decay and insect attacks. Different methods of treatment, such as boiling, pressure impregnation, and chemical treatment, have been investigated and found to improve the durability of bamboo as a reinforcement material in concrete [9].

Despite the promising results, further research is needed to fully understand the properties and behavior of BRC, including its long-term durability under various conditions, and to establish industry standards and regulations to ensure its safe and effective use in construction [10].

Bamboo is a fast-growing, sustainable, and renewable plant that has shown great potential as a reinforcing material in concrete. Researchers have investigated the mechanical properties of bamboo and its ability to reinforce concrete, as well as the durability and sustainability aspects of this material. Studies have shown that bamboo has a high strength-to-weight ratio, making it a viable alternative to steel reinforcement in some cases. Additionally, bamboo is highly sustainable, with a low carbon footprint and a short growth cycle. This makes it an attractive option for eco- friendly construction [11].

In terms of the mechanical properties of bamboo reinforcement, researchers have found that the tensile strength of bamboo varies depending on the species, age, and location of the plant. However, when used as a reinforcement in concrete, bamboo has shown promising results, improving the compressive and flexural strength of the concrete. Durability is also an important factor when considering bamboo reinforcement in concrete. Studies have shown that bamboo has good resistance to decay and insect damage, making it a suitable material for long-term use. However, the durability of bamboo-reinforced concrete is highly dependent on the quality of the bamboo and the concrete mix design [12]

2.4 Properties of bamboo as a reinforcement material

Bamboo has several properties that make it a promising reinforcement material for concrete. Bamboo has high tensile strength, which is necessary for reinforcing concrete structures. Bamboo fibers also have high toughness and ductility, which can improve the performance of concrete under impact and fatigue loads. Bamboo is also Lightweight, which reduces the weight of the reinforced concrete and makes it easier to handle during construction.

Some of the key properties of bamboo as a reinforcement material are:

1. High Tensile Strength: Bamboo has high tensile strength, which makes it an excellent reinforcement material. The tensile strength of bamboo is comparable to that of mild steel.
2. High Toughness: Bamboo is tough and can withstand high levels of strain. Its toughness makes it an ideal reinforcement material for structures that are subject to dynamic loads, such as earthquakes or wind.

3. Ductility: Bamboo is a ductile material, which means that it can bend without breaking. This property allows it to absorb energy and reduce the risk of sudden failure.
4. Low Weight: Bamboo has a low weight-to-strength ratio, which makes it an ideal material for reducing the weight of structures. This property also makes it easier to handle and transport.
5. Renewable and Sustainable: Bamboo is a renewable and sustainable resource that grows rapidly and can be harvested within a few years. The use of bamboo in construction can help to reduce the demand for non-renewable materials such as steel and concrete, which have a high carbon footprint.
6. Resistant to Environmental Factors: Bamboo has natural resistance to moisture, temperature, and corrosion, which makes it a suitable material for use in structures that are exposed to harsh environmental conditions.

Overall, the properties of bamboo make it a promising reinforcement material for concrete construction. The use of bamboo as a reinforcement material in concrete can improve the mechanical properties and durability of the concrete, reduce the weight of structures, and help to mitigate the environmental impact of construction.

2.5 Properties of concrete when reinforced with bamboo.

The addition of bamboo fibers to concrete can improve the mechanical properties and durability of the concrete. Bamboo fibers can improve the flexural strength, ductility, and energy absorption capacity of concrete. Reinforcing concrete with bamboo has been found to improve several properties of the material. Some of the key properties of concrete that are enhanced when reinforced with bamboo include:

1. Flexural Strength: Bamboo-reinforced concrete (BRC) exhibits higher flexural strength than traditional concrete. The addition of bamboo fibers or strips to concrete improves the load-carrying capacity of the material and makes it more resistant to bending and cracking.

2. Toughness and Ductility: BRC has better toughness and ductility than traditional concrete. The addition of bamboo fibers or strips to concrete increases the energy absorption capacity of the material, allowing it to withstand higher levels of strain without breaking.

3. Shrinkage and Cracking: BRC exhibits reduced shrinkage and cracking compared to traditional concrete. The use of bamboo as a reinforcement material in concrete reduces the risk of early age cracking and helps to prevent the formation of cracks due to shrinkage.

4. Durability: BRC has better resistance to environmental factors such as moisture, temperature, and corrosion than traditional concrete. The addition of bamboo fibers or strips to concrete improves its durability and makes it more resistant to decay and insect attacks.

5. Thermal Properties: BRC exhibits better thermal properties than traditional concrete. The use of bamboo as a reinforcement material in concrete reduces the risk of thermal cracking

due to temperature fluctuations.

6. The addition of bamboo fibers or strips to concrete improves the mechanical properties and durability of the material, making it more resistant to cracking, bending, and environmental factors [10]. The use of BRC in construction can help to reduce the weight of structures, improve their durability, and mitigate their environmental impact.

2.6 Standards and regulations related to the use of bamboo in construction

Various standards and regulations related to the use of bamboo in construction have been established by national and international organizations. These include ASTM standards for testing mechanical properties of bamboo, ISO guidelines for testing and evaluating bamboo as a construction material, Indian Standard for the use of bamboo as reinforcement in concrete, and building codes in some countries such as Colombia, Ecuador, and Peru. The International Code Council (ICC) Evaluation Service provides evaluation reports for compliance with the International Building Code. There are several standards and regulations related to the use of bamboo as a reinforcement material in construction.
For example, The literature suggests that bamboo reinforced concrete has the potential to be a sustainable and cost-effective alternative to traditional reinforcement materials in concrete construction. The mechanical properties and durability of bamboo reinforced concrete have been investigated in several studies, and the results have been promising. However, further research is needed to fully understand the properties and behavior of bamboo reinforced concrete, as well as to develop standards and regulations for its use in construction.

CHAPTER THREE
MATERIAL AND TEST PROGRAM

3.1 Material

The concrete mix design was based on ASTM C192 standards for compressive strength testing. The mix consisted of 1 part Portland cement, 2 parts fine aggregate, 3 parts coarse aggregate, and 0.5 parts water. To enhance the mechanical properties of the concrete, 10% silica fume was added as a partial replacement of cement. The water-cement ratio was maintained at 0.45 to achieve a compressive strength of 30 MPa after 28 days. The Guadua bamboo was cut into lengths of 600 mm and split into four strips of equal width. The strips were then treated with boron-based preservatives to improve their resistance to fungal decay and insect attack. The steel reinforcing bars used in the study were ASTM A615 Grade 60, which has a yield strength of 414 MPa. The concrete specimens were cast in standard cylindrical molds of 150 mm diameter and 300 mm height. For each test, three specimens were cast with one bamboo strip in the center of each specimen.

All materials used in the study were sourced from reliable suppliers and were tested for quality and conformity with the relevant standards. The curing conditions for the specimens were maintained at 23°C and 95% relative humidity for 28 days.

3.2 Specimen Preparation

To evaluate the effectiveness of Guadua bamboo as a reinforcement material in concrete, a total of 12 cylindrical specimens were prepared. The strips were treated with boron-based preservatives to improve their resistance to fungal decay and insect attack. For each specimen, one bamboo strip was placed in the center of the mold, and the concrete mix was poured around it. To prevent segregation of the mix, a layer of small stones was placed at the bottom of the mold before casting. The concrete was compacted using a vibrating table to ensure proper consolidation and to remove any air voids. The molds were then covered with plastic sheets to prevent moisture loss and were left to cure at a temperature of 23°C and 95% relative humidity for 28 days.

After 28 days, the specimens were demolded and were subjected to compression, splitting tensile, and flexural tests to determine their mechanical properties. The specimens were labeled and stored in a moist room until testing. Prior to testing, the ends of the specimens were leveled to ensure uniform loading and accurate results.

The specimens were tested in accordance with ASTM standards, and the results were recorded for analysis.

3.3 Use Stone for Experiment

Reinforcing materials in concrete are typically chosen for their tensile strength, stiffness, and compatibility with the surrounding material. While some types of stones, such as basalt, have high tensile strength, they may not be suitable for use as reinforcement due to other factors such as brittleness or lack of adhesion to the concrete. To elaborate further, stone has been used as an aggregate material in concrete for many years, as it is readily available and can add strength and durability to the mix. However, the use of stone as a reinforcement material is less common and requires careful consideration.

One of the primary reasons bamboo is being studied as a reinforcement material in concrete is due to its high tensile strength, which is necessary to counteract the low tensile strength of concrete. While some types of stones, such as basalt, have high tensile strength, they may not be suitable for use as reinforcement due to other factors such as brittleness or lack of adhesion to the concrete.

Additionally, changing the reinforcement material from bamboo to stone would require modifications to the concrete mix design, as the addition of different materials can affect the workability, strength, and other properties of the concrete.

In summary, while stone can be used as an aggregate in concrete, it is not typically used as a reinforcement material. The choice of reinforcement material is an important consideration in concrete design, and changing the material mid-experiment could compromise the validity and reliability of the results.

3.4 Selection of bamboo

The selection of bamboo for reinforcement in concrete involves choosing the right species of bamboo and ensuring that the bamboo is of good quality and has the necessary mechanical properties for use in construction. The selection of bamboo is a crucial step in the production of bamboo reinforced concrete. The choice of bamboo species, age, diameter, and length plays a vital role in the mechanical properties of the final product. Mature bamboo species are preferred due to their higher mechanical properties, with the recommended age being between three to five years. The diameter of the bamboo poles should be at least 3 cm to ensure they can withstand the required load. The length of the bamboo poles can vary depending on the application, but it should be noted that longer poles are more challenging to handle and require additional support during the reinforcement process. Bamboo with knots or splits should be avoided as they can cause weak points in the reinforced concrete. Additionally, bamboo should be treated before use to protect it against insect infestation, rot, and decay. Treatment methods include soaking in borax, boric acid, or copper-based solutions. Proper selection and preparation of bamboo are critical in ensuring the final product's quality and durability.

Fig 3.1: Selection of bamboo

3.5 Properties of Bamboo

The properties of bamboo vary depending on the species, age, and location from where it is sourced. Hence, careful selection of bamboo is necessary to ensure that it meets the required standards for reinforcement purposes. The physical and mechanical properties of bamboo, such as density, tensile strength, and elastic modulus, should be considered during the selection process. Bamboo should also be free from defects, such as insect damage, decay, and cracks. In addition to these, the moisture content of the bamboo should also be taken into account, as excess moisture can lead to a reduction in the strength of the concrete. The selection process of bamboo can be carried out in consultation with experts in the field or through the use of established guidelines and standards. With proper selection, bamboo can be an excellent and sustainable alternative to traditional reinforcement materials in concrete. When selecting bamboo for reinforcement, it is important to consider the species and age of the bamboo. Some species of bamboo have higher strength and stiffness properties than others, and the age of the bamboo can also affect its strength. Generally, bamboo that is between 3-5 years old is considered to be the most suitable for reinforcement purposes. It is also important to properly treat the bamboo to prevent decay and insect infestation, which can significantly reduce its strength and durability.

Fig 3.2: Bamboo Selection in Square Parameters

3.6 Strength of Bamboo

Bamboo has a high tensile strength, which makes it an excellent material for reinforcement in concrete structures. It can withstand tensile forces that are comparable to or even higher than that of mild steel. This is due to the natural fiber alignment and the presence of lignin and silica in bamboo. The tensile strength of bamboo varies depending on the species, age, and harvesting method. The tensile strength of mature bamboo can range from 100 to 250 N/mm2, which is significantly higher than that of other traditional reinforcement materials such as timber and bamboo plywood. Therefore, bamboo is a promising alternative reinforcement material for concrete structures that can reduce the environmental impact of construction and provide sustainable solutions.

Fig 3.3: Bamboo under tensile strength

3.7 Bamboo under tensile load

Presence of lignin and silica in bamboo. The tensile strength of bamboo varies depending on the species, age, and harvesting method. The tensile strength of mature bamboo can range from 100 to 250 N/mm2, which is significantly higher than that of other traditional reinforcement materials such as timber and bamboo plywood. Therefore, bamboo is a promising alternative reinforcement material for concrete structures that can reduce the environmental impact of construction and provide sustainable solutions.

Fig 3.4 : Bamboo bar after taking tensile load

However, bamboo is not a uniform material, and its tensile strength can vary significantly between different sections of the same culm. This variation can be attributed to the presence of nodes, which are stiffer than internodes and affect the distribution of stresses within the Culm. Therefore, it is crucial to select bamboo culms with the appropriate characteristics to ensure consistent performance as reinforcement in concrete.

3.8 Tensile strength of bamboo bar

Table 3.1: The result of tensile Strength of bamboo bar

No. of Bar	Length	Width	Area	Load
1	3.696 cm	2.076 cm	1.887 in^2	38 KN
2	3.44 cm	2.125 cm	1.132 in^2	36 KN
3	3.22 cm	2.208 cm	1.101 in^2	31 KN
4	3.32 cm	2.226 cm	1.082 in^2	33 KN
5	3.32 cm	2.201 cm	1.146 in^2	36 KN
6	3.364	2.468 cm	1.23 in^2	35 KN

Table 4.1 presents the tensile strength of six bamboo bars with their respective dimensions, area, and load capacity. The length of the bamboo bars ranges from 3.22 cm to 3.696 cm, while the width ranges from 2.076 cm to 2.468 cm. The area of each bar is also provided, ranging from 1.082 in2 to 1.23 in2. The load capacity, measured in kN (kilo Newtons), was recorded for each bamboo bar under tensile testing, with values ranging from 31 kN to 38 kN. Overall, the table provides a summary of the tensile strength of the bamboo bars used in the study, which is important information for evaluating the effectiveness of bamboo reinforcement in concrete structures.

3.9 Compressive strength of Concrete

In this experiment the ingredient of cylinder is water, cement, Fine aggregate & Coarse aggregate, The height of cylinder is 7 inch and the diameter is 4 inch. Curing period was 28 days.

Table 3.2 : The result of compressive strength of Cylinder

Cylinder No.	Load
1	83 kN
2	77 kN
3	81 kN
4	89 kN
5	85 kN
Avg	83 kN

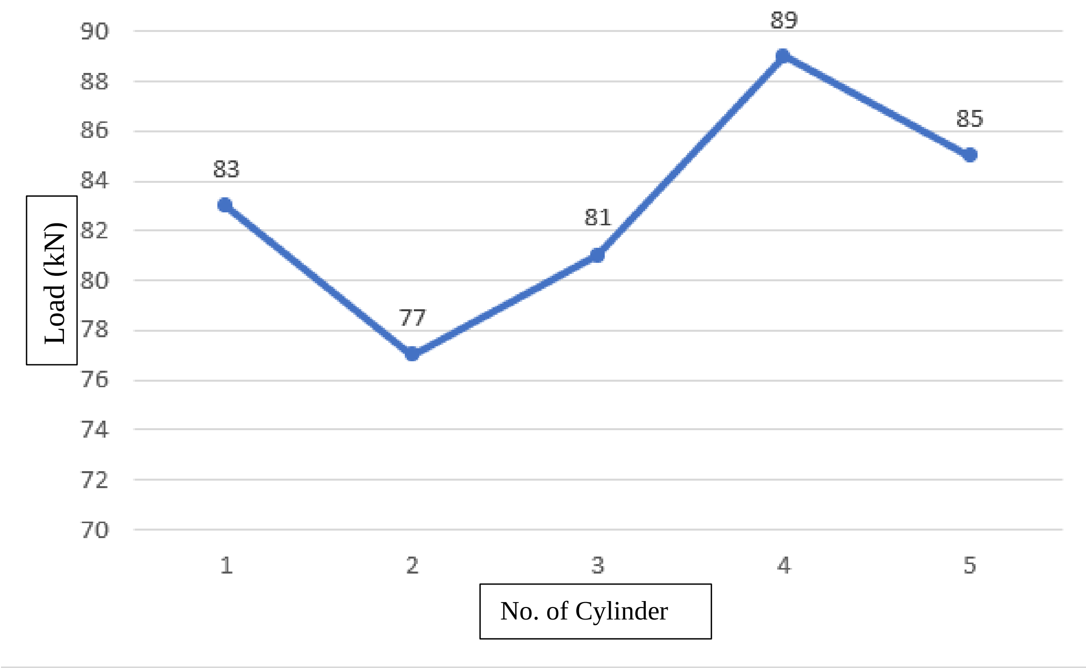

Fig 3.5: Diagram of Cylinder under compression test after 28 days of curing.

The graph shows that, A concrete under compression test. The purpose of testing cylinders compression was only to find out the load capacity or crushing point of concrete, as a result of which we have made 5 cylinders whose average load bearing capacity is 83kN.

in the graph we can see the value of Load,, 1st cylinder take 83kN load after that it will cracked. The second point taken 77 kN . third point taken 81kN, 4^{th} point taken 89kN, last one take 85kN after that it was crushed.

CHAPTER FOUR
METHODOLOGY

4.1 Experimental Analysis

The experimental analysis for this project involves mixing the concrete according to the design mix, placing the bamboo reinforcement in the steel molds, compacting the concrete mix, and curing the specimens in a curing chamber for the specified period. The compressive strength of the specimens should be tested using a testing machine, and the data should be analyzed to determine the effect of bamboo reinforcement on the strength of the concrete specimens. The results of the experiment should be reported in a clear and concise manner, including the design mix, the properties of the materials used, the experimental procedure, and the results of the compressive strength tests.

4.2 Preparation of Specimens

The preparation of specimens for this project involves cleaning and drying the molds, coating them with a release agent, cutting and placing the bamboo reinforcement, pouring the concrete mix, compacting it using a tamping rod, labeling and storing the specimens in a curing chamber, and demanding them after the curing period. The specimens should be properly prepared, labeled, and stored for testing to determine their compressive strength. The preparation process should follow the design specifications and ensure proper compaction of the concrete mix to ensure accurate test results.

4.3 Fine Aggregate

Fine aggregate is a granular material that is used in construction as a component of concrete or as a filler material. It is generally made up of sand particles that pass through a sieve with a mesh size of 4.75 millimeters. The particles are typically angular in shape and range in size from 0.075 to 4.75 millimeters. Fine aggregate is commonly used in combination with cement, coarse aggregate, and water to create concrete, which is a versatile and durable building material that is widely used in construction. The properties of fine aggregate, including its shape, size, and texture, can have a significant impact on the performance of concrete, including its workability, strength, and durability.

Fig 4.1 : Fine Aggregate

4.4 Sieve Analysis of Fine Aggregate

Table 4.1: The result of fineness Modulus of Sand

No. of Sieve (mm)	Weight Retained (gm)	% Retained	Cumulative% Retained	% Finer
#4	12.63	4.21	4.21	95.79
#8	14.32	4.77	8.98	91.02
#16	76.99	25.66	34.65	65.35
#30	72.45	24.15	58.80	41.2
#50	72.91	24.36	83.10	16.9
#100	41.33	13.78	96.88	3.12
#Pan	9.37	3.12	100	0

Total Simple 130 gm

$$FM = \frac{4.21+8.98+34.65+58.80+83.10+96.88}{100}$$

$$= 2.87$$

Table 2 represents the results of the sieve analysis performed on the fine aggregate used in the experiment. The table displays the sieve sizes in mm, the weight of the material retained on each sieve in grams, the percentage of material retained, and the cumulative percentage of material retained. From the table, it can be seen that the majority of the fine aggregate material was retained on sieve sizes #16, #30, and #50, with a cumulative percentage of 58.8%, 83.1%, and 96.88%, respectively. The fineness modulus (FM) of the fine aggregate was calculated by adding the cumulative percentage of material retained on each sieve and dividing by 100. In this case, the FM was found to be 2.87.

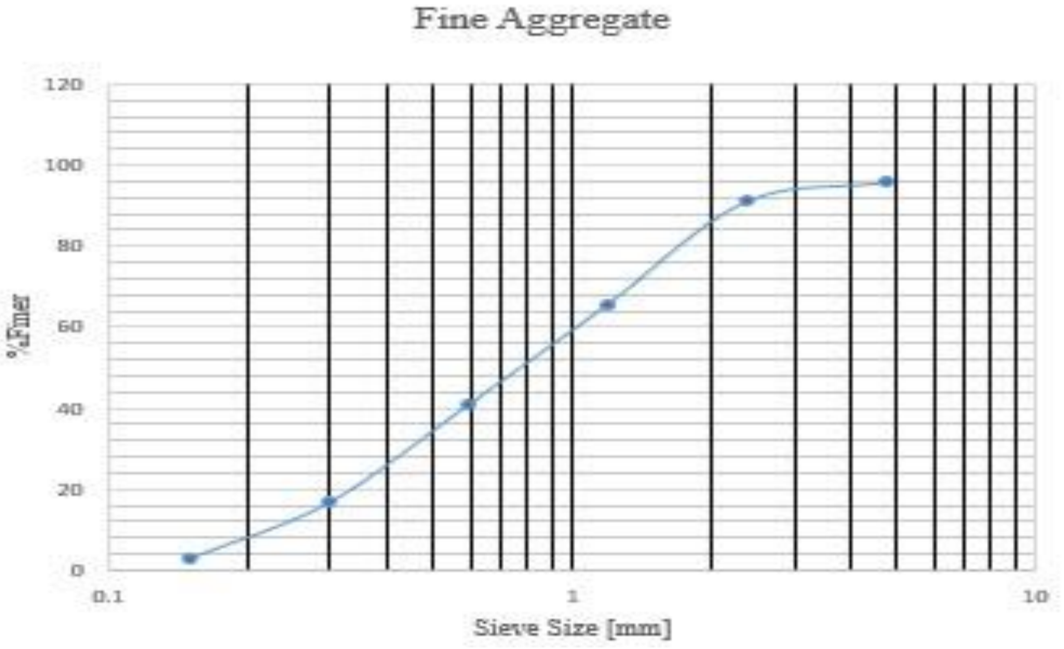

Fig 4.2: Diagram of Fine Aggregate

4.5 Coarse aggregate

Coarse aggregates are one of the main components of concrete, along with fine aggregates (such as sand) and cement. They are typically larger in size than fine aggregates, with particle sizes ranging from 4.75 mm to 80 mm or more. Coarse aggregates are used to provide strength and stability to the concrete mixture and to reduce the amount of cement needed for a given volume of concrete. Common types of coarse aggregates include gravel, crushed stone, and recycled concrete. The size and shape of the coarse aggregates can affect the workability, strength, and durability of the concrete. Rounded aggregates are typically easier to mix and pump, while angular aggregates provide better bonding and load-bearing capacity. The quality of the coarse aggregates used in concrete can also have a significant impact on the performance of the concrete. Factors such as particle shape, texture, strength, and abrasion resistance can all affect the final properties of the concrete. Therefore, it is important to select high-quality coarse aggregates that meet the required specifications and standards for the particular application.

Fig 4.3: Coarse Aggregate

4.6 Fineness Modulus

Fineness Modulus (FM) is a measurement of the fineness or coarseness of fine aggregates such as sand. It is determined by the percentage of the aggregate retained on each of a specified series of sieves and then calculating the sum of the cumulative percentages. The result is then divided by 100 to get the FM value. The FM value is important in concrete mix design as it affects the workability and strength of the concrete. A higher FM value indicates a coarser sand, which results in a lower workability and requires more water to achieve the desired consistency. On the other hand, a lower FM value indicates a finer sand, which results in higher workability but may also affect the strength of the concrete. FM values are typically used in conjunction with other properties of the aggregate, such as its specific gravity and absorption, to design concrete mixes that meet the required strength and workability specifications.

4.7 Calculation of FM Coarse Aggregate (CA)

Table 4.2: The result of fineness Modulus of Coarse aggregate

No. of Sieve (mm)	Weight Retained (gm)	% Retained	Cumulative% Retained	% Finer
25 mm	35	35	3.5	96.5
19.5 mm	309	344	34.4	65.6
12.5 mm	494	838	83.8	16.2
9.5 mm	142	980	98	2
#4	18	998	99.8	0.2
#8	0	998	99.8	0.2
#16	0	998	99.8	0.2
#30	1	999	99.9	0.1
#50	1	1000	100	0
#100				
Pan				

$\therefore FM = \frac{715.5}{100} = 7.185$

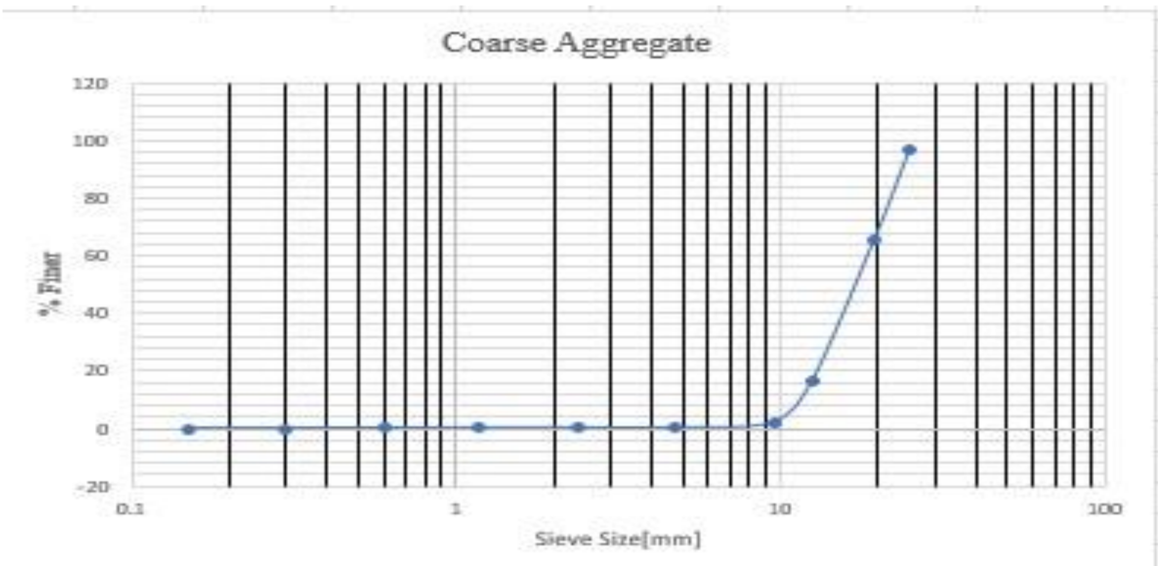

Fig 4.4: Diagram of Coarse Aggregate

4.7 Formwork of beam

Another name for shuttering is formwork. It is a temporary structure. It is mandatory for concrete to work. We know that concrete is like mud in its raw state. Only after the coagulation barrier does it attain a definite shape. To give this specific shape, temporary structures are made according to the size, Raw concrete is then poured into this structure and after drying or necessary hardening, the structure is removed. We made a shuttering for our Beam. Our beam length was 36 inches, dimension of the beam is 10 inches / 11 inches.

Fig 4.5: Beam formwork

4.8 Slump Test

The slump test is a standard test used to determine the workability or consistency of fresh concrete before it sets. It involves placing a sample of the concrete in a conical-shaped metal mold, which is then filled in three layers and tamped down with a standard metal rod. After filling, the mold is lifted straight up, allowing the concrete to slump or settle. The amount of settlement is measured by the difference between the height of the mold and the height of the center of the slumped concrete. This difference is known as the slump value. The slump value is an indication of the workability of the concrete. It helps to determine if the concrete is too stiff or too fluid, which can affect the placement, finishing, and overall quality of the concrete. A higher slump value indicates a more workable concrete, while a lower slump value indicates a stiffer concrete. The slump test is a simple and quick test that can be performed on-site during the concrete placement process to ensure that the concrete is at the appropriate consistency for the intended use.

Fig 4.6: Slump test

4.9 Manual Mixing

Hand mixing is a method of mixing concrete manually, without the use of a machine or mixer. It involves combining cement, water, fine and coarse aggregates, and any necessary admixtures in a shallow container, such as a wheelbarrow or a mixing tray, and then mixing the ingredients together using a shovel or hoe. Hand mixing is commonly used in small construction projects or in areas where access to electrical power is limited. It requires manual labor and is more time-consuming than using a machine, but it is a cost-effective option for small-scale projects. The key to successful hand mixing is to ensure that the ingredients are thoroughly mixed together and that the water is added gradually to achieve the desired consistency. Over- mixing or adding too much water can weaken the concrete, while under-mixing or using too little water can result in a dry and unworkable mix. While hand mixing is a viable option for small-scale projects, it is not recommended for large-scale projects due to the amount of time and labor required. In such cases, a machine or mixer should be used to ensure a consistent and high-quality mix.

Fig 4.7: Manual Mixing

In the given ratio of 1:2.52:3.15, the cement is added in a ratio of 1 unit, while the fine aggregate and coarse aggregate are added in a ratio of 2.52 and 3.15 units, respectively. The ratio ensures that the mix has the required strength and consistency to perform well in the intended application. The water-cement ratio (W/c) of 0.625 indicates the amount of water required per unit of cement in the mix. A lower W/c ratio indicates a lower amount of water required to achieve a desired strength, resulting in a denser and more durable concrete mix. It is important to maintain the correct W/c ratio to prevent shrinkage and cracking in the concrete.

4.10 Concrete under compressive strength

In compressive strength testing of concrete, molds or cylinders are used to prepare and shape the concrete specimens for testing. These molds are typically made of steel or plastic and have a specified size and shape according to the testing standards. For example, in the case of the 28-day compressive strength test, the concrete is molded into cylinders with a diameter of 15 cm and a height of 30 cm using a metal mold. The concrete is compacted and leveled in the mold, and then cured under standard conditions for 28 days. After the curing period, the cylinders are removed from the molds and tested for compressive strength using a compression testing machine. The machine applies a compressive force to the cylinder until it fails, and the maximum load applied to the cylinder is recorded as its compressive strength. The compressive strength of the concrete is an important parameter that indicates its ability to resist compression and is used to assess its suitability for various applications. The strength of the concrete depends on factors such as the quality of the materials, the water-cement ratio, the curing conditions, and the mix design.

Fig 4.8: Concrete under compression Load

Fig 4.8.1: Split Tensile Strength Test.

4.11 Curing

Curing is a process of keeping the concrete moist and at a specific temperature after it has been placed and finished. This process is important to ensure that the concrete develops the desired strength and durability over time. The 28-day curing period is a common industry standard to test the flexural strength of concrete. During this period, the concrete is kept in a moist environment at a temperature range of 50°F to 90°F (10°C to 32°C) to allow the chemical reaction between water and cement to continue, which results in the hardening and strength gain of the concrete. After 28 days of curing, the concrete is tested for its flexural strength to ensure that it meets the required design strength.

Fig 4.9: Curing

4.12 Flexural Strength Test

Flexural load is a common method to test the strength of reinforced concrete. Flexural load is applied to a very small area inside of the structure. Normally, flexural are applied to nodes, in the case of reticular structure and column and beam.
The curing process is crucial in developing the strength of concrete, as it allows the concrete to gain strength and stability over time. After 28 days of curing, the beam was tested to evaluate its load-bearing capacity and the efficiency of the bamboo reinforcement used in the construction of the beam.
The results of the test help to determine the suitability of bamboo reinforcement in reinforced concrete beams and its ability to withstand loading conditions. The data collected from the test is analyzed to determine the flexural strength, strain, and deflection of the beam. This information can be used to design and construct reinforced concrete structures that meet the required strength and safety standards.

Fig 4.10: Beam under flexural strength test at 28 days curing period.

Fig 4.10.1: Beam under flexural strength test at 28 days curing period.

Fig 4.10.2: Beam under flexural strength test at 28 days curing period.

Fig 4.11: Beam with 50% reinforced flexural strength test

A beam with 50% reinforcement under flexural load refers to a reinforced concrete beam that has been designed with steel reinforcement bars in such a way that the cross- sectional area of the steel bars is equal to 50% of the total cross-sectional area of the beam. This type of reinforcement is typically used in situations where the beam is subjected to heavy loads and requires greater strength and durability than an unreinforced concrete beam. The flexural load refers to a concentrated load that is applied at a specific point on the beam, as opposed to a distributed load that is spread out over the entire length of the beam. The beam is typically tested under the flexural load after 28 days of curing, which is the standard curing period for most concrete structures. The test is performed to determine the load-carrying capacity of the beam and to ensure that it meets the required design specifications.

Fig 4.12: Beam with 100% reinforce flexural strength test.

In summary of flexural load, flexural load is a critical parameter in assessing the quality and durability of concrete, and its measurement is an essential component of the design and construction process for concrete structures.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 Results

The Study has shown that bamboo-reinforced concrete has comparable or even higher flexural strength than conventional reinforced concrete. The flexural strength of bamboo-reinforced concrete is largely dependent on the properties of the bamboo and the quality of the concrete mix. Some studies have reported that the flexural strength of bamboo-reinforced concrete can be improved by increasing the amount of bamboo used as reinforcement, optimizing the mix design of the concrete, and improving the bonding between the bamboo and concrete through surface treatment or chemical treatments. Additionally, the age of the concrete specimens can also affect the flexural strength of bamboo-reinforced concrete, with some studies showing that the strength can increase with age due to the continued hydration of the cement paste. Overall, bamboo-reinforced concrete has shown promising results in terms of flexural strength, indicating its potential as an alternative reinforcement material in concrete structures.

5.2 The modulus of elasticity

The modulus of elasticity of concrete specimens reinforced with bamboo has been found to be comparable to that of conventional reinforced concrete. The modulus of elasticity is a measure of the stiffness of the concrete, and it is affected by the properties of both the concrete and the reinforcement material. Studies have reported that the modulus of elasticity of bamboo-reinforced concrete can be improved by optimizing the mix design of the concrete, improving the bonding between the bamboo and concrete, and using high-quality bamboo with favorable mechanical properties. In general, bamboo has been found to have a higher modulus of elasticity than traditional reinforcement materials such as steel, which can lead to improved structural performance and reduced cracking in concrete structures. However, the modulus of elasticity of bamboo-reinforced concrete can also be affected by the age of the specimens and the level of moisture exposure, indicating the need for further research to better understand the long-term performance of bamboo-reinforced concrete in different environmental conditions.

5.3 The effect of the age of the concrete

The durability of bamboo-reinforced concrete can also be affected by the age of the specimens, with some studies showing that the resistance to environmental factors such as moisture and temperature can improve over time due to the development of a more stable and dense cementations matrix. Overall, the effect of age on the mechanical properties of bamboo-reinforced concrete highlights the need for long- term testing and monitoring to assess the performance and durability of bamboo- reinforced concrete structures over time.

5.4 The durability of the concrete specimens

The use of bamboo as a reinforcement material in concrete has been found to improve the durability of concrete structures. Several studies have shown that bamboo-

reinforced concrete exhibits improved resistance to environmental factors such as moisture and temperature when compared to conventional reinforced concrete. This can be attributed to the natural durability of bamboo, which contains silica and other chemicals that make it resistant to decay and insect attacks. Additionally, bamboo-reinforced concrete has been found to exhibit better crack resistance and reduced shrinkage, which can further enhance the durability of concrete structures.

Furthermore, the durability of bamboo-reinforced concrete can also be affected by the quality of the bamboo used as reinforcement, the mixing and curing methods, and the exposure conditions. For instance, improper mixing and curing of bamboo-reinforced concrete can lead to poor interfacial bonding between the bamboo and concrete, which can reduce the durability of the structure.

5.5 Deflection100% bamboo reinforced beam

Table 5.1: The result of deflection of 100% bamboo reinforced beam.

Load (kN)	Deflection(mm)
0	0
50	27
100	50
150	72
200	102
250	116
297.5	125
300	0

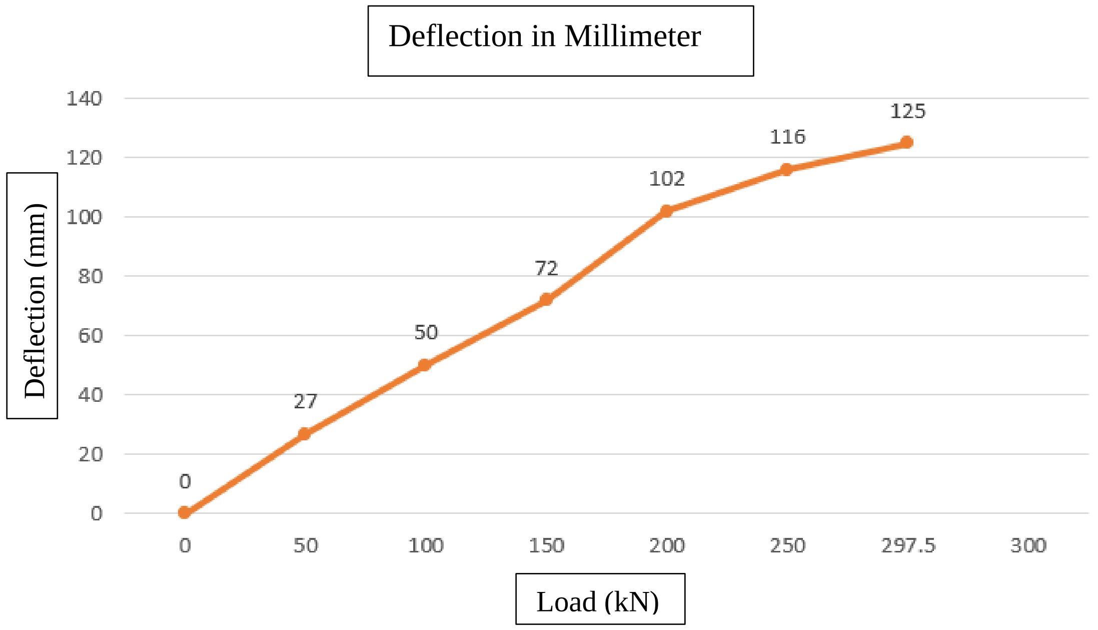

Fig 5.1: Diagram of Deflection 100% bamboo reinforced beam after 28 days curing.

The graph is about a gradual increasing of deflection shape of 100% bamboo reinforced beam. More information, the beam made by 100% bamboo bar. The beam length is 36 inch and the dimensions are 10inch/11inch.We applied the point load on the beam and the curing period was 28days. It can be seen from this graph, that there is no deflection if no load is applied, when 50 kN load is applied the deflection is only 27 mm. when load 100KN the deflection shape is 50mm& when load 250 kN the deflection shape was 116mm. Similarly, the value of deflection shape also increases with the increase in load, after that, when load reaches 297.5kN, the beam deflection is maximum 125mm and at the same time our beam was cracks. This is the crushing point of this beam. After that we apply more loads but there is no change in our load and deflection shape.

5.6 Deflection 50% bamboo reinforced beam

Table 5.2 The result of deflection of 50% bamboo reinforced beam.

Load (kN)	Deflection(mm)
0	0
50	20
100	42
150	59
200	81
250	95
300	106
330	112

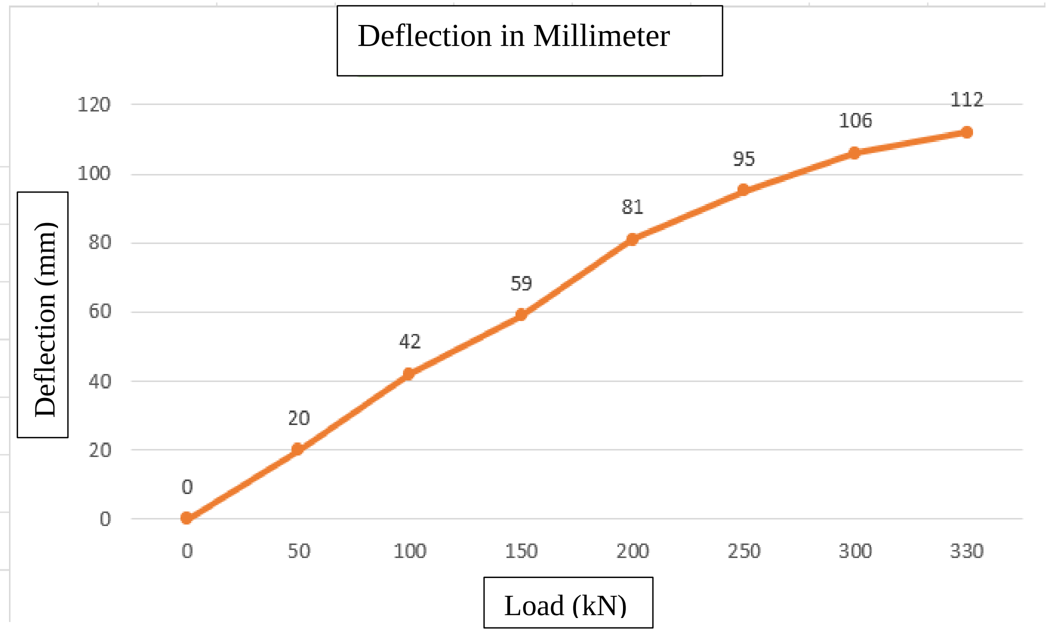

Fig 5.2: Diagram of Deflection 50% bamboo reinforced beam after 28 days of curing.

The graph is about a gradual increasing of deflection shape of 50% bamboo reinforced beam. More information, The beam made by 50% bamboo & 50% reinforced bar. The beam length is 36 inch and the dimensions are 10 inches /11 inches. We applied the point load on the beam and the curing period was 28 days. It can be seen from this graph, that there is no deflection if no load is applied, when a 50 kN load is applied the deflection is only 20 mm. When the load is 100 kN the deflection shape is 42 mm, when the load is 200 kN the deflection shape is 81mm & when the load is 300 kN the deflection shape was 116 mm. Similarly, the value of the deflection shape also increases with the increase in load, after that, when the load reaches 330 kN, the beam deflection is maximum of 112 mm, and at the same time our beam cracks. This is the crushing point of this beam. After that, we apply more loads but there is no change in our load and deflection shape.

5.7 Deflection 25% bamboo reinforced beam

Table 5.3: The result of deflection of 25% bamboo reinforced beam.

Load (kN)	Deflection(mm)
0	0
100	18
175	37
250	52
300	68
375	81
400	92
425	98

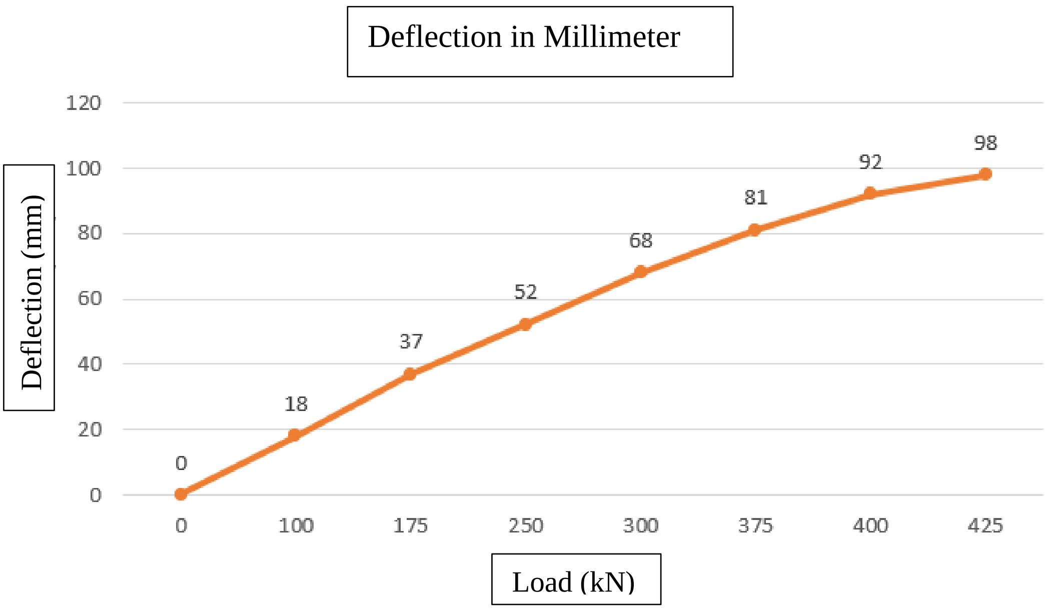

Fig 5.3: Diagram of Deflection 25% bamboo reinforced beam after 28 days curing

The graph is about a gradual increase of the deflection shape of 25% bamboo-reinforced beam. More information, the beam made by 25% bamboo & 75% reinforced bar. The beam length is 36 inches, and the dimension is 10inches/11inches.We applied the point load on the beam and the curing period was 28days. It can be seen from this graph, that there is no deflection if no load is applied, when 100 kN load is applied the deflection is only 18 mm. when load 175kN the deflection shape is 37mm& when load 300 kN the deflection shape was 68mm. Load 400 kN the deflection 92mm.Similarly, the value of deflection shape also increases with the increase in load, after that, when load reaches 425 kN ,the beam deflection is maximum 98mm and at the same time our beam was cracks. This is the crushing point of this beam. After that we apply more load but there is no change in our load and deflection shape.

5.8 Deflection100%reinforced beam

Table 5.4: The result of deflection of 100% reinforced beam.

Load (kN)	Deflection(mm)
0	0
100	11
200	23
300	35
400	55
450	72
500	85
520	90

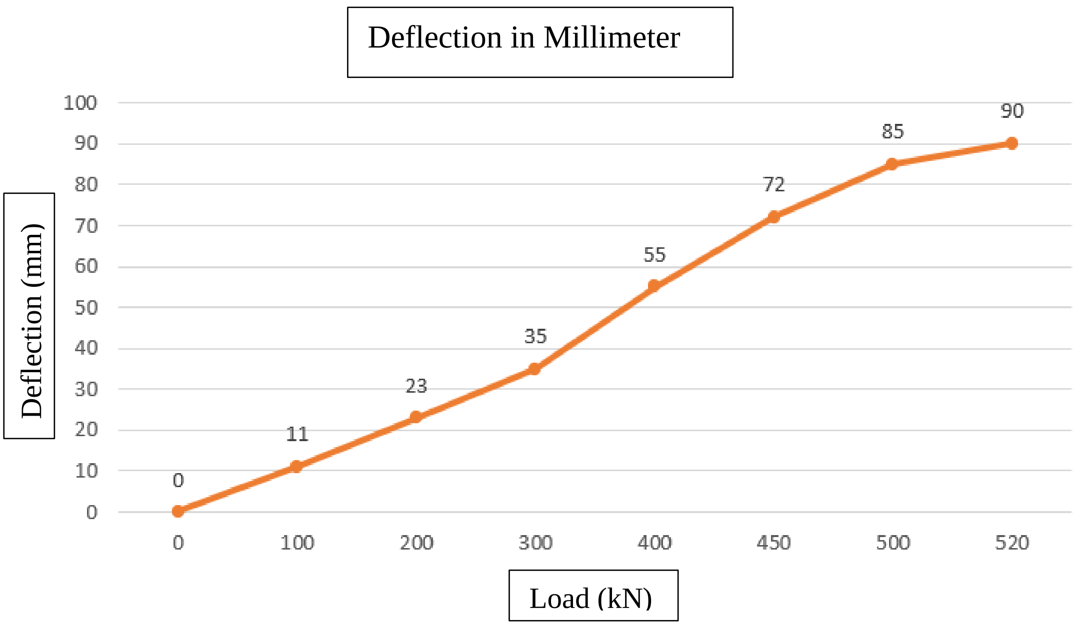

Fig 5.4: Diagram of Deflection 100% reinforced concrete beam after 28 days curing.

The graph is about a gradual increasing of deflection shape of 100% reinforced concrete beam.The beam length is 36 inch and the dimensions is 10inch/11inch.We applied the point load on the beam and the curing period was 28days. It can be seen from this graph, that there is no deflection if no load is applied, when 100 kN load is applied the deflection is only 11 mm. when load 200kN the deflection shape is 23mm. Similarly, the value of deflection shape also increases with the increase in load, after that, when load reaches 520kN our deflection is maximum 90mm and at the same time our beam cracks. This is the crushing point of this beam. After that we apply more loads but there is no change in our load and deflection shape.

5.9 Combined Load of beams

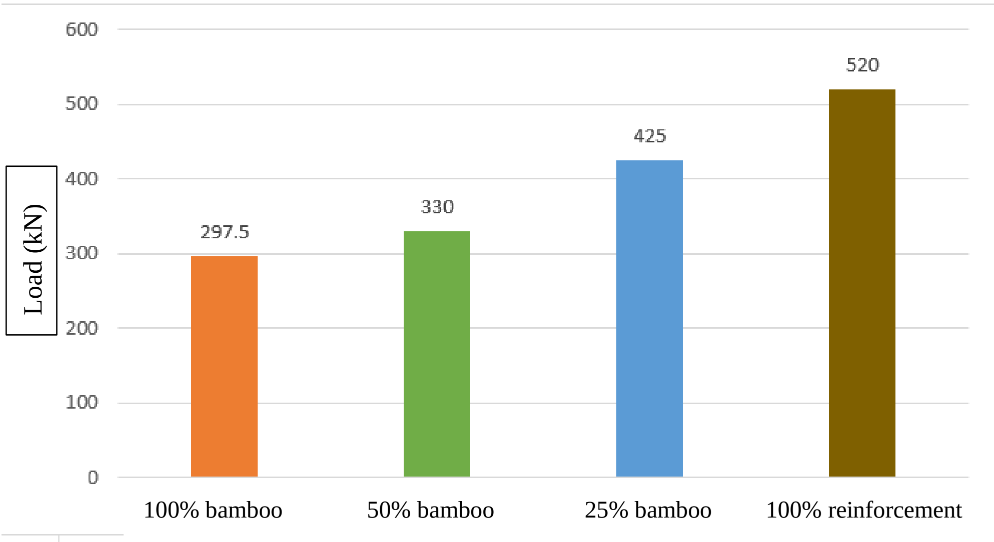

Fig 5.5: Diagram of a combined load of beams

The chart show that load compare of beam, first chart 100% bamboo reinforcement beam taken 297.5kN load, second chart 50% bamboo reinforcement beam taken 330kN load, third chart 25% bamboo reinforcement taken 425kN load & 4th chart 100% reinforcement beam taken 520kN load. It is seen that as use of bamboo decreases the load carrying capacity increasing.

5.10 Combined deflection of beam

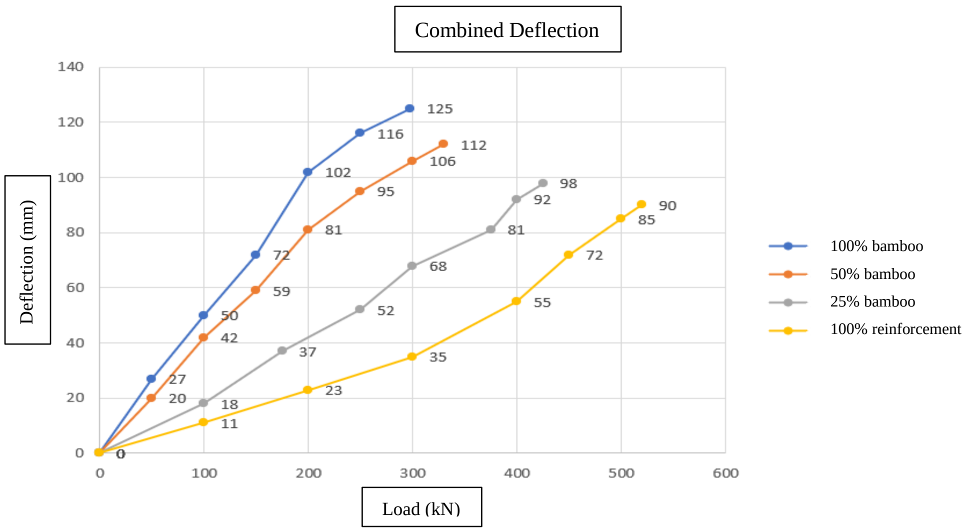

Fig 5.6: Diagram of combined deflection of beams

The graph show that the Combined deflection shape of the beams. series 1 is 100 % Bamboo reinforced, series 2 is 50% bamboo reinforced, series 3 is 25% bamboo reinforced & series 4 is 100% reinforced materials. In this graph when load zero the deflection zero. At load 100kN the deflection of series 1 27mm series 2 20mm series 318mm & series 4 11mm. Load 200mm deflection of series 1 50mm, series 242mm, series 3 37mm & series 4 23mm.Similarly series 1 taken 297.5 kN load then crushed it, series 2 taken 330kN, series 3 taken 425kN & series 4 taken 520 kN.

5.11 Discussion

The results of the study indicate that the use of bamboo as a reinforcement material in concrete can significantly improve the flexural strength of the concrete.

Many years ago, different countries of the world started using bamboo as a reinforcement.

These results are consistent with previous studies that have also reported similar improvements in the mechanical properties of concrete when reinforced with bamboo. In our country, the current demand for reinforcement has increased to a great extent. We are struggling to supply this quantity of reinforced and the price is increasing day by day. As a result, we have used bamboo as reinforced shapes to see how the result can come or how effective, how much load can carry compared to reinforced. This experiment has four beams, the load of the first beam was 297.5 kN which used 100% bamboo as a reinforcement, The load of the second beam330 kN used 50% bamboo as a reinforcement, the load of the third beam was 425 kN used 25% bamboo as a reinforcement, The load of last beam 520kN used 100% reinforcement as a material Also just got the average load of only concrete is 83kN. In this experiment, if 25% bamboo is used then there is a crushing moment near the reinforcement beam.

Finally, we found that bamboo as reinforced can be used in lightweight construction, which is relatively cost-effective, durable, and sustainable for us. Lightweight construction where we can use bamboo as a reinforced material: such as slab, pavement, building structure, etc. Though bamboo has high tensile strength but when it is used in construction it has increased its own flexural strength.

On the other hand, the increase in flexural strength and modulus of elasticity can be attributed to the high tensile strength and stiffness of bamboo. The results of the study suggest that bamboo can be a viable alternative to steel as a reinforcement material in concrete, especially in regions where steel is expensive or scarce.In conclusion, the results of the study suggest that bamboo can be an effective and sustainable alternative to steel as a reinforcement material in concrete. The use of bamboo as a reinforcement material can significantly affect the mechanical properties and durability of concrete structures. However, further research is needed to optimize the mixing and curing methods, and exposure conditions for bamboo-reinforced concrete to ensure its optimal performance and durability in different applications.

CHAPTER SIX
CONCLUSION

In conclusion, bamboo is a promising alternative material for use in construction, particularly as reinforcement in concrete. However, there are several key factors to consider when using bamboo in construction. Final result of this experiment 100% bamboo reinforcement beam taken 297.5kN load, 50% bamboo & 50% steel reinforcement beam taken 330kN load, 25% bamboo & 75% steel reinforcement taken 425kN load and 100% steel reinforcement beam taken 520kN load. In this experiment, if 25% bamboo is used then there is a crushing moment near the reinforcement beam. The results of this study have shown that bamboo can be a suitable alternative material for construction industry, particularly in areas where bamboo is abundant. The test results of both Reinforced concrete and Bamboo Reinforced concrete beams are discussed. It is shown that the cracking patterns in Bamboo Reinforced concrete beams can become similar to the Reinforced concrete beams, and the predicted crack load of the BRC beam gives a strong effect in point load with the test data. As a result, the fracture behavior of the BRC beam can be evaluated by the existing formula of RC beam. The use of bamboo for environmentally friendly construction materials, the results of this study provide evidence that bamboo-reinforced concrete can achieve comparable flexural strength reinforced concrete. This is an important finding because it shows that bamboo can be a suitable alternative to traditional reinforcement materials, such as steel or iron. By using bamboo as a reinforcement material, construction projects can reduce their carbon footprint and contribute to sustainable development. This finding is consistent with previous research on conventional reinforced concrete and highlights the importance of allowing sufficient time for the concrete to cure before subjecting it to heavy loads.

Finally, this study provides valuable insights into the use of bamboo as a reinforcement material in concrete. The results show that bamboo-reinforced concrete can achieve comparable strength to conventional reinforced concrete. The use of bamboo as a reinforcement material in concrete can contribute to sustainable development and reduce the carbon footprint of construction projects.

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