SUSTAINABLE POTENTIAL OF FIBER REINFORCED CONCRETE BEAM ANALYZED WITH ETABS

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Certification

The thesis titled "Experimental Study of Fiber Reinforced Concrete Beams" has been approved as meeting the requirements for the Bachelor of Science degree in Civil Engineering in May 2024. To our knowledge, aside from appropriately referenced external sources, this thesis presents original research without relying on others' work.

If you need a simplified certification statement, it could be:

"This thesis, titled "**Sustainable Potential of Fiber Reinforced Concrete Beam-Analyzed With ETABS**", has been certified as meeting the requirements for the degree of Bachelor of Science in Civil Engineering in May 2024. It contains original research with proper acknowledgment of external sources.

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I conducted the dissertation titled "**Sustainable Potential of Fiber Reinforced Concrete Beam Analyzed with ETABS**" under the guidance of Mr. Md. Asaduzzaman Naeem, Lecturer at the Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh. This dissertation has been approved as part of my Bachelor of Science in Civil Engineering degree requirements. To the best of my knowledge, everything in this dissertation is my own work, and any sources or materials used are properly referenced.

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ABSTRACT

This thesis details an experimental study that investigates the structural behavior of recycled fiber-reinforced concrete (FRC) beams. As a sustainable and renewable resource, fiber has garnered significant attention as a potential alternative to conventional steel reinforcement in structural elements. The research aims to evaluate the flexural performance and load-carrying capacity of FRC beams through a series of laboratory tests.

The experimental program involves the fabrication and testing of multiple beam specimens with varying fiber reinforcement configurations, including different fiber types, lengths, and orientations. Key parameters investigated include ultimate strength, deflection characteristics, crack propagation, and failure modes. Test results are compared with control beams reinforced with conventional steel bars to assess the feasibility and effectiveness of fiber reinforcement. Notably, using fiber in the reinforcement resulted in a crushing moment near the reinforced section.

Furthermore, an analysis of concrete performance has been carried out using ETABS software. Cotton bars material property 2175 psi. Weight density 2-12 mm 70 lb/ft^3, 3-12 mm 115 lb/ft^3. Polyester bars weight density 2-12 mm 80 lb/ft^3, 3-12 mm 120 lb/ft^3. Nylon bars weight density 2-12 mm 80 lb/ft^3, 3-12 mm 120 lb/ft^3. Mechanical properties, Modulus of elasticity (E):1115.31 lb/ft^3, Minimum yield strength (FY) 42 lb/ft^3, Minimum tensile strength (Fu) 43 lb/ft^3.

The findings from this study provide valuable insights into the potential utilization of fiber as an eco-friendly reinforcement material in civil engineering structures. The outcomes contribute to sustainable development by promoting the use of renewable resources in the construction industry, helping engineers and architects design safe and efficient structures that meet project requirements.

1.1.1.1 Contents

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CHAPTER ONE: INTRODUCTION

1.1 Introduction:

The use of recycle fiber-reinforced concrete (FRC) is gaining traction in modern construction due to its enhanced performance characteristics compared to traditional concrete. This study focuses on three types of fiber-reinforced concrete beams: cotton fiber, nylon fiber, and polyester fiber. Each type of fiber offers unique properties that contribute to the overall strength, durability, and flexibility of concrete structures.

Cotton fiber, known for its sustainability and lightweight nature, enhances the tensile strength and crack resistance of concrete.

Cotton fiber, recognized for its sustainability and lightweight properties, plays a significant role in enhancing the tensile strength and crack resistance of concrete. As a natural fiber, cotton is biodegradable and renewable, making it an environmentally friendly option compared to traditional reinforcement materials. The addition of cotton fiber to concrete mixes improves the material's ability to withstand tensile stresses, which are crucial for preventing cracking. This improvement in tensile strength is particularly beneficial in structures that experience dynamic loads or environmental stresses, as it helps maintain structural integrity over time.

Furthermore, cotton fibers contribute to better crack resistance by bridging cracks that may form during the curing process or under load. This bridging action helps to control crack propagation, ensuring that any cracks that do develop remain small and manageable. Consequently, the overall durability of the concrete is enhanced, leading to longer-lasting structures. The lightweight nature of cotton fiber also makes it an attractive alternative for applications where reducing weight is essential, such as in lightweight structures and repairs. Its integration into concrete can help achieve desired performance characteristics while minimizing additional mass.

In summary, the incorporation of cotton fiber into concrete not only addresses sustainability concerns but also enhances the material's mechanical properties, making it a valuable option in modern construction practices. Further research into optimizing cotton fiber's use in various concrete applications could pave the way for more innovative and environmentally friendly building solutions. (Hettiwatte, 2019)

Nylon fiber, recognized for its toughness and resistance to abrasion, further improves the structural integrity of concrete beams (NGUYEN, 2020.08.25)

Nylon fiber is increasingly recognized in the construction industry for its exceptional toughness and resistance to abrasion, which significantly enhance the structural integrity of concrete beams. By incorporating nylon fibers into concrete mixes, the overall performance of the material can be improved, particularly in terms of its mechanical properties and durability.

One of the key advantages of nylon fiber reinforcement is its ability to absorb energy, which helps concrete withstand dynamic loads and impacts. This is especially important in applications where structures are subjected to vibrations or heavy traffic, as it reduces the likelihood of cracking and extends the service life of the concrete.

Additionally, nylon fibers improve the bond between the concrete matrix and the reinforcement, enhancing the composite action within the beam. This leads to better load distribution and improved flexural strength, allowing the concrete to perform more effectively under various loading conditions. The fibers also contribute to crack control, as they can bridge micro-cracks and prevent them from growing into larger fissures.

Furthermore, the resistance of nylon fiber to chemical degradation and moisture makes it a suitable choice for concrete exposed to harsh environmental conditions. This resistance contributes to preserving both the performance and aesthetic qualities of the concrete over time, thereby minimizing maintenance requirements and lowering lifecycle costs

In summary, the integration of nylon fiber into concrete beams provides significant benefits in terms of toughness, abrasion resistance, and overall structural performance. Its application not only improves the durability of concrete structures but also fosters the creation of more resilient and long-lasting infrastructure. Further exploration of nylon fiber applications in various concrete formulations could lead to innovative solutions in modern construction (Mir Mohiuddin, April 2023)

Polyester fiber, with its excellent bonding properties and resistance to moisture, provides additional support and durability.

Polyester fiber is gaining recognition in the construction industry for its excellent bonding properties and resistance to moisture, which significantly enhance the support and durability of concrete structures. When incorporated into concrete mixes, polyester fibers contribute to improved mechanical performance and longevity.

One of the key benefits of polyester fiber is its ability to create a strong bond with the concrete matrix. This bonding enhances the overall structural integrity, ensuring that the fibers effectively distribute loads throughout the concrete. The result is a composite material that exhibits improved flexural strength and toughness, making it particularly effective in applications where structural resilience is critical.

Moreover, polyester fiber's resistance to moisture and chemical degradation makes it suitable for use in environments where exposure to water, chemicals, or harsh weather conditions is a concern. This durability helps prevent the deterioration of the concrete over time, ensuring that structures remain safe and functional.

The inclusion of polyester fibers also aids in crack control. By bridging micro-cracks that develop under load or due to shrinkage, these fibers help maintain the integrity of the concrete, reducing the likelihood of larger, more damaging cracks. This characteristic is particularly valuable in applications where aesthetic considerations are important, as it helps preserve the appearance of the concrete surface.

In summary, the incorporation of polyester fiber into concrete enhances its bonding capacity and moisture resistance, leading to improved support and durability. As the construction industry continues to seek innovative solutions for more resilient structures, polyester fiber presents a promising option that aligns with the need for sustainable and long-lasting building materials. Further research into its applications could unlock even greater benefits for concrete performance. (Saroj Gupta,, 2007,2011)

To evaluate the performance of these fiber-reinforced concrete beams, this study employs ETABS (Extended 3D Analysis of Building Systems) software. ETABS is widely used in the construction industry for its advanced capabilities in structural analysis and design, enabling accurate modeling of complex building systems. Through a series of laboratory tests and simulations, the research aims to assess the flexural performance, load-carrying capacity, and failure modes of the different fiber-reinforced concrete beams.

1.1 Scope of the study

This study on fiber Reinforced Concrete fiber aims to thoroughly examine the properties, performance, and potential applications of fiber as a sustainable and cost-effective alternative to traditional reinforcement materials. The research will concentrate on the following key areas:

Materials:
The study will investigate the physical and mechanical properties of fiber used as a reinforcement material, along with the characteristics of rope-reinforced concrete. This includes analyzing the effects of various processing and treatment methods on fiber performance.

Performance:
Experimental testing will assess the structural performance of fiber, covering aspects such as tensile, compressive, and flexural strength. Additionally, the study will evaluate durability and resistance to environmental factors like moisture and corrosion.

Applications:
The research will explore potential applications of fiber in construction, including beams, bridges, and other infrastructure. It will also evaluate the economic feasibility and cost-effectiveness of fiber compared to traditional reinforcement materials.

Future Research:

The study will identify areas requiring further investigation to enhance the performance and durability of fiber. It will also consider the potential for integrating fiber with other sustainable materials to improve the eco-friendliness of construction practices

1.2 **Objective:**

The principal aim of this project is to explore the potential use of Fiber Reinforced Concrete (FIBER) in future buildings. To achieve this overarching goal, the following sub-objectives related to sustainability and flexural behavior have been defined for the preliminary stages:

I. Examine the sustainability potential of fiber in comparison to conventional reinforced concrete.

II. Analyze the mechanical properties and structural performance of fiber beams.

III. Carry out a behavioral comparison between conventional reinforced concrete and textile-reinforced concrete using ETABS.

1.3 Research outline:

Chapter 1: Introduction-

Fibers are fundamental components in various materials, playing a crucial role in enhancing strength, flexibility, and durability. They can be natural or synthetic and are utilized across multiple industries, including textiles, construction, and composites. This chapter introduces the significance of fibers, their properties, and their applications, setting the stage for a deeper exploration of specific types of fibers used in this study, such as nylon, cotton, and polyester. Understanding these fibers is essential for advancing material science and improving product performance in various applications.

Chapter 2: Literature review

This chapter provides a comprehensive review of existing literature related to Fiber Reinforced Concrete (FIBER) and its applications in construction. Previous studies examining the mechanical properties, sustainability aspects, and structural performance of fiber will be analyzed. Key findings from various research efforts will be synthesized to identify trends, gaps, and challenges in the current knowledge base. This literature review will lay the groundwork for understanding the significance of fiber and its potential impact on modern construction practices.

Chapter 3: Materials and methodology

This chapter outlines the materials utilized in the study and the methodologies employed for analyzing fiber beams. The selection criteria for materials, including the sourcing and preparation of fiber, will be discussed, as well as the testing procedures implemented to evaluate their mechanical properties. The methodology section will detail the experimental setup, analytical techniques, and software used for structural analysis, ensuring a comprehensive understanding of the research approach.

Chapter 4: Results and discussion

In this chapter, present the findings from the analysis conducted on fiber beams. Key results obtained from experimental tests and simulations will be summarized, followed by a thorough discussion of their implications. This section will compare the performance of fiber with conventional reinforced concrete, highlighting observed advantages and limitations. Additionally, we will interpret the data in the context of sustainability and structural efficiency, offering insights into the future application of fiber in construction.

Chapter 5: Conclusion and recommendations

Conclusion: The study confirms that nylon, cotton, and polyester fibers each have unique strengths and applications. Nylon fibers demonstrate excellent strength and shock absorption, while cotton fibers offer softness and ease of handling, and polyester fibers combine durability with resistance to environmental factors.

Recommendations: Further research is encouraged to explore the long-term performance of these fibers in various applications. Additionally, investigating new composite materials that incorporate these fibers could lead to advancements in construction and textile industries. Implementing innovative reinforcement strategies may enhance material properties and sustainability.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction:

Recycled reinforced concrete fiber has demonstrated several advantages over traditional concrete, including reduced shrinkage and cracking. It also exhibits improved resistance to environmental factors such as moisture, temperature variations, and corrosion. The use of rope as a reinforcement material enhances fiber due to its high tensile strength, toughness, and ductility. Historically, rope has been utilized in construction for thousands of years, particularly in regions such as Asia, South America, and Africa. Its high strength-to-weight ratio, rapid renewability, and sustainability contribute to its popularity in various applications. (A., 2023)

Recently, Fiber has gained attention as a sustainable and eco-friendly alternative to conventional reinforcement materials. The growing demand for sustainable building practices supports the exploration of fiber, making it a compelling subject for research and application in modern construction.

2.2 Overview of the use of fiber in construction:

Research into fiber Reinforced Concrete fiber has highlighted its potential as an alternative to traditional reinforcement materials. Several studies have explored various aspects of fiber, revealing promising results: (Elisabetta Monaldo, 2019)

Jiang et al. (2023) found that incorporating fiber, into concrete enhances its mechanical properties. Specifically, the addition of fiber, increased flexural strength and toughness, making the concrete more resilient to bending forces.

Another study examined fiber’s performance in aggressive environments and discovered that rope fibers improved resistance to chloride ion penetration, thereby reducing the risk of corrosion. This suggests that fiber, can perform well under harsh conditions, extending its longevity. (Weige Chen, 2020)

Early research indicates that fiber, can outperform traditional steel-reinforced concrete in certain areas. One study noted that fiber, demonstrated superior mechanical properties compared to steel reinforcement, prompting further investigation into its full potential. (M. Iqbal Khan, 2023)

Fiber, enhances various aspects of concrete, including flexural strength, toughness, ductility, and reduced shrinkage and cracking. These improvements contribute to the material’s overall durability and performance. Additionally, fiber, exhibits better resistance to environmental factors such as moisture, temperature fluctuations, and corrosion compared to conventional concrete. (Lin Chen, 2023)

Research into the properties and geometry of fiber has shown that these factors significantly impact fiber’s mechanical performance. Studies also emphasize the need for proper treatment of fiber to enhance its durability and resistance to decay and insect damage. Methods such as boiling, pressure impregnation, and chemical treatment have been explored to improve the longevity of fiber as a reinforcement material. (Balasubramanian Kandasubramanian, 2024.)

2.3 **Previous research on fiber reinforced concrete:**

Several studies have investigated the use of fiber as a reinforcement material in concrete. For instance, Jiang et al. (2024) examined the mechanical properties of rope-reinforced concrete fiber and found that incorporating rope fibers significantly increased both flexural strength and toughness. Other research focused on the durability of fiber in aggressive environments, revealing that fiber fibers enhance resistance to chloride ion penetration and reduce the risk of corrosion.

Overall, prior research underscores the potential of fiber as a viable substitute for traditional reinforcement materials. Studies indicate that adding fiber or strips can markedly improve the mechanical properties and durability of concrete. Fiber has demonstrated enhanced flexural strength, toughness, and ductility, alongside reduced shrinkage and cracking compared to conventional concrete. Additionally, it shows superior resistance to environmental factors such as moisture, temperature variations, and corrosion.

Early studies have suggested that fiber can outperform steel-reinforced concrete in some respects, prompting recommendations for further exploration of its potential. Subsequent research has delved into various aspects of fiber, including the impact of rope properties and geometry on mechanical performance, behavior under different loading conditions, and long-term durability. Investigations have also identified the necessity of treating fiber to improve its durability and resistance to decay and insect damage. Treatment methods such as boiling, pressure impregnation, and chemical applications have proven effective in enhancing the longevity of fiber as a reinforcement material. (Sarno, 2024.)

Despite these promising findings, further research is needed to fully understand fiber 's properties and behavior under diverse conditions, as well as to establish industry standards and regulations for its safe and effective use. Fiber, being a fast-growing, sustainable, and renewable material, presents an attractive option for eco-friendly construction. Its high strength-to-weight ratio and low carbon footprint position it as a potential alternative to steel reinforcement. Nonetheless, the effectiveness of fiber reinforcement is contingent upon the quality of both the fiber and the concrete mix

2.4 **Properties of fiber as a reinforcement material:**

Fiber exhibits several properties that make it a promising reinforcement material for concrete. Key characteristics include:

recycle Fiber possesses high tensile strength, essential for reinforcing concrete structures. This quality enables the concrete to withstand tension without failing. fiber fibers demonstrate high toughness and ductility, enhancing concrete performance under impact and fatigue loads, making it more resilient. The lightweight nature of fiber reduces the overall weight of reinforced concrete, facilitating easier handling during construction. (Articles, 2012 to 2020)

Nylon fiber, when designing a concrete beam with nylon fiber, it serves as reinforcement much like traditional steel bars. Here’s how it works:

Nylon fiber is strategically placed in the concrete formwork before pouring. This ensures it is fully encased, maximizing reinforcement. The strong tensile properties of nylon fiber improve the beam's resistance to bending and breaking. Using nylon fiber can be lighter and more cost-effective than steel, while also reducing the risk of corrosion associated with steel reinforcement. (Spadea, 2015)

Cotton fiber E, while cotton fiber is not typically used in structural applications due to its lower strength, it can illustrate tensile forces conceptually in a beam design:

In a theoretical context, cotton fiber can demonstrate where tension might occur in a concrete beam, although steel rebar is preferred for real-world applications. Engineers usually place steel rebar in areas of expected tensile stress, while concrete handles compressive forces. (S.K. Bajpai, 2014 to 2015)

Polyester fiber, Polyester fiber is another option for reinforcing concrete beams:

Like nylon, polyester fiber is designed to handle tensile forces, providing support against bending and cracking.

During construction, polyester fiber is positioned in the formwork before pouring concrete to ensure full embedding. Polyester fiber is lightweight, flexible, and resistant to corrosion, simplifying construction processes and potentially reducing costs compared to traditional steel reinforcement. (Karim S. Rebeiz, 1995)

2.5 **Properties of concrete when reinforced with fiber**

The incorporation of fiber into concrete significantly enhances its mechanical properties and durability. Key improvements observed with fiber -reinforced concrete fiber include:

Fiber exhibits greater flexural strength compared to traditional concrete. The addition of fiber or strips enhances the material's load-carrying capacity, making it more resistant to bending and cracking. Fiber demonstrates improved toughness and ductility, increasing the concrete's energy absorption capacity. This allows it to endure higher levels of strain without failure. (El-Abbasy, 2023.)

Fiber reinforcement minimizes early-age cracking and decreases the likelihood of cracks forming due to shrinkage, leading to a more stable structure. The inclusion of fiber improves the concrete's overall durability, making it more resistant to moisture, temperature fluctuations, corrosion, decay, and insect damage. The addition of fiber as reinforcement helps mitigate the risk of thermal cracking caused by temperature changes, further enhancing the longevity of the concrete. In addition, topics such as usage, tools, tasks, research, etc. have been chosen to be easily understood.

2.6 **Standards and regulations related to the use of fiber in construction**

The use of fiber as a reinforcement material in construction is governed by various standards and regulations established by national and international organizations. These guidelines ensure the safety, performance, and reliability of fiber -reinforced concrete. Key standards include:

The American Society for Testing and Materials (ASTM) establishes standards for evaluating the mechanical properties of fiber. (ASTM, 2021) These standards evaluate the performance characteristics essential for construction applications. The International Organization for Standardization (ISO) has developed guidelines for testing and evaluating fiber as a construction material. These guidelines standardize the assessment of fiber's suitability for use in concrete reinforcement. (N. Saba, 2018-2019,)

India has established specific standards for using fiber as reinforcement in concrete, addressing the technical requirements and performance criteria relevant to fiber - reinforced concrete within the Indian construction context. (Kandasamy1, © 2006-2011)

Some countries, such as Colombia, Ecuador, and Peru, have included regulations for the use of fiber in their building codes. These codes provide guidelines for the application and performance of rope-reinforced concrete in various construction projects. The International Code Council (ICC) Evaluation Service provides evaluation reports that determine compliance with the International Building Code. These reports provide an additional layer of verification for the use of innovative materials like fiber -reinforced concrete. (Walraven, 2009)

2.7 **ETABS:**

ETABS extended three-dimensional analysis of building systems is a sophisticated software used primarily for structural analysis and design of buildings. Here are some key topics to discuss regarding ETABS:

ETABS is specifically designed for multi-story buildings. It includes a range of analysis techniques, such as linear and nonlinear static and dynamic analysis. User-Friendly Interface: Easy navigation with graphical inputs and outputs. Integrated Design Tools: Features for designing concrete and steel structures. Dynamic Analysis: Ability to perform time-history and response spectrum analyses. 3D Modeling Capabilities: Users can create complex geometry using various modeling tools. Load Assignments: Efficient methods to apply dead loads, live loads, wind loads, and seismic loads. Static Analysis: Determining the response of structures under static loads. Dynamic Analysis: Analyzing structures subjected to time-dependent loads. ports various international design codes, allowing for compliance with local regulations. Comprehensive reports including deflections, stress distribution, and more. Graphical representations of results aid in understanding structural behavior. Can integrate with other software for BIM (Building Information Modeling) and CAD applications Used by civil and structural engineers in designing residential, commercial, and industrial buildings. Online tutorials, webinars, and forums for community support and continuous learning. Enhanced integration with AI and machine learning for predictive analysis and optimization. (A. Ravi Kumar, 2017)

CHAPTER THREE : MATERIAL AND METHODLOGY

3.1 Materials used:

All materials utilized in this study are pertinent to the research objectives and have been selected based on their specific characteristics and suitability. A variety of materials were employed, including fine aggregate, coarse aggregate, cement, reinforced steel, reinforced cotton fiber, nylon fiber, and polyester fiber.

The concrete mix design adhered to ACI standards for compressive strength testing, consisting of 1 part crown cement, 2 parts fine aggregate, 4 parts coarse aggregate, and 0.5 parts water. A water-cement ratio of 0.5 was maintained to achieve a target compressive strength of 15 MPa after 28 days. Steel reinforcing bars conforming to ASTM A615 Grade 60 were used in the study. Concrete specimens were cast in standard cylindrical molds with dimensions of 101.6 mm in diameter and 203.2 mm in height.

Additionally, various chemicals were incorporated into the testing process: sodium chloride (NaCl), magnesium sulfate ($MgSO_4$), calcium carbonate ($CaCO_3$), and sulfuric acid (H_2SO_4). The impact of these chemicals on the workability of concrete was assessed as follows.

A solution was prepared with 10% NaCl in 1 liter of water, which was found to reduce workability. A comparable solution of 10% $MgSO_4$ in 1 liter of water also led to reduced workability. A solution containing 1% $CaCO_3$ in 1 liter of water was prepared, demonstrating a similar reduction in workability. Lastly, a solution of 2% H_2SO_4 in 1 liter of water was prepared, which also showed a reduction in workability.

3.2 Specimen preparation:

To evaluate fiber as a reinforcement material in concrete, 16 cylindrical specimens were prepared as follows:

Fiber strips were treated with sodium chloride, magnesium sulfate, sulfuric acid, and calcium carbonate to enhance resistance to decay. Each mold was lined with small stones to prevent segregation, and one treated fiber strip was placed in the center. The concrete mixture was poured around the fiber strip and compacted with a tamping rod to eliminate air voids. Molds were covered with plastic sheets to retain moisture. Specimens were cured at 23°C and 95% humidity for 28 days.

After curing, specimens were demolded, labeled, and stored in a moist environment until testing. Ends of specimens were leveled for uniform loading. All tests followed ASTM standards, and results were recorded for analysis.

3.3 **Use stone for experiment:**

In concrete reinforcement, materials are selected for their tensile strength, stiffness, and compatibility with the concrete matrix. Although some stones, like basalt, have high tensile strength, they are not typically used as reinforcement due to factors such as brittleness and poor adhesion to the concrete.

Stones have long been employed as aggregate materials in concrete, contributing to the strength and durability of the mix. However, their use as reinforcement is less common and presents challenges. Stone's brittleness and the difficulty in achieving a good bond with concrete make it less suitable compared to other reinforcement materials.

One of the primary reasons for studying rope as a reinforcement material is its high tensile strength, which helps offset the low tensile strength of concrete. Stones, despite their strength, are generally not used for this purpose because they do not effectively address the issues of tensile strength and bonding.

3.4 Properties of fiber:

Figure 3-1: Cotton fiber

Cotton fiber: All the fibers used as raw material for making yarn are called textile fibers. Currently many types of fibers are used in the textile industry. Some of these fibers occur naturally and have been used since the invention of cloth. Among the natural fibers, the most commonly used fiber is cotton or cotton. It is also called natural cellulose fiber. Cotton fiber is the king of fibers. This cotton fiber is the most produced from nature. Here, this cotton fiber has been used instead of reinforcement in the research work. (Amarjit S. Basra, 1984) (Alfred D. French, 10 November 2018)

Figure 3-2: Nylon fiber

Nylon fiber is a synthetic material composed of high molecular weight polyamides. It is typically manufactured in the form of fibers, which are widely used in textiles and other applications due to their strength, elasticity, and resistance to abrasion. It can be drawn, cast, or extruded through a spinneret from a melt or solution, resulting in fibers, filaments, bristles, or sheets that are used to create yarn, fabric, and cordage. The most common types of nylon fiber are those synthesized from adipic acid and hexamethylenediamine. In this research, nylon fiber has been utilized as a reinforcement material to enhance the properties of the composite. (P.S. Song, August 2005)

Figure 3-3: Polyester fiber

Polyester fiber: Polyester fiber is a synthetic fiber derived from the polymerization of organic acids and alcohols. Commonly used in clothing fabrics, polyester is known for its high strength, stability, and dimensional integrity. It offers excellent insulation properties and is energy-efficient in production. With notable strength and elastic recovery, polyester fiber is both durable and resistant to wrinkling and fire. Additionally, it demonstrates good resistance to various chemicals, showing minimal degradation from acids and alkalis. In this research, polyester fiber has been utilized as a reinforcement material to enhance the composite's performance. (Dr. Mohammed Qadir Ismael, January 2015)

3.5 **Strength of fiber:**

Cotton fiber: Cotton fiber is soft, lightweight, and easy to handle, often used in decorative and handicraft applications. While its tensile strength is relatively low, making it suitable for light-load uses, cotton is ideal for soft, flexible applications, such as pet toys and window treatments.

Nylon fiber: Manufactured to ISO 1140:2012 standards, nylon fibers come in various diameters and are typically supplied in 220-meter coils. Known for their impressive strength-to-weight ratio, nylon fibers exhibit high breaking tenacity and excellent shock absorption, making them suitable for heavy or dynamic loads. However, nylon can absorb water, reducing its strength by up to 20% when wet. With moderate to high elongation, they provide shock-absorbing qualities and excellent abrasion resistance. Nylon exhibits moderate resistance to acids and good resistance to alkalis, oils, and UV radiation, making it a durable choice for outdoor applications.

Polyester fiber: Polyester fibers are known for high tensile strength and resistance to stretching and UV damage. They are durable and can handle dynamic loads due to their elasticity. The strength varies with the weaving or braiding method, with tightly braided fibers being stronger. While polyester fibers generally have lower tensile strength than steel, they offer flexibility and environmental resistance, making them versatile for various applications.

3.6 **Amounts of materials in concrete:**

The details of mixtures of conventional concrete of class M15 used for all types of textiles reinforced are describe:

3.6.1.1 Table1: Quantity of materials

Component	kg/m3
Sand	92
Stone	193
Cement	44
Water	22

3.7 **Compressive strength of concrete:**

In this experiment the ingredient of cylinder is water, cement, Fine aggregate & Coarse aggregate, The height of cylinder is 8 inch and the diameter is 4 inches. Curing period was 28 days.

3.7.1.1 Table 2: Concrete compressive test for 28 days

Slender	Target Strength (MPa)	Test Strength (MPa)
1	15	17
2	15	18
3	15	20

Figure 3-4: Dry concrete mix

Figure 3-5: Dry concrete mix

Figure 3-6: Wet concrete mix

3.8 **Experimental analysis:**

This project involved mixing concrete according to a specific design mix, incorporating fiber reinforcement into steel molds, compacting the mix, and curing the samples in a chamber for a designated period. The compressive strength of the samples was then tested using a testing machine. Data analysis concentrated on evaluating the effect of fiber reinforcement on concrete strength. The results are presented clearly, covering the design mix, material properties, experimental methods, and compressive strength outcomes.

3.9 **Preparation of specimens:**

Preparation of the specimen consisted of cleaning and drying the mold, applying the release agent, cutting and placing the fiber reinforcement, pouring the concrete mix and compacting with tamping rods. The samples were labeled and stored in the curing chamber. This process conforms to design specifications, ensuring accurate test results for compressive strength.

3.10 **Sand aggregate:**

Sand aggregate is a granular material used in construction, primarily as a concrete component or filler. It consists of sand particles that pass through a 2.0 mm sieve, with sizes ranging from 0.06 to 2.0 mm. Typically angular in shape, these particles influence concrete properties. Sand is blended with cement, coarse aggregate, and water to form concrete, which is both versatile and durable. The size and shape of sand particles impact mixing and placement ease, while their properties contribute to concrete strength and long-term durability. Selecting suitable sand aggregate is crucial for achieving desired concrete performance, as variations can affect final properties.

Figure 3-7: Sand aggregate

Figure 3-8: Fiennes modulus for sand aggregate

3.11 **Coarse aggregate:**

Coarse aggregates are essential components of concrete, alongside fine aggregates (like sand) and cement. They typically range in size from 4.75 mm to over 80 mm and enhance the strength and stability of the concrete mixture while reducing the cement requirement. Common types include gravel, crushed stone, and recycled concrete. The size and shape of coarse aggregates affect concrete properties such as workability, strength, and durability; rounded aggregates improve mixing and pumping, while angular aggregates enhance bonding and load-bearing capacity. The quality of coarse aggregates significantly influences concrete performance, making the selection of high-quality materials crucial for achieving desired specifications.

Figure 3-9: Coarse aggregate

Figure 3-10: Fiennes modulus for coarse aggregate

3.12 **Formwork of beam:**

Formwork, or shuttering, is a temporary structure crucial for shaping concrete. Since raw concrete is fluid, it requires formwork to attain a specific shape as it hardens. We created formwork for our beam, measuring 30 inches in length and 6 by 8 inches in dimension. After pouring the concrete, the formwork is removed once the concrete has cured.

Figure 3-11: Formwork of beam

3.13 **Slump test:**

Figure 3-12: Slump test

The slump test is a standard method to assess the workability of fresh concrete. A sample is placed in a conical mold, filled in three layers, and compacted with a rod. After lifting the mold, the settlement of the concrete is measured, known as the slump value. This value indicates the consistency: a higher slump means more workable concrete, while a lower slump indicates stiffness. The test is quick and helps ensure proper concrete placement and quality, contributing to the M15 design ratio calculations.

3.14 **Manual mixing:**

Figure 3-13: Manual mixing

The necessary materials have been collected such as: Trowel, shovel, meson ring pan, measuring jar. And determine a clean place. Mix the dry ingredients (cement, sand and aggregate) together until evenly distributed. Make a small well in the middle of the dry mixture and slowly add the water while mixing continuously. Mix until the concrete reaches a uniform consistency, leaving no dry spots.

3.15 **Concrete under compressive load:**

Figure 3-14: Concrete under compressive load

Compressive strength testing involves shaping concrete specimens in molds, typically made of steel or plastic, according to testing standards. For the 28-day test, cylinders are molded with a diameter of 10.16 cm and a height of 20.32 cm. The concrete is compacted and leveled, then cured for 28 days under standard conditions. After curing, the cylinders are evaluated in a compression testing machine, which applies force until failure. The maximum load recorded indicates the concrete's compressive strength, a critical measure of its ability to resist compression and suitability for various applications. Strength is influenced by material quality, water-cement ratio, curing conditions, and mix design

3.16 **Curing:**

Figure 3-15: Curing

The strength of concrete depends on the hydration reaction of water with its constituent cement. In general, the more effective the curing, the greater the strength of the concrete.

Curing is the process of curing the concrete continuously for a few days after placing the concrete and activating the computer. Curing usually starts 24 hours after placing the concrete and lasts for 21 to 28 days. However, 28 days of curing has been done in this work. The following method is adopted for curing and that is by trapping water with enclosures which are suitable for flat surfaces.

3.17 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 results of the test help to determine the suitability of fiber 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.

Figure 3-16: Pure concrete beam setup for test

Figure 3-17: Reinforcement beam setup for test

Figure 3-18: Nylon fiber beam setup for test

Figure 3-19: Polyester fiber beam setup for test

3.18 ETABS model and data uses pictures

Properties:

Materials= Concrete,

f'c = 2175psi

Section Size = 6" X 6"

Procedure:

Defining Grid System and Story Data in ETABS:

Open ETABS Software launch the ETABS application. Create a New Model. Click on File in the top menu. Select New Model. When prompted, select No to create a new model without a template. Set Units. In the unit selection dialog, choose Kip-ft for units of measurement. Define Grid System. Set the Number of lines in X-direction to 2. Set the Number of lines in Y-direction to 1. Set the Number of stories to 1. Specify Grid Spacing. For X-direction Grid spacing, input 2.5 ft. Click on Custom Grid spacing to define grid spacing. Choose Grid Only to concentrate on grid definition. Press OK to confirm your settings. Complete the process.

Material Properties Summary

Material properties summary for Cotton, Nylon, and Polyester fiber material strength: 2175psi. Modulus of elasticity=265830Ib/ft^3. Material weight and mass density: Weight density: 20 lb/ft^3. Minimum yield strength (Fy): 143 lb/ft^2. Minimum tensile strength (Fu): 143 lb/ft^2. Expected yield strength (Fye): 66,000 lb/ft^2. Expected tensile strength (Fue): 99,000 lb/ft^2. Assigning Supports and Loads in ETABS:

Assign Support: Select Support Point. Select the point in your model where you wish to assign the support. Access Support Assignment. Navigate to Display in the top toolbar. Select Joint/Point. Choose Supports from the dropdown menu. Select Support Type. In the support assignment dialog, choose the Roller support type by clicking the corresponding symbol. Confirm the assignment. Press OK to apply the support assignment.

Assign Loads: Select Beam for Load Assignment. Click on the beam to which you want to assign the load. Access Load Assignment. Navigate to Display in the top toolbar. Select Frame and then Line Loads. Define Load Properties. In the line load assignment dialog: Load Case Name: Select or enter Live.

Units: Ensure it is set to Kip-ft. Direction: Select Gravity. Set Load Distance and Value. Click on Absolute Distance from End-I. Enter the following values: Distance: 15 in (for the distance from the end of the beam). Load: Provide the desired load value. Confirm Load Assignment. Click OK to apply the load. Repeat for Other Loads. Follow the same procedure to assign other distributed loads and point loads as necessary, selecting different beams or points as needed.

Analyze - Run Analysis

Support Reactions in ETABS:

Access Support Reactions. Open the Display Menu. Navigate to Display in the top toolbar. Select Member Forces/Stress Diagrams. Choose Show Member Forces/Stress Diagrams. Select Support/Spring Reactions. Click on Support/Spring Reactions. Choose Load Case. Select the desired Load case (Live, Dead,). Click OK. Select Support Point. Click on Support Point. In the elevation view, click on the specific support point you wish to analyze. View Reaction Values. Right-click on the selected support point. Look for the values you need, such as: Vertical Force, Horizontal Force.

Maximum Bending Moment on a Beam in ETABS:

Access Bending Moment Results. Open the Display Menu. Navigate to Display in the top menu. Show Member Forces/Stress Diagrams. Select Show Member Forces/Stress Diagrams. Choose Frame/Pier/Spandrel Forces. Click on Frame/Pier/Spandrel Forces. Select Load Case. Choose the relevant Load case (Live, Dead). Under Moment, select 3-3. Display Values on Diagram. Click on Show Values on Diagram. Click OK to apply the selection. Select the Beam. Click on the Beam. In the elevation view, click on the beam you want to analyze. View Moment Values. Right-click on the selected beam. Find the following values: Vertical Force, Horizontal Force, Moment.

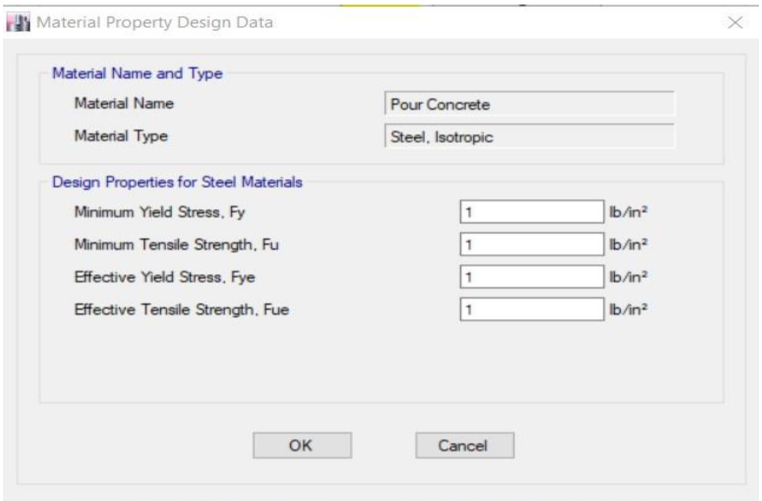


Figure 3-20: ETABS data provide (Pure concrete beam)

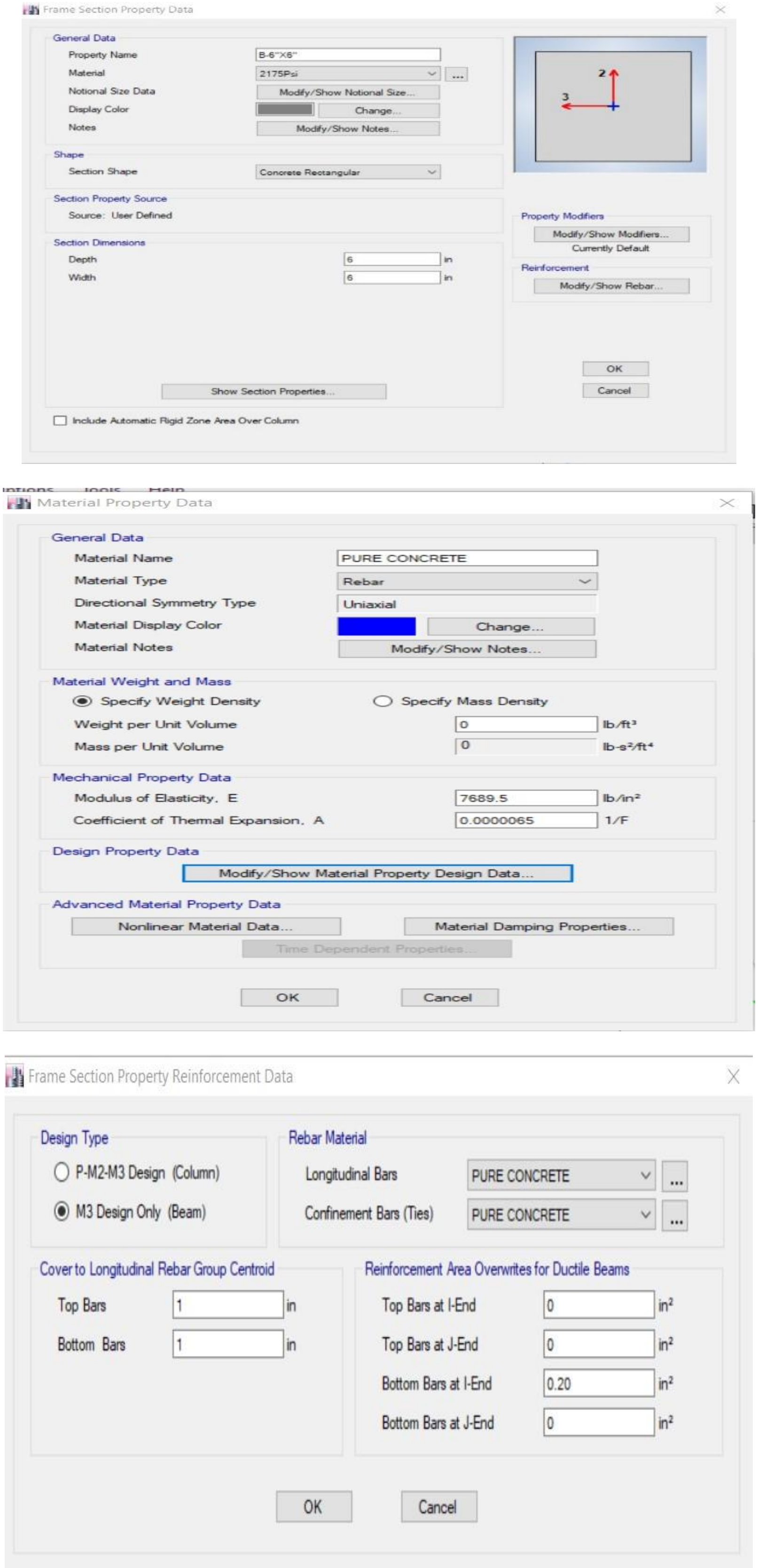
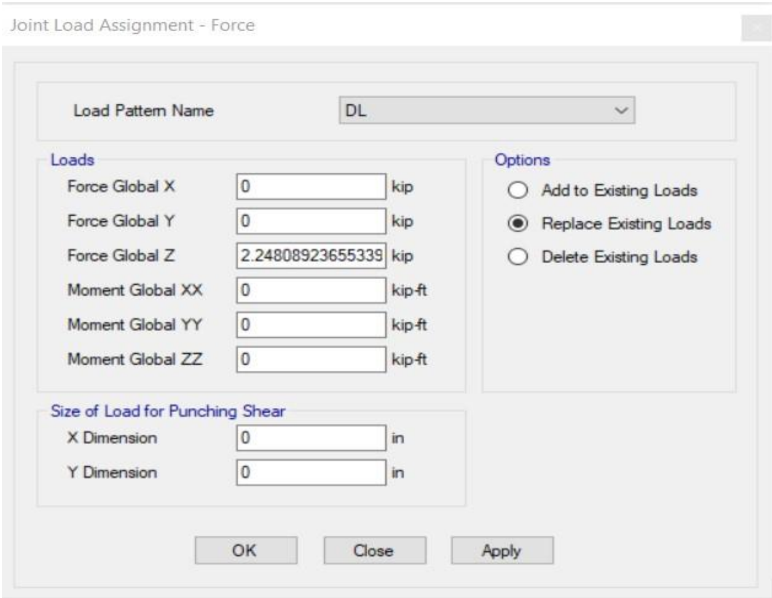


Figure 3-21: ETABS data provide (Reinforcement concrete beam)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DL
Loads
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0
kip
Force Global Y
0
kip
Force Global Z
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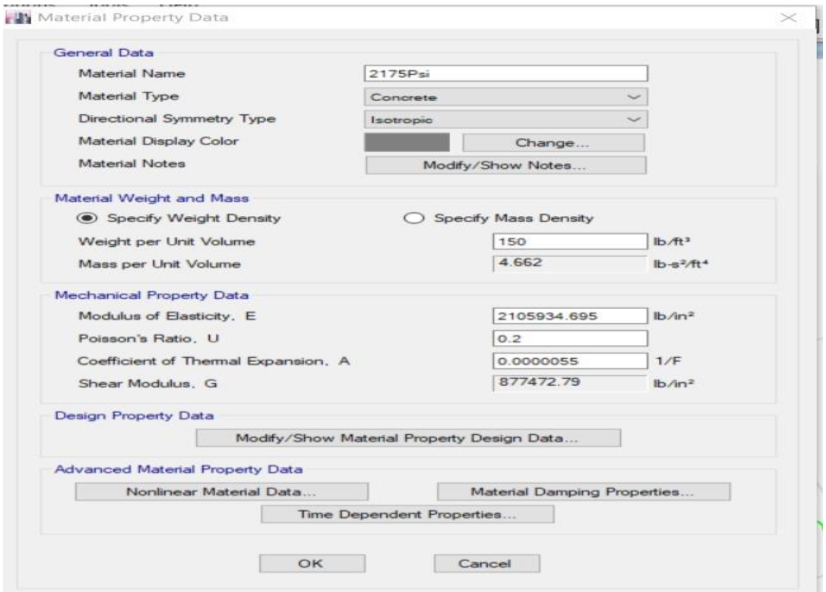
0
kip-ft
Moment Global YY
0
kip-ft
Moment Global ZZ
0
kip-ft
Options
Add to Existing Loads
Replace Existing Loads
Delete Existing Loads
Size of Load for Punching Shear
X Dimension
0
in
Y Dimension
0
in
OK
Close
Apply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General Data
Material Name
2175Psi
Material Type
Concrete
Directional Symmetry Type
Isotropic
Material Display Color
Change...
Material Notes
Modify/Show Notes...
Material Weight and Mass
Specify Weight Density
Specify Mass Density
Weight per Unit Volume
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lb/ft³
Mass per Unit Volume
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lb-s²/ft⁴
Mechanical Property Data
Modulus of Elasticity, E
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lb/in²
Poisson's Ratio, U
0.2
Coefficient of Thermal Expansion, A
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1/F
Shear Modulus, G
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Advanced Material Property Data
Nonlinear Material Data...
Material Damping Properties...
Time Dependent Properties...
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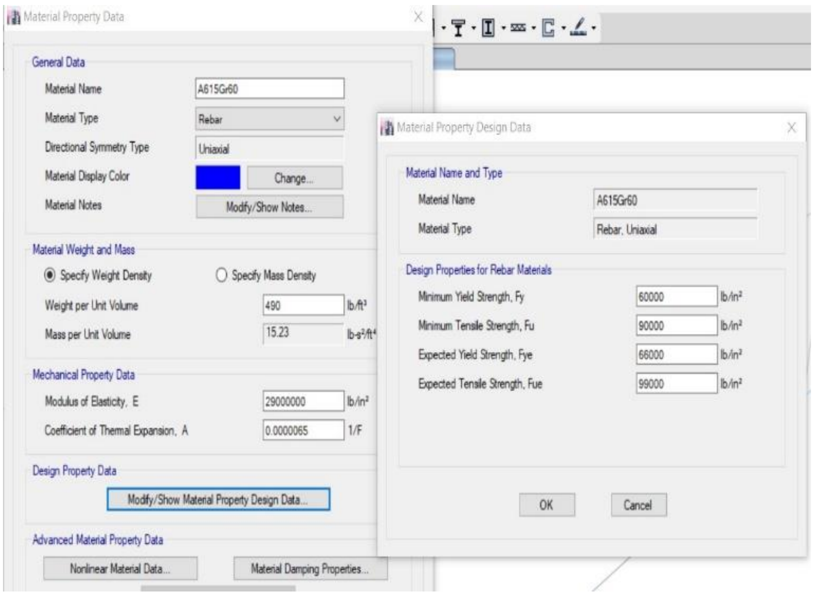
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General Data
Material Name
A615Gr60
Material Type
Rebar
Directional Symmetry Type
Uniaxial
Material Display Color
Change...
Material Notes
Modify/Show Notes...
Material Weight and Mass
Specify Weight Density
Specify Mass Density
Weight per Unit Volume
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lb/ft³
Mass per Unit Volume
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lb-s²/ft⁴
Mechanical Property Data
Modulus of Elasticity, E
29000000
lb/in²
Coefficient of Thermal Expansion, A
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1/F
Design Property Data
Modify/Show Material Property Design Data...
Advanced Material Property Data
Nonlinear Material Data...
Material Damping Properties...
Material Property Design Data
Material Name and Type
Material Name
A615Gr60
Material Type
Rebar, Uniaxial
Design Properties for Rebar Materials
Minimum Yield Strength, Fy
60000
lb/in²
Minimum Tensile Strength, Fu
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lb/in²
Expected Yield Strength, Fye
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lb/in²
Expected Tensile Strength, Fue
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lb/in²
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Cancel

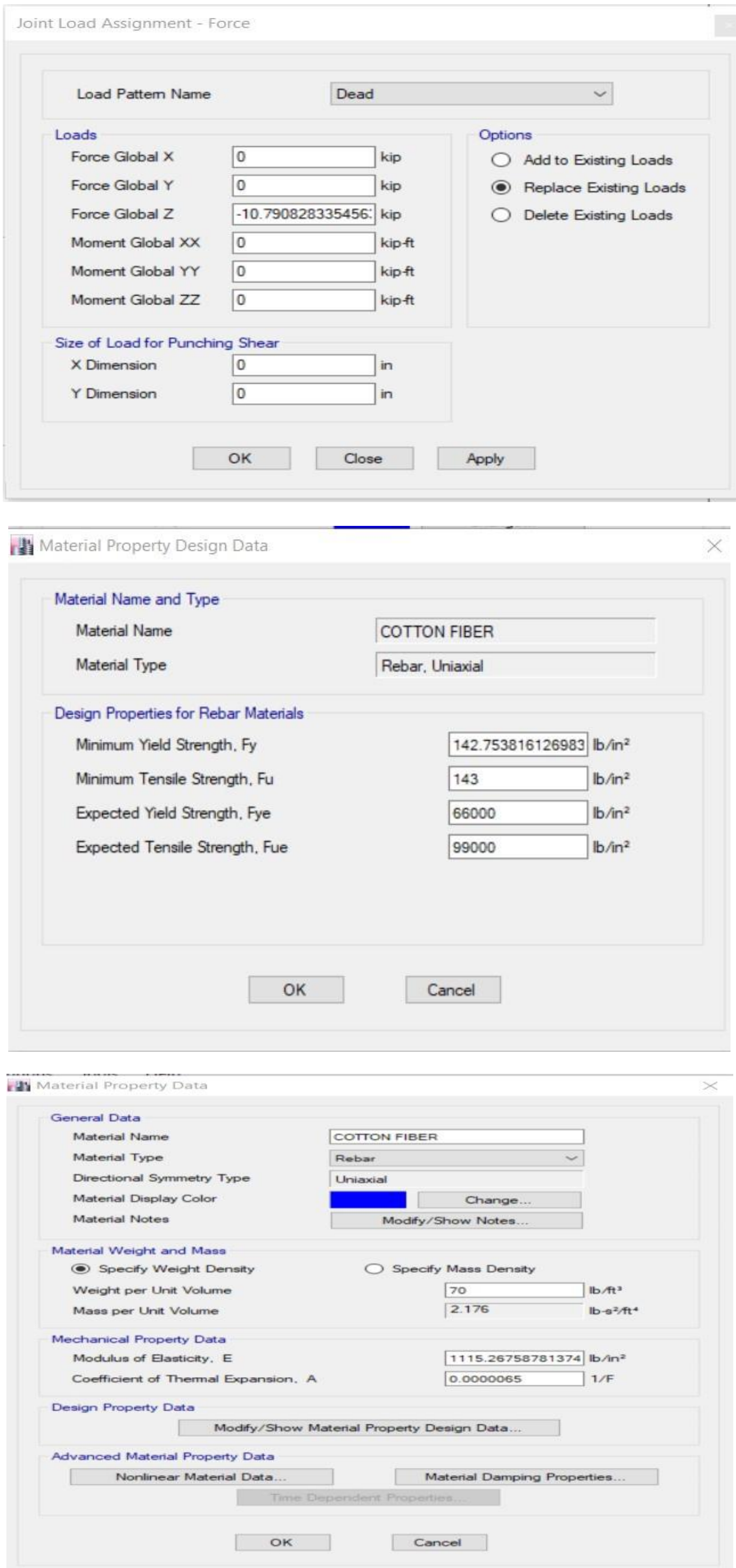
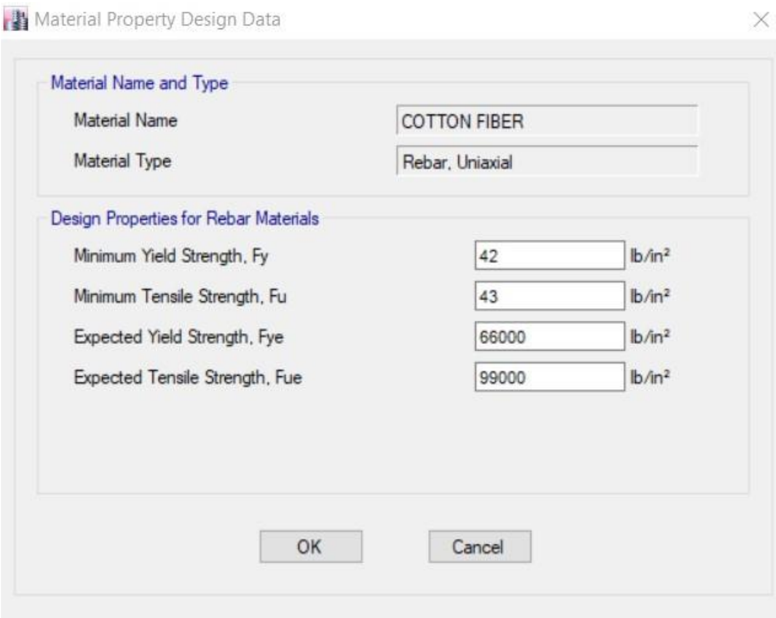


Figure 3-22: ETABS data provide (2 nose12mm Cotton fiber beam)



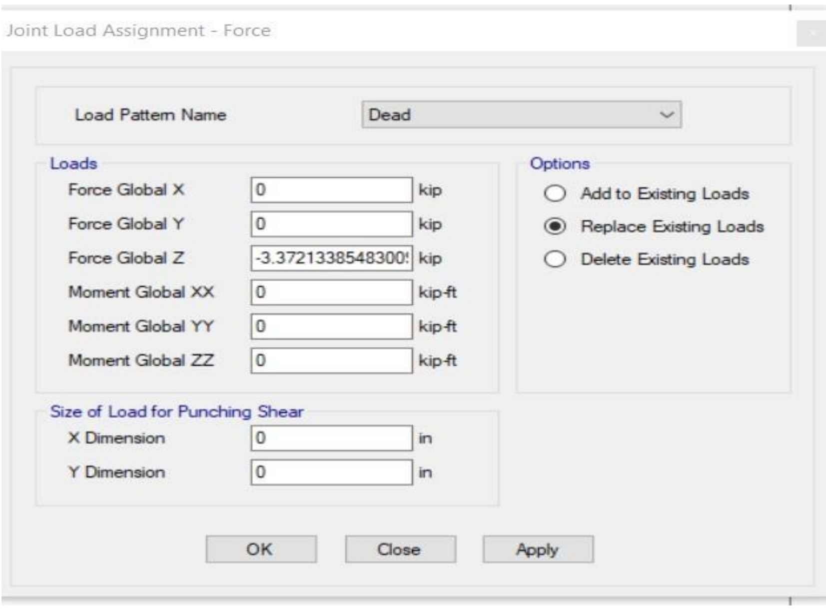


Figure 3-23: ETABS data provide (3 nose12mm Cotton fiber beam)

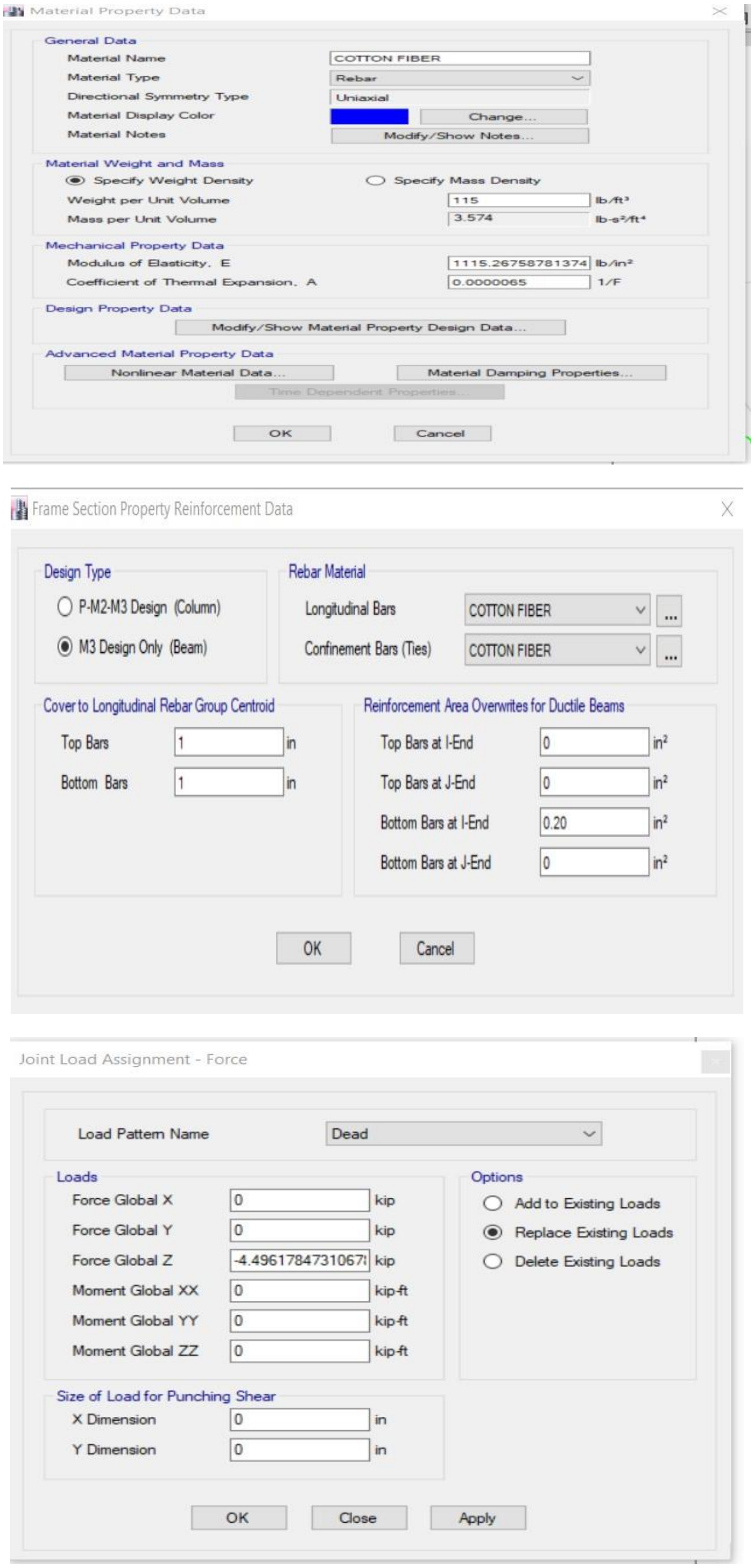
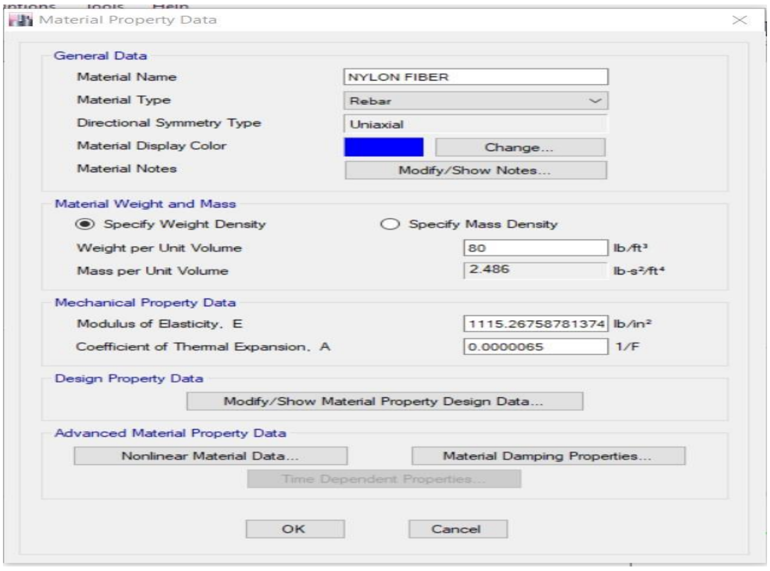


Figure 3-24: ETABS data provide (2 nose12mm Nylon fiber beam)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NYLON FIBER
Material Type
Rebar
Directional Symmetry Type
Uniaxial
Material Display Color
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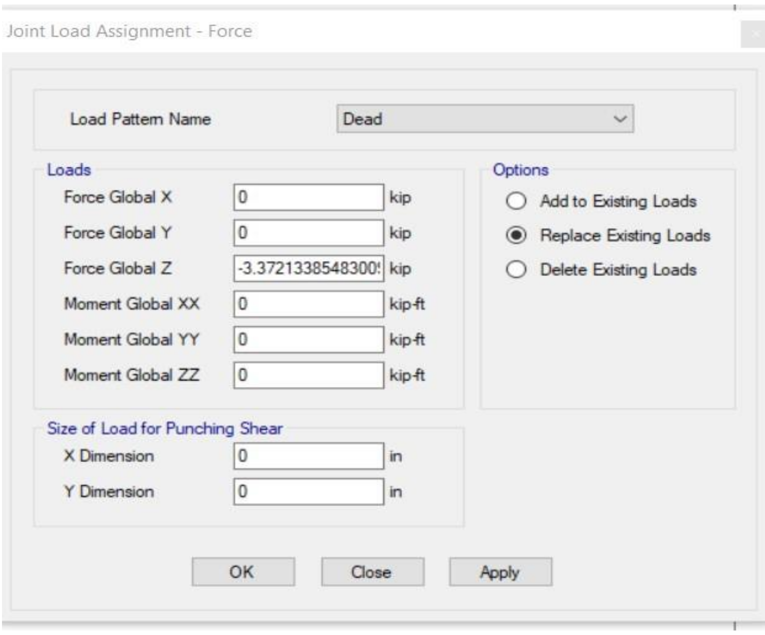
Material Notes
Modify/Show Notes...
Material Weight and Mass
Specify Weight Density
Specify Mass Density
Weight per Unit Volume
80
lb/ft³
Mass per Unit Volume
2.486
lb-s²/ft⁴
Mechanical Property Data
Modulus of Elasticity, E
1115.26758781374
lb/in²
Coefficient of Thermal Expansion, A
0.0000065
1/F
Design Property Data
Modify/Show Material Property Design Data...
Advanced Material Property Data
Nonlinear Material Data...
Material Damping Properties...
Time Dependent Properties...
OK
Cancel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Load Pattern Name
Dead
Loads
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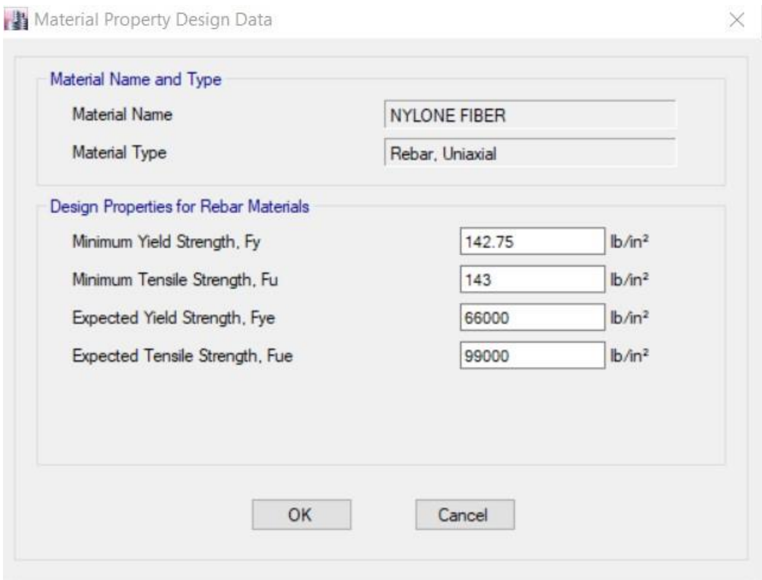
kip
Force Global Y
0
kip
Force Global Z
-3.3721338548300
kip
Moment Global XX
0
kip-ft
Moment Global YY
0
kip-ft
Moment Global ZZ
0
kip-ft
Options
Add to Existing Loads
Replace Existing Loads
Delete Existing Loads
Size of Load for Punching Shear
X Dimension
0
in
Y Dimension
0
in
OK
Close
Apply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Material Name and Type
Material Name
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Material Type
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lb/in²
Minimum Tensile Strength, Fu
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lb/in²
Expected Yield Strength, Fye
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lb/in²
Expected Tensile Strength, Fue
99000
lb/in²
OK
Cancel

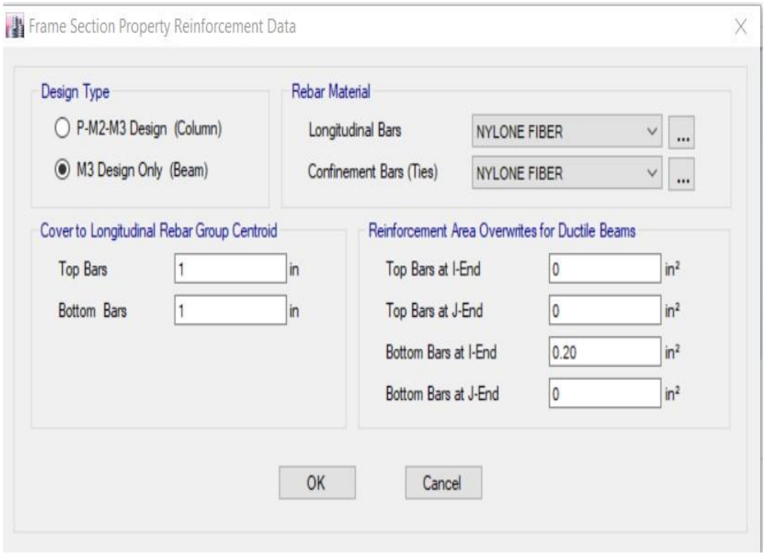
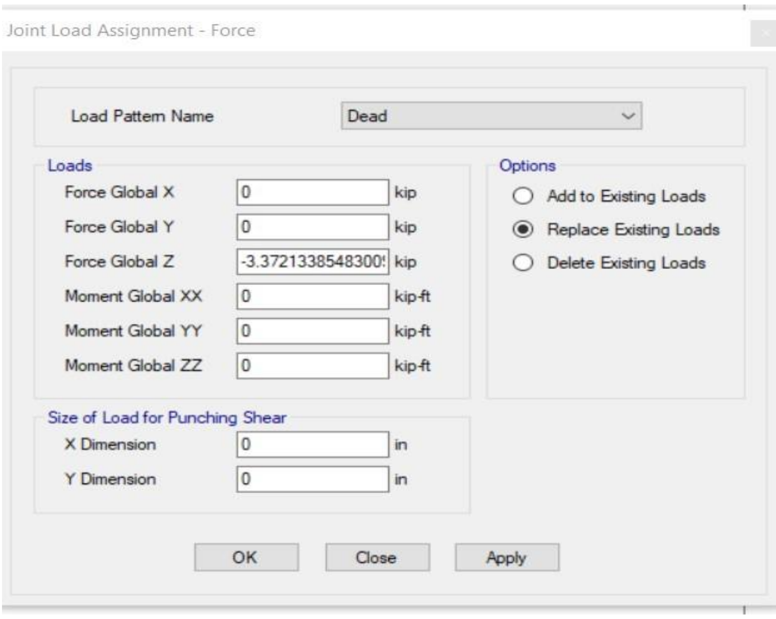
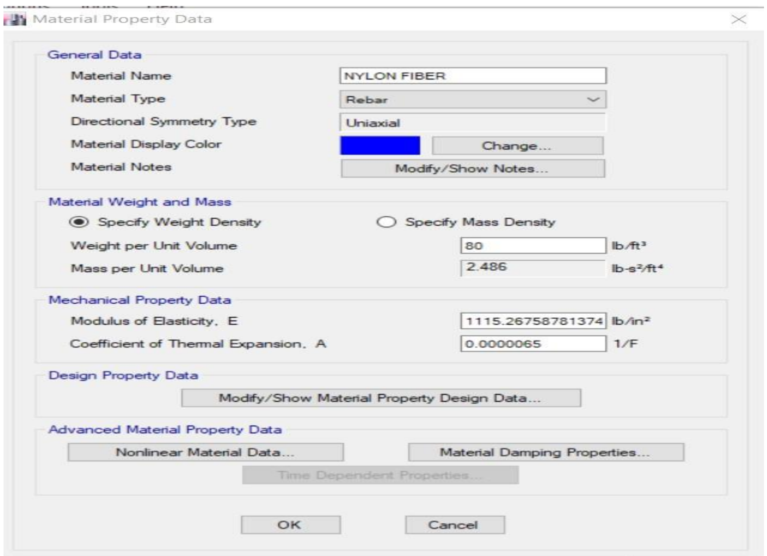


Figure 3-25: ETABS data provide (2 nose12mm Nylon fiber beam)





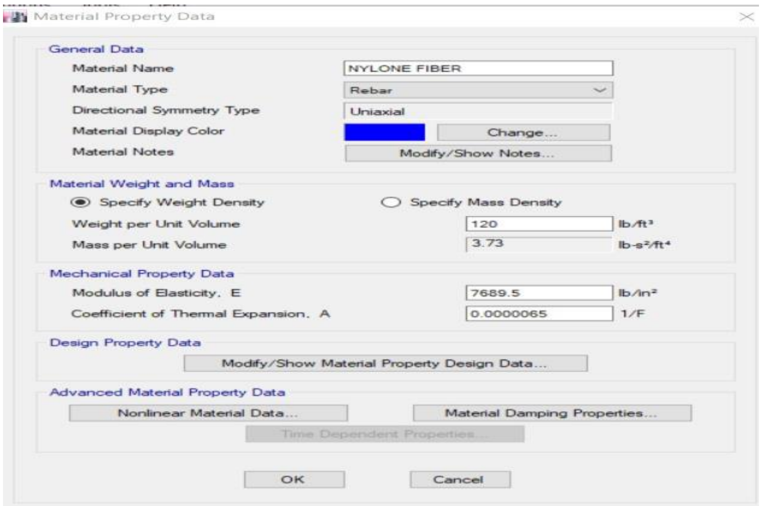


Figure 3-26: ETABS data provide (3 nose12mm Nylon fiber beam)

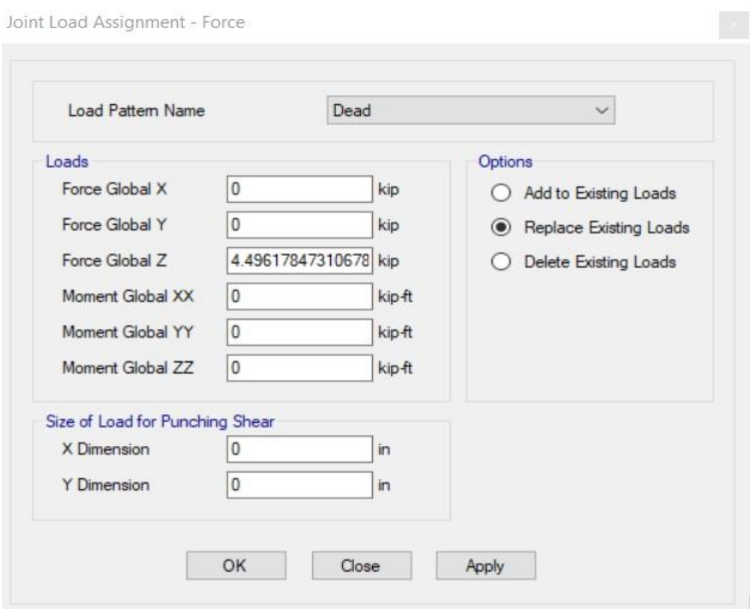


Figure 3-27: ETABS data provide (Polyester fiber concrete beam)

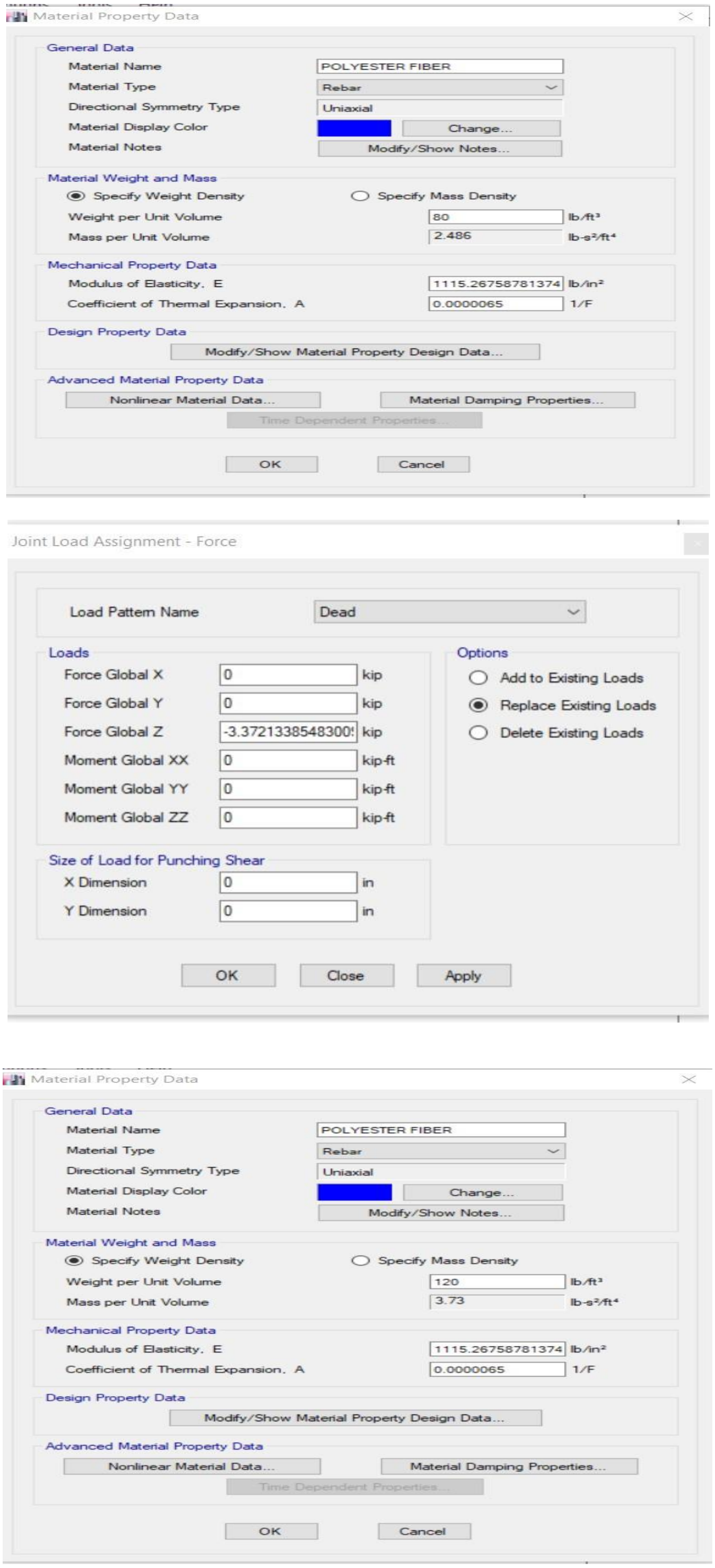
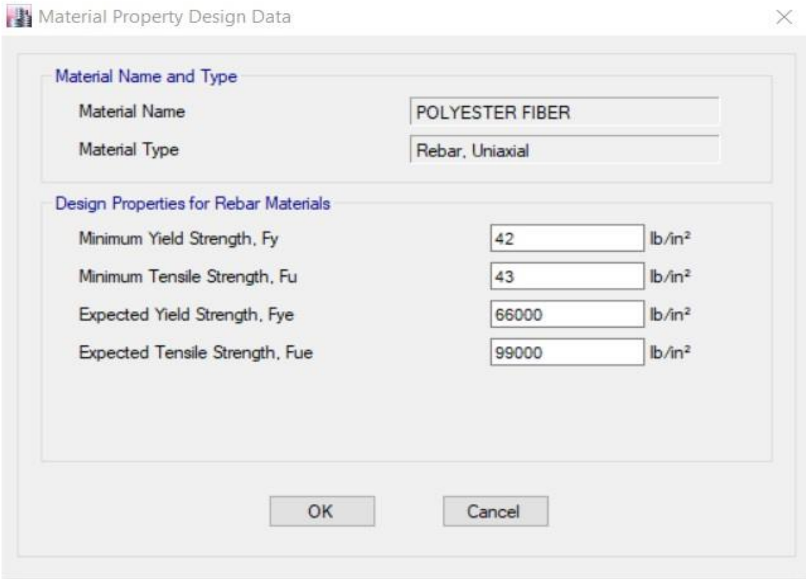


Figure 3-28: ETABS data provide (3 nose12mm Polyester fiber beam)



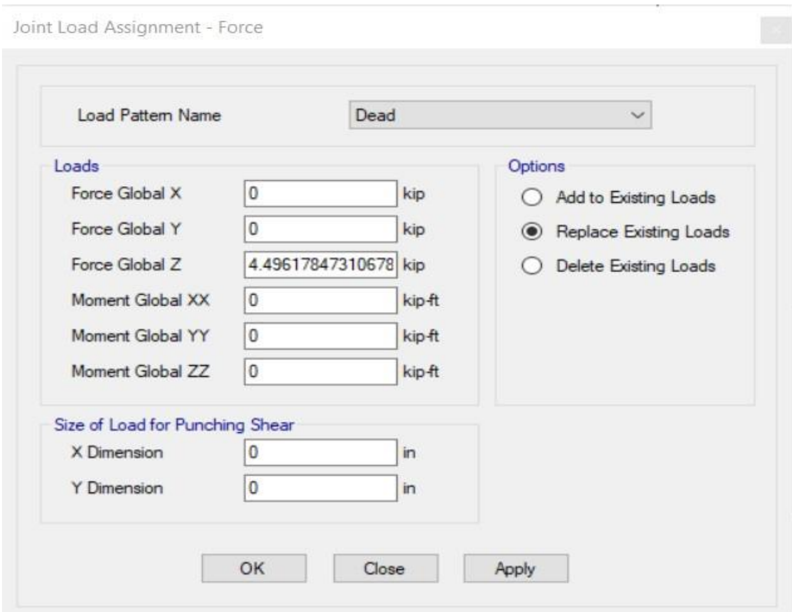


Figure 3-29: ETABS data provide (2 nose12mm Cotton fiber beam)

CHAPTER FOUR: RESULT AND DISCUSSION

4.1 Result:

The results of tests conducted on control specimens and other beams are shown in the table below.

4.2: Pure concrete beam

Figure 4-1:Pure concrete beam setup for test

Figure 4-2: Failure pattern (Pure concrete beam)

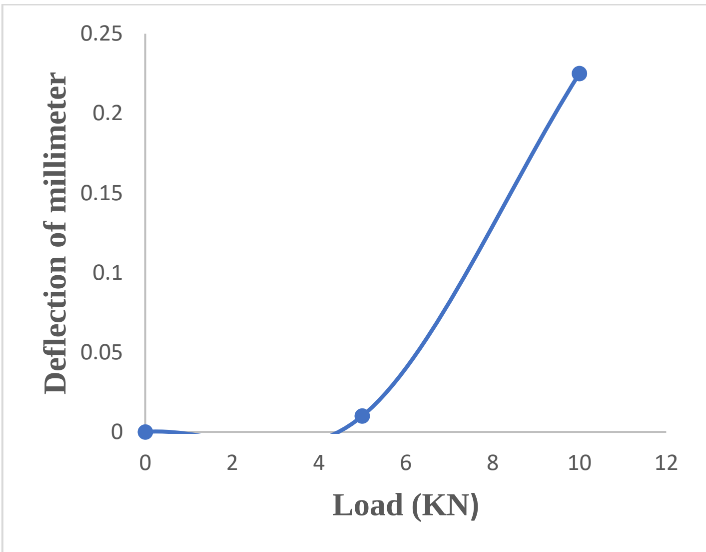


Figure 4-3: Load displacement relation

Analyzed the pure concreate beam under vertical loads and found by the following values:

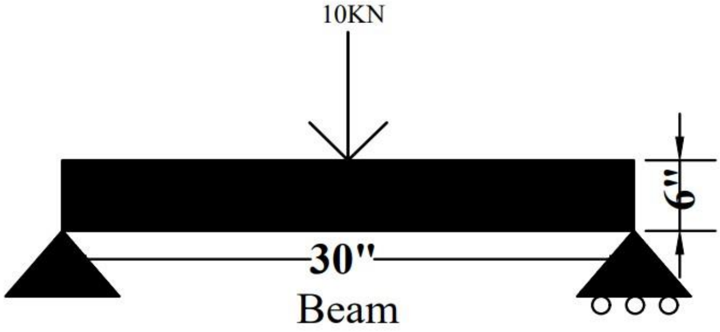


Figure 4-4: Pin and Ruler support beam

Figure 4-5: Support reaction

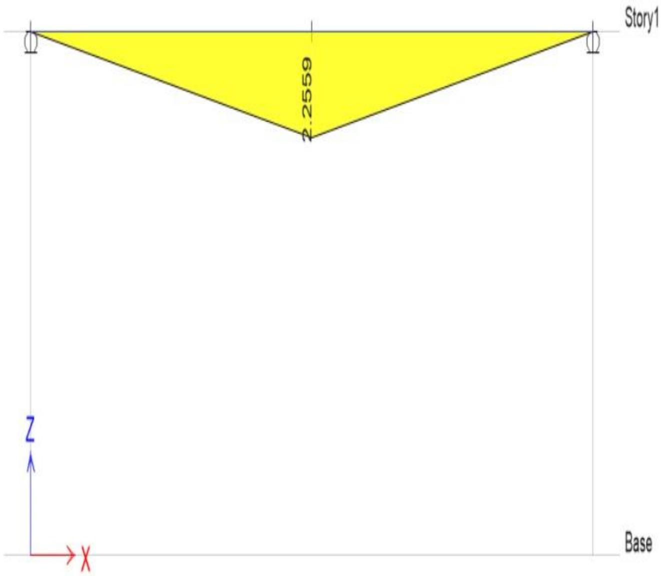


Figure 4-6: Bending moment diagrams

The concrete beam, designed with full reinforcement, exhibits a load capacity of 10 KN while experiencing a deflection of only 0.225 mm under the applied load. This performance highlights the beam's structural integrity and stability under the specified loading conditions.

Support reactions: The support reaction value is 5.23 KN, indicating the force at the supports after analysis. This value illustrates how the structure responds to applied loads.

Bending moment diagrams: These diagrams illustrate the distribution of bending moments along the structure, helping identify areas of maximum stress.

Displacement: The maximum displacement recorded is 2.2559 mm, representing the structure's movement due to applied loads. This measurement is crucial for evaluating the safety and effectiveness of the design.

The ETABS analysis provides essential insights into the structure's reactions, bending moments, and displacements, confirming the design's strength and stability.

4.3 Reinforcement concrete beam

Figure 4-7: Reinforcement beam setup for test

Figure 4-8: Failure pattern (Reinforcement beam)

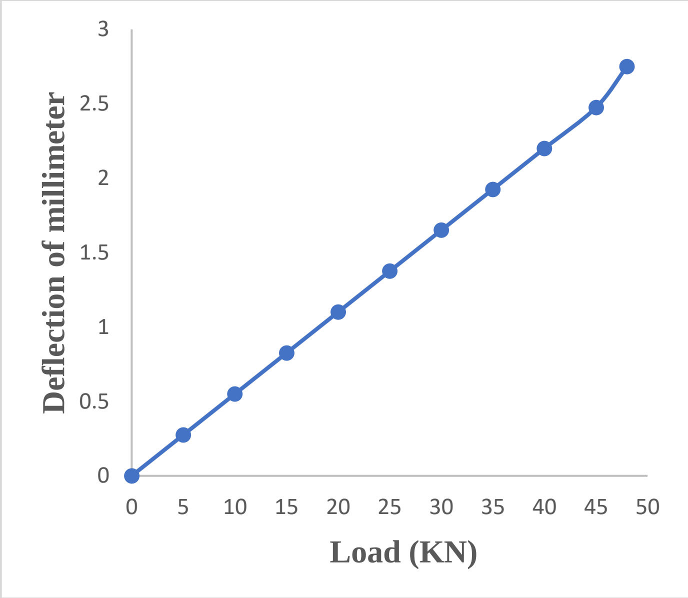


Figure 4-9: Load displacement relation

Analyzed the reinforcement concreate beam under vertical loads and found by the following values:

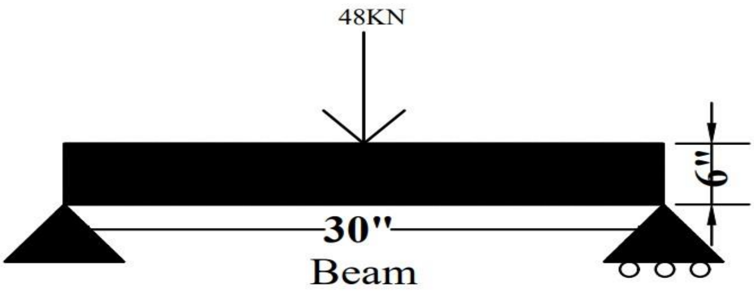


Figure 4-10: Ruler support beam

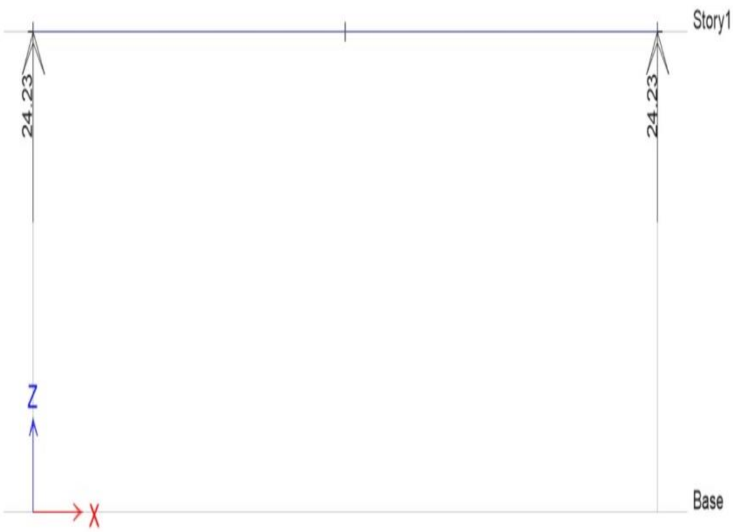


Figure 4-11: Support reaction

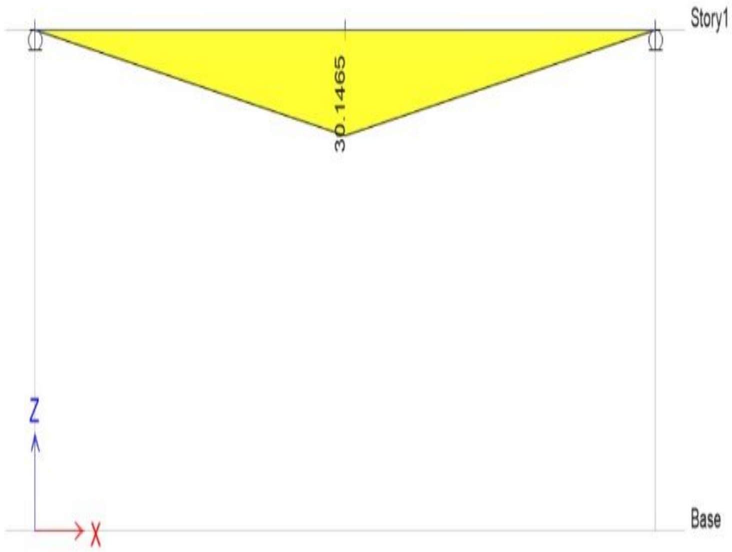


Figure 4-12: Bending moment diagrams

This fully reinforced concrete beam demonstrates a load capacity of 48 KN, with a measured deflection of 2.75 mm under the applied load. These characteristics indicate the beam's robust structural performance and stability in supporting significant loads.

The graph illustrates the relationship between load and displacement. The following breakdown summarizes how displacement changes with varying load levels: Initially, as the load increases from 0 KN to 1 KN, the displacement remains at 0 mm. With a further increase in load to 5 KN, the displacement rises to 0.5 mm. The displacement continues to grow in accordance with the load. As the load reaches 48 KN, this trend persists, resulting in a final displacement of 2.75 mm.

Support reactions: The support reaction value is 24.23 KN, representing the force at the supports after analysis. This value indicates how the structure reacts to applied loads.

Bending moment diagrams: These diagrams depict the distribution of bending moments along the structure, highlighting areas of maximum stress.

Maximum displacement: The maximum recorded displacement is 30.25 mm, indicating the structure's movement due to applied loads. This measurement is critical for assessing the safety and effectiveness of the design.

The ETABS analysis provides vital insights into the structure's reactions, bending moments, and displacements. This information is essential for confirming the design's strength and stability, ensuring that it is both safe and effective.

4.4 Used 2 nos 12mm bar cotton fiber reinforcement concrete beam

Figure 4-13: Cotton fiber beam setup for test

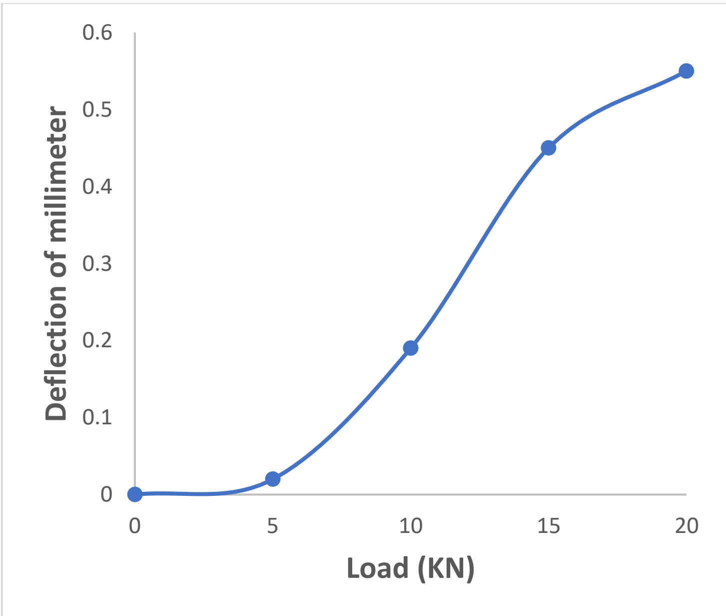


Figure 4-14: Load displacement relation

Analyzed the cotton fiber concreate beam under vertical loads and found by the following values:

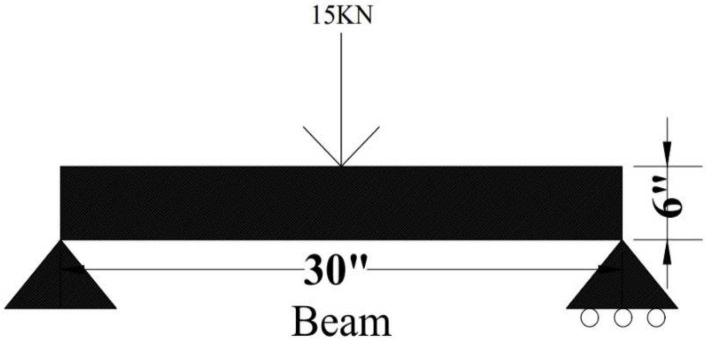


Figure 4-15: Pin and Ruler support beam

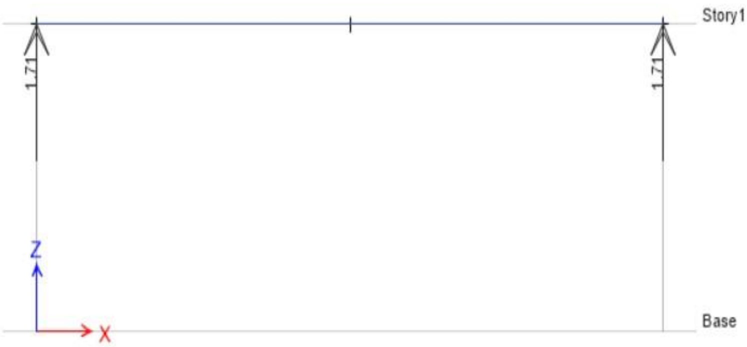


Figure 4-16: Support reaction

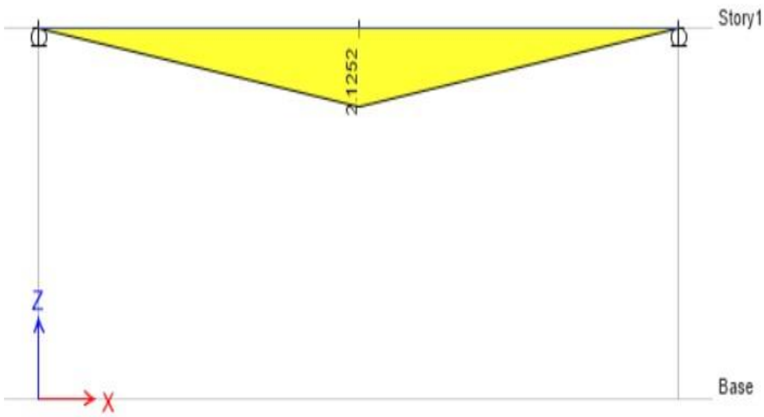


Figure 4-17: Bending moment diagrams

The third beam utilizes two 12mm cotton fiber bars, providing a load capacity of 15 KN and a deflection of 0.60 mm under load. This design is particularly suitable for supporting light, unladen goods, making it a strong candidate for applications requiring both flexibility and strength.

The accompanying graph illustrates the relationship between load and displacement. Notably, displacement increases to 0.5 mm as the load reaches 5 KN.

The support reaction value is calculated at 1.92 kips, indicating the force at the supports after analysis. This value reflects how the structure responds to applied loads.

Additionally, bending moment diagrams illustrate the distribution of bending moments along the beam, highlighting areas of maximum stress.

The maximum displacement recorded is 2.3 mm, representing the greatest movement of the structure due to the applied loads. This measurement is essential for evaluating the design's safety and effectiveness.

4.5 Used 3 nos 12mm bar cotton fiber reinforcement concrete beam

Figure 4-18: Cotton fiber beam setup for test

Figure 4-19: Failure pattern (cotton fiber beam)

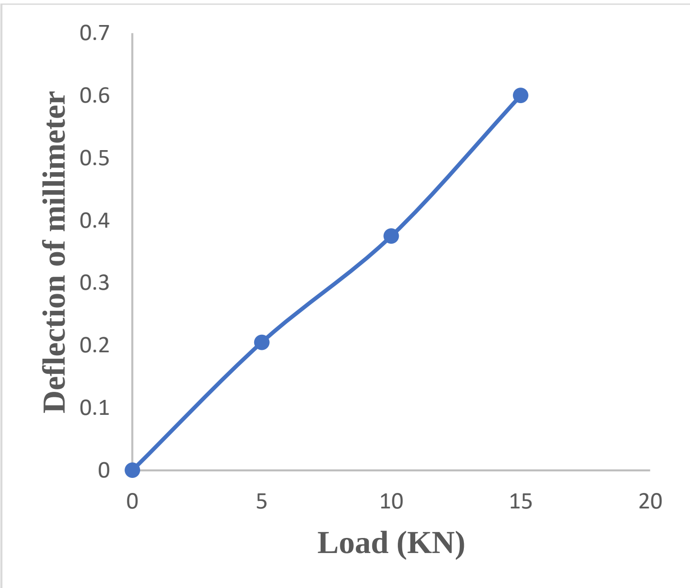


Figure 4-20: Load displacement relation

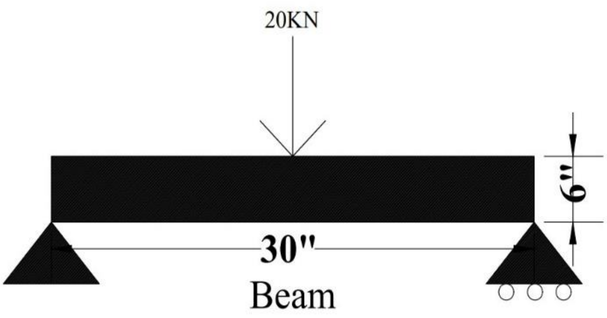


Figure 4-21: Pin and Ruler support beam

Figure 4-22: Support reaction

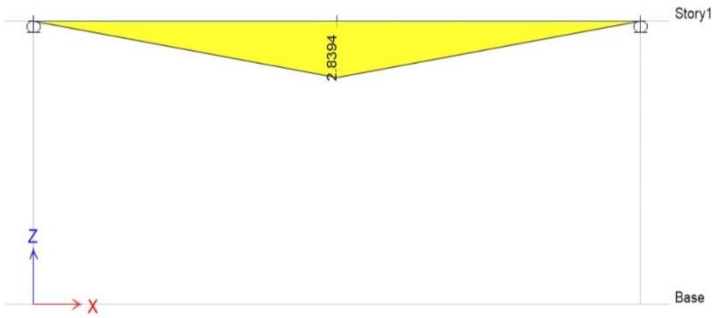


Figure 4-23: Bending moment diagrams

Analyzed the cotton fiber concreate beam under vertical loads and found by the following values:

The fourth beam employs three 12mm cotton fiber bars, providing a load capacity of 20 KN and a deflection of 0.55 mm under load. This configuration is particularly suitable for supporting light, unladen goods, making it an effective choice for applications requiring both flexibility and strength.

The accompanying graph illustrates the relationship between load and displacement. Notably, the displacement increases to 0.205 mm as the load reaches 5 KN.

The support reaction value is calculated at 2.3 kips, representing the force at the supports following the analysis. This value indicates how the structure reacts to applied loads. Additionally, bending moment diagrams illustrate the distribution of bending moments along the beam, highlighting areas of maximum stress.

The maximum recorded displacement is 2.8394 mm, reflecting the highest movement of the structure due to applied loads. This measurement is crucial for assessing the design's safety and effectiveness.

4.6 **Used 2 nos 12mm bar Nylon fiber reinforcement concrete beam**

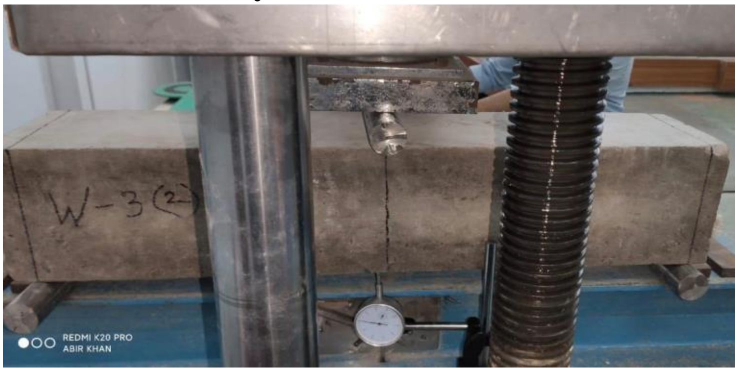


Figure 4-24: Nylon fiber beam setup for test

Figure 4-25: Failure pattern (Nylon fiber beam)

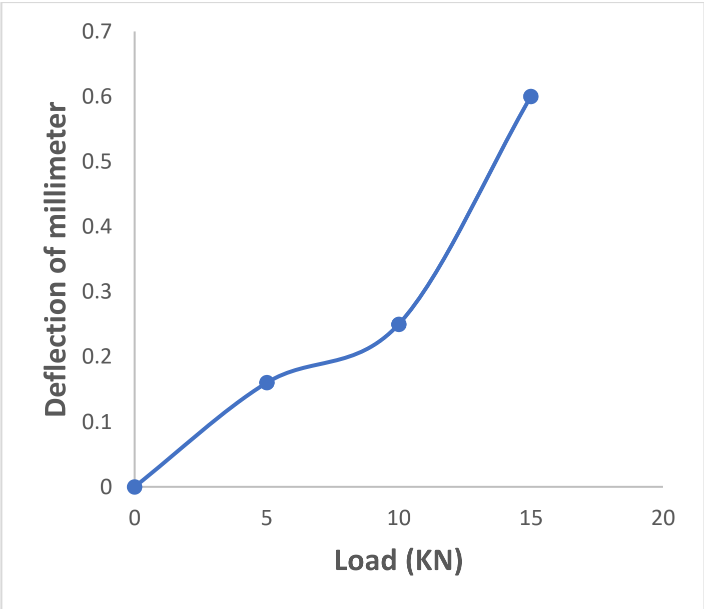


Figure 4-26: Load displacement relation

Analyzed the nylon fiber concreate beam under vertical loads and found by the follow values:

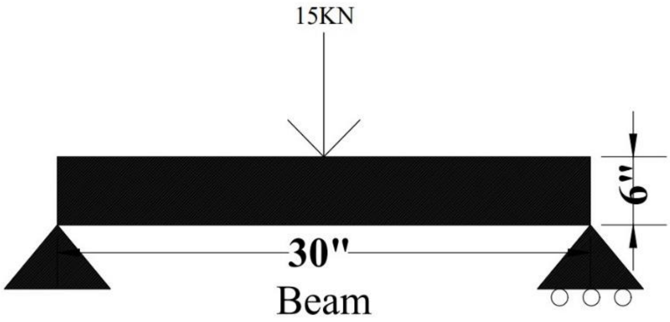


Figure 4-27: Pin and Ruler support beam

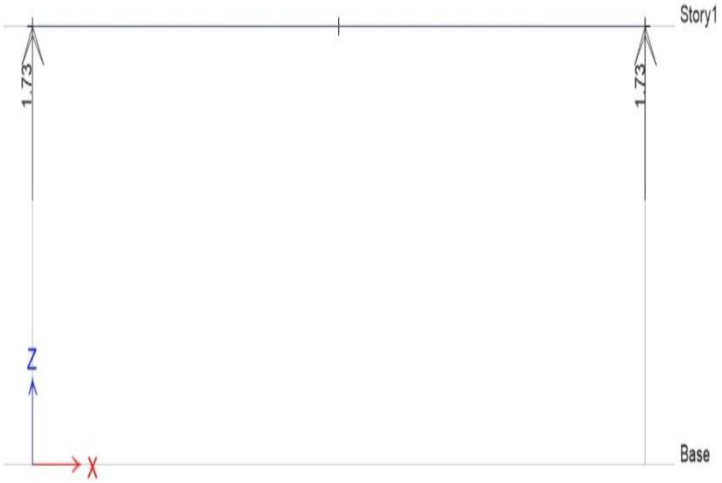


Figure 4-28: Support reaction

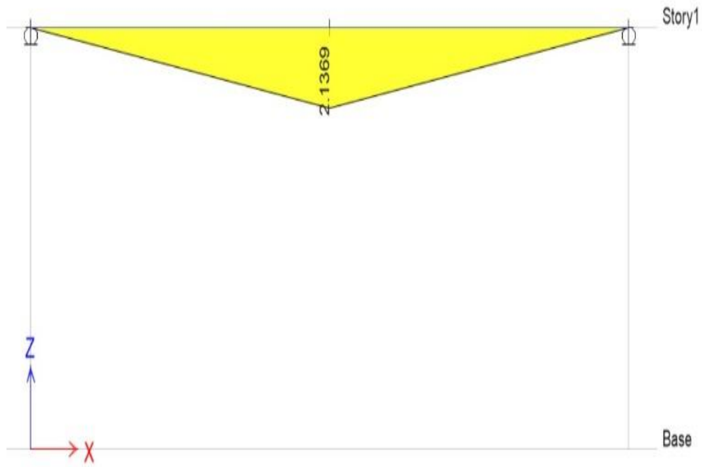


Figure 4-29: Bending moment diagrams

The load and deflection values obtained from the third beam are identical to those of the fifth beam, as discussed below. The fifth beam employs two 12mm nylon fiber bars, providing a load capacity of 15 KN and a deflection of 0.60 mm under load. This design is particularly suitable for supporting light, unladen goods, making it an effective option for applications requiring both flexibility and strength.

The accompanying graph illustrates the relationship between load and displacement, showing that displacement increases to 0.16 mm as the load reaches 5 KN.

The support reaction value is calculated at 1.73 kips, indicating the force at the supports after analysis. This value reflects the structure's response to applied loads. Additionally, bending moment diagrams illustrate how bending moments are distributed along the beam, highlighting areas of maximum stress.

The maximum recorded displacement is 2.1369 mm, representing the greatest movement of the structure due to applied loads. This measurement is crucial for evaluating the design's safety and effectiveness.

4.7 Used 3 nos 12mm bar nylon fiber reinforcement concrete beam

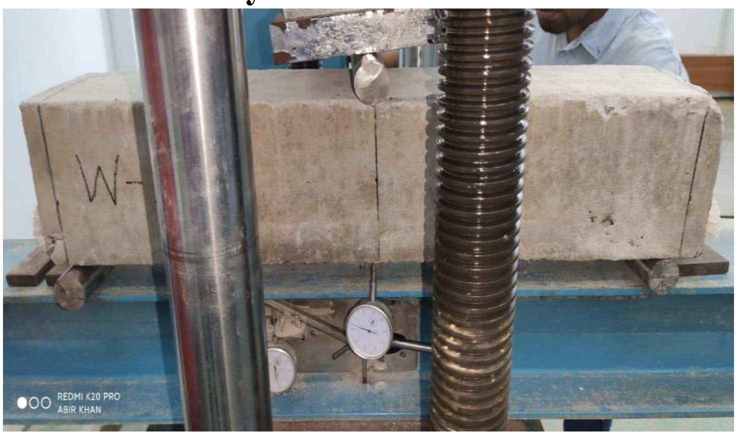


Figure 4-30: Nylon fiber beam setup for test

Figure 4-31: Failure pattern (Nylon fiber beam)

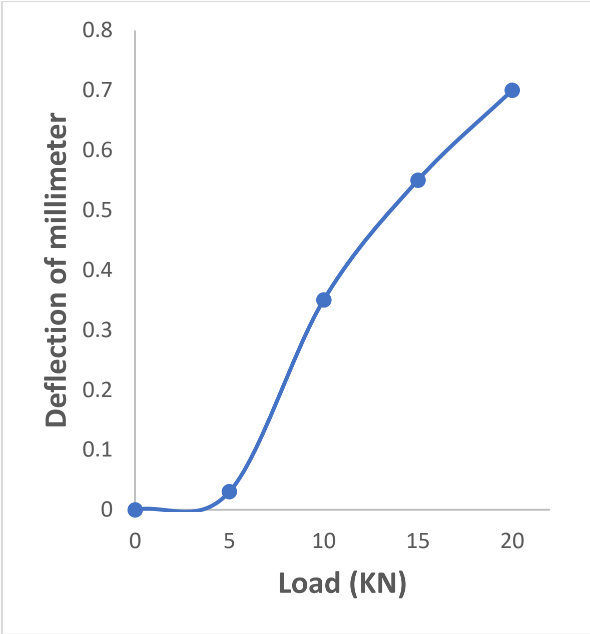


Figure 4-32: Load displacement relation

Analyzed the nylon fiber concreate beam under vertical loads and found by the following values:

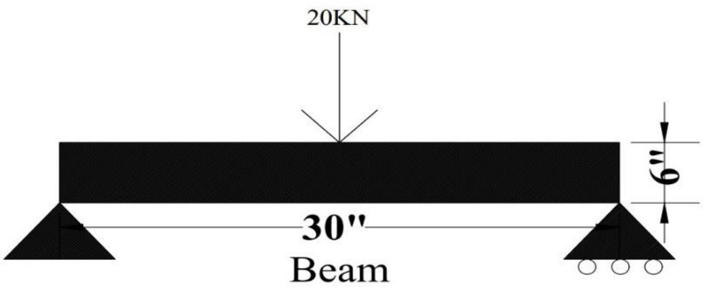


Figure 4-33: Pin and Ruler support beam

Figure 4-34: Support reaction

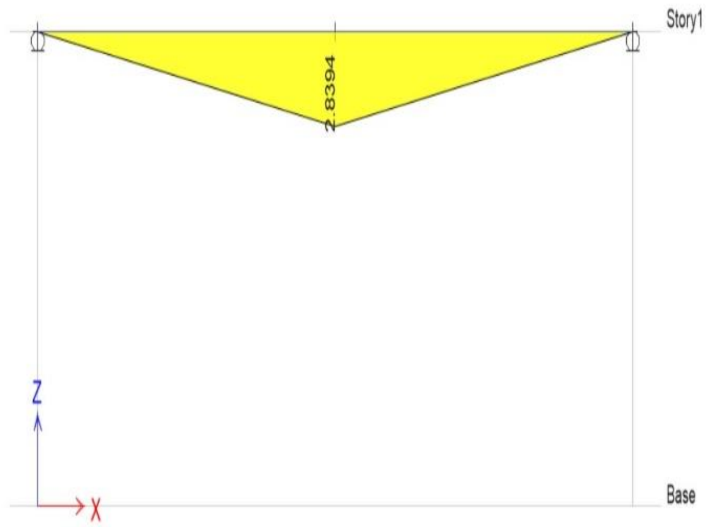


Figure 4-35: Bending moment diagrams

The load and deflection values obtained from the third beam are identical to those of the fifth beam. The fifth beam utilizes three 12mm nylon fiber bars, offering a load capacity of 20 KN and a deflection of 0.70 mm under load. This design is particularly suitable for supporting light, unladen goods, making it an effective choice for applications requiring both flexibility and strength.

The accompanying graph illustrates the relationship between load and displacement, showing that displacement increases to 0.03 mm as the load reaches 5 KN. The support reaction value is calculated at 2.3 kips, indicating the force at the supports after analysis. This value reflects the structure's response to applied loads.

Bending moment diagrams further illustrate the distribution of bending moments along the beam, highlighting areas of maximum stress. The maximum recorded displacement is 2.8394 mm, which represents the greatest movement of the structure due to applied loads. This measurement is crucial for evaluating the design's safety and effectiveness.

4.8 Used 2 nos 12mm bar polyester fiber reinforcement concrete beam

Figure 4-36: polyester fiber beam setup for test

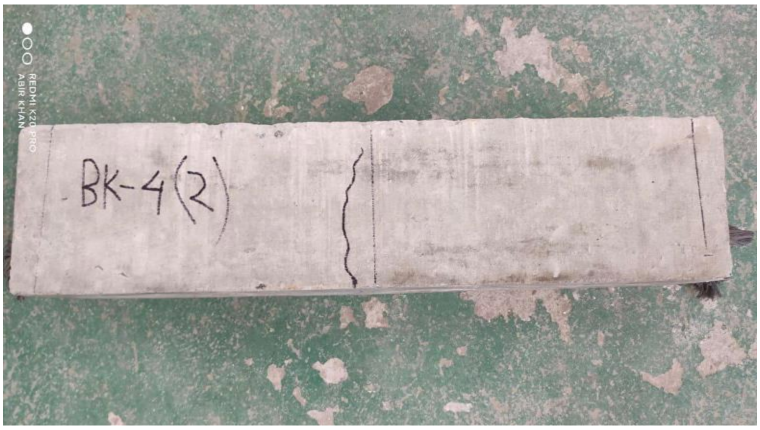


Figure 4-37: Failure pattern (Polyester fiber beam)

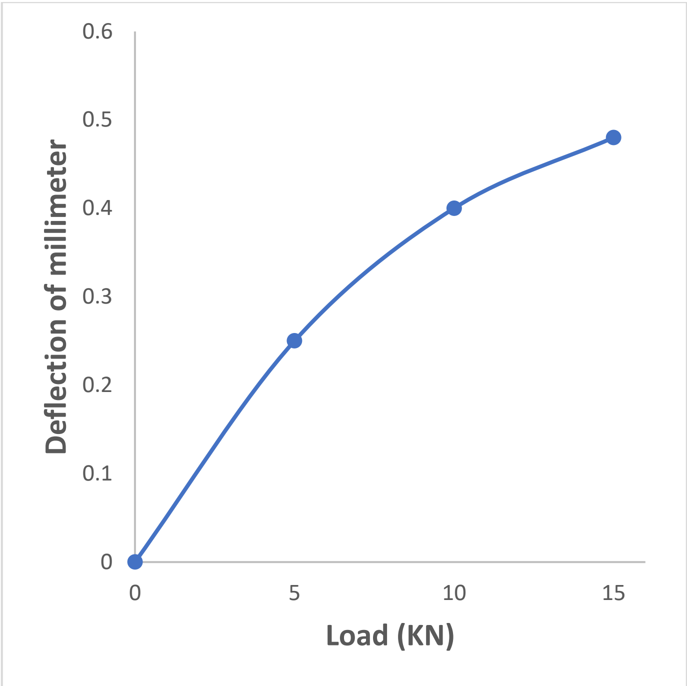


Figure 4-38: Load displacement relation

Analyzed the polyester fiber concreate beam under vertical loads and found by the following values:

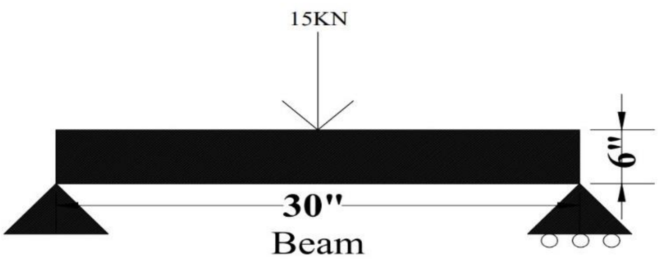


Figure 4-39: Pin and Ruler support beam

Figure 4-40: Support reaction

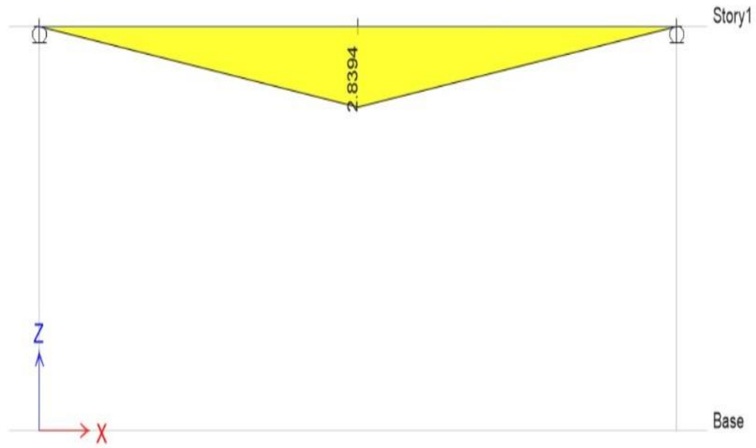


Figure 4-41: Bending moment diagrams

The fifth beam utilizes two 12mm nylon fiber bars, providing a load capacity of 15 KN and a deflection of 0.48 mm under load. This configuration is particularly well-suited for supporting light, unladen goods, making it an effective choice for applications requiring both flexibility and strength.

The accompanying graph illustrates the relationship between load and displacement, showing that displacement increases to 0.25 mm as the load reaches 5 KN.

The calculated support reaction value is 2.3 kips, which represents the force at the supports following the analysis. This value indicates how the structure responds to applied loads. Additionally, bending moment diagrams depict the distribution of bending moments along the beam, highlighting areas of maximum stress.

The maximum recorded displacement is 2.8394 mm, reflecting the greatest movement of the structure due to the applied loads. This measurement is essential for evaluating the design's safety and effectiveness.

4.9 Used 3 nose 12mm bar polyester fiber reinforcement concrete beam

Figure 4-42: Polyester fiber beam setup for test

Figure 4-43: Failure pattern (Polyester fiber beam)

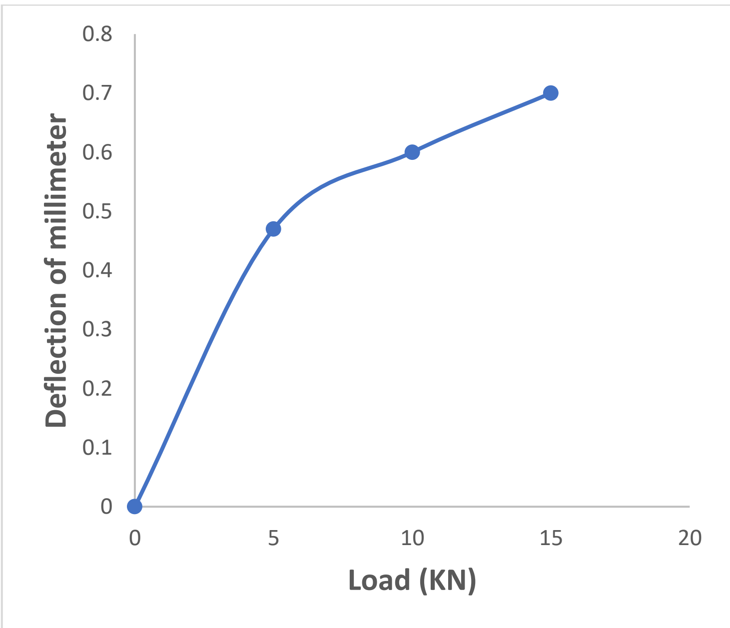


Figure 4-44: Load displacement relation

Analyzed the Polyester fiber concreate beam under vertical loads and found by the following values:

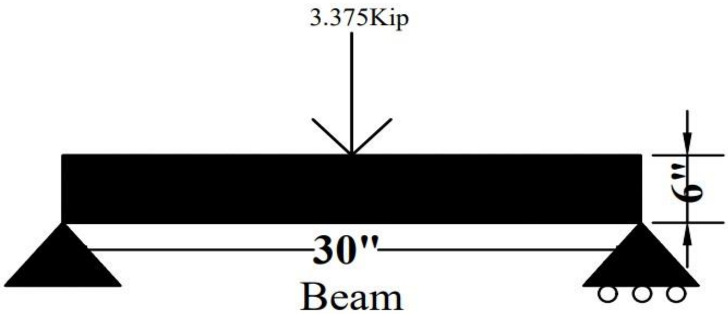


Figure 4-45: Pin and Ruler support beam

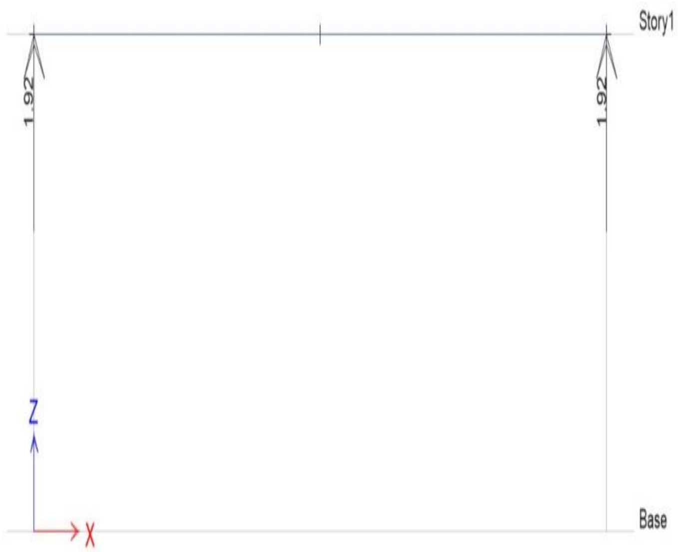


Figure 4-46: Support reaction

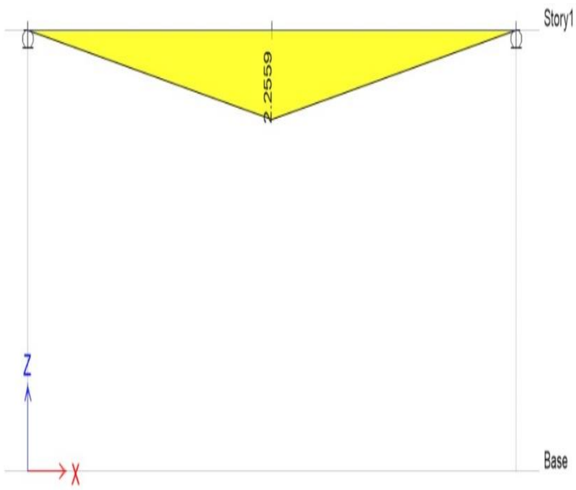


Figure 4-47: Bending moment diagrams

The fifth beam utilizes three 12mm fiber bars made of polyester, providing a load capacity of 15 KN and a deflection of 0.70 mm under load. This configuration is particularly suitable for supporting light, unladen goods, making it an effective choice for applications requiring both flexibility and strength.

The accompanying graph illustrates the relationship between load and displacement, indicating that displacement increases to 0.47 mm as the load reaches 5 KN.

The calculated support reaction value is 1.92 kips, which represents the force at the supports after analysis. This value reflects how the structure responds to the applied loads. Additionally, bending moment diagrams depict the distribution of bending moments along the beam, highlighting areas of maximum stress.

The maximum recorded displacement is 2.2559 mm, representing the greatest movement of the structure due to the applied loads. This measurement is crucial for evaluating the design's safety and effectiveness.

4.10 Combined load of beams

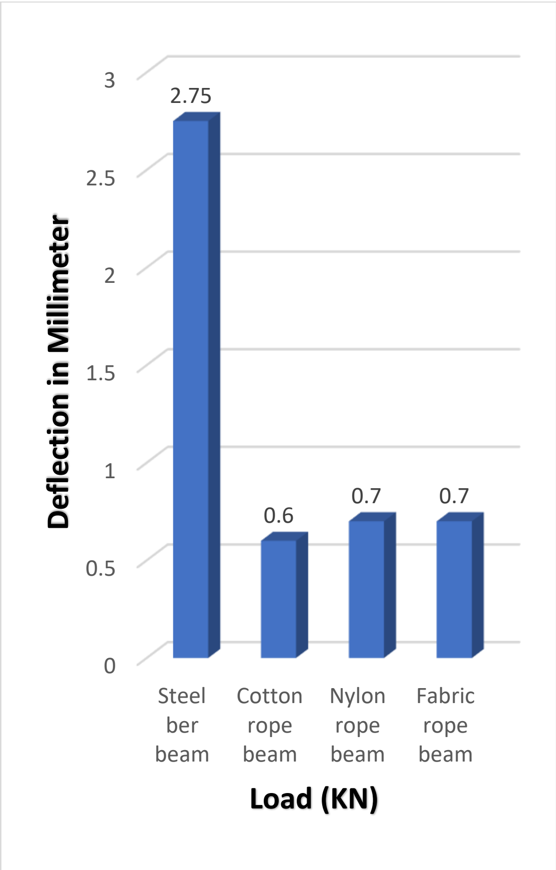


Figure 4-48: Diagram of combined load of beams

The chart show that load compare of beam, first chart 100% pure concrete, second chart 100% Steel reinforcement beam taken 48kN load, third chart 100% Cotton fiber reinforcement beam taken 20kN load, fourth chart 100% Polyester fiber reinforcement taken 15kN load & fifth chart 100% Nylone fiber reinforcement taken 20kN load.

4.11 : Combined deflection of beam

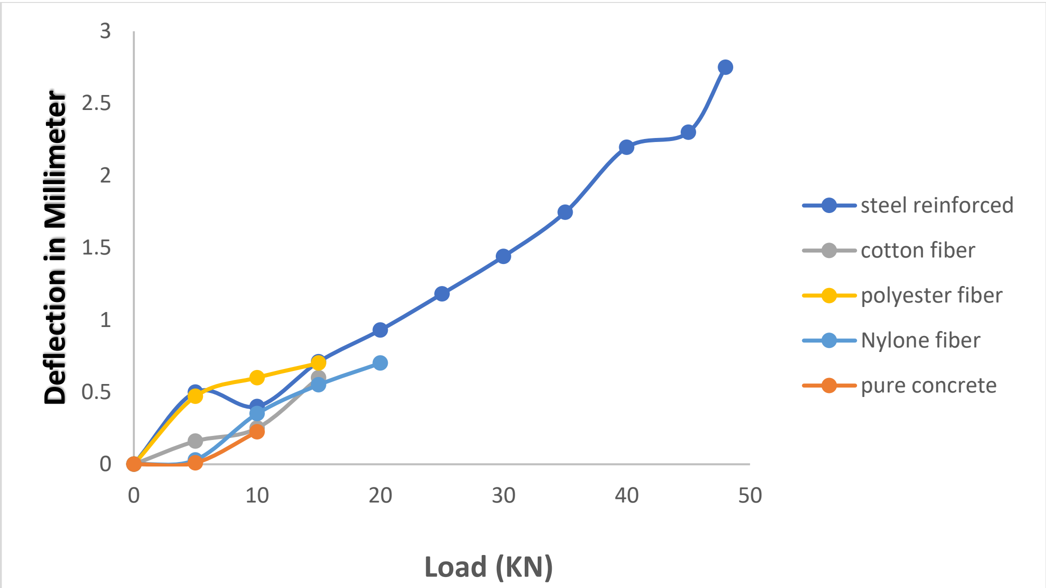


Figure 4-49: Load displacement relation

Table 1: Tensile test for normal cotton fiber

Sl. No.	Original length(mm)	Final length(mm)	Distance(mm)	Elongation(mm)
1	500	590	90	75.67
2	448	510	62	
3	475	550	75	

Table 2: Tensile test for normal polyester fiber

Sl. No.	Original length(mm)	Final length(mm)	Distance(mm)	Elongation(mm)
1	461	524	63	64.33
2	468	532	64	
3	464	530	66	

Table 3: Tensile test for normal nylon fiber

Sl. No.	Original length(mm)	Final length(mm)	Distance(mm)	Elongation(mm)
1	432	530	98	
2	446	533	87	87
3	453	529	76	

4.12 **Cost analysis**

Five different types of beams have been constructed. It has 100% reinforcements for the first beam. The second beam is made of 100% concrete. The third beam is constructed from 100% reinforced textile, while the fourth beam is made of 100%. reinforced textile and, Here The number five beam is made of 100% reinforced textile, since beams third, fourth and fifth have less reinforcement, the cost is also lower.

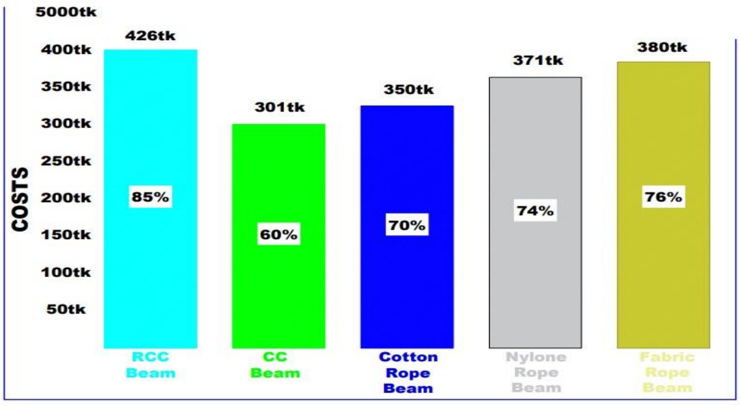


Figure 4-50: Cost analysis

4.13 **Discussion**

In this study, eight different beams were constructed, and their loads and deflections were compared with 2-12 mm diameter reinforced concrete beams. The study discusses the amount and application of recycled textile cotton fiber, nylon fiber, and polyester reinforcement for both 2-12 mm and 3-12 mm diameter bars.

The materials used for making the beams included coarse aggregate, sand aggregate, crown cement, and water. For fine aggregate, selected sand with a fineness modulus (FM) of 1.6 was used, while the coarse aggregate consisted of selected stone with a unit weight of 3360 kg/m³, an absorption rate of 0.5%, and a bulk dry specific gravity of 2.68. Reinforcement was replaced with textile cotton fibers, specifically selected for their tensile strength of 10 KN.

The main objective of this study was to replace traditional reinforcement with textile cotton, nylon, and polyester fibers. The eight beams designed are as follows:

Type 1 Pure concrete, load capacity 10 KN, deflection 0.225 mm. Type 2 2-12 mm diameter reinforced concrete beam, load capacity 48 KN, deflection 2.75 mm. Type 3: 2-12 mm diameter textile cotton fiber reinforced concrete beam, load capacity 20 KN, deflection 0.55 mm. Type 4: 3-12 mm diameter textile cotton fiber reinforced concrete beam, load capacity 15 KN, deflection 0.60 mm. Type 5: 2-12 mm diameter textile nylon fiber reinforced concrete beam, load capacity 15 KN, deflection 0.60 mm. Type 6: 3-12 mm diameter textile nylon fiber reinforced concrete beam, load capacity 20 KN, deflection 0.70 mm. Type 7: 2-12 mm diameter textile polyester fiber reinforced concrete beam, load capacity 15 KN, deflection 0.48 mm. Type 8: 3-12 mm diameter textile polyester fiber reinforced concrete beam, load capacity 15 KN, deflection 0.70 mm.

The beam analyses conducted with ETABS provide valuable insights into the performance of various beam materials and configurations. Here are the key findings:

Concrete beam load capacity 10 KN, Deflection 0.225 mm, Support reaction 5.23 KN, Displacement 2.26 mm. Reinforced concrete beam load capacity 48 KN, Deflection 2.75 mm, Support reaction 24.23 kips, Displacement 30.25 mm. Cotton fiber beam (2 x 12 mm dia bars) load capacity 15 KN, Deflection 0.60 mm, Support reaction 1.92 kips, Displacement 2.3 mm. Cotton fiber beam (3 x 12 mm dia bars) load capacity 120 KN, Deflection 0.55 mm, Support reaction 2.48 kips, Displacement 2.96 mm. Nylon fiber beam (2 x 12 mm dia bars) load capacity 15 KN, Deflection 0.60 mm, Support reaction 1.92 kips, Displacement 2.3 mm. Nylon fiber beam (3 x 12 mm dia bars) load capacity 20 KN, Deflection 0.70 mm, Support reaction 2.48 kips, Displacement 2.96 mm. Polyester fiber beam (2 x 12 mm dia bars) load capacity 15 KN, Deflection 0.48 mm, Support reaction 1.92 kips, Displacement 2.26 mm. Polyester fiber beam (3 x 12 mm dia bars) load capacity 15 KN, Deflection 0.70 mm, Support reaction 1.92 kips, Displacement 2.26 mm.

The ETABS analysis provides critical data on the structure's reactions, bending moments, and displacements. This information is essential for ensuring the strength and stability of the design, confirming that it meets safety and performance standards. The comparisons highlight the varying performance characteristics of different materials and configurations, aiding in the selection of the most suitable beam design for specific applications.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

How much load and deflection can be achieved by replacing steel with recycle fiber reinforced, and where it can be used is discussed in this research.

- Type-1: beam has a 48kN load capacity and a 2.75mm deflection.
- Type 4 and type 6 beam has a 20kN load capacity and a 0.70mm deflection. Where there is less load, type 4 and type 6 beams can be employed.
- Type 4 and 6 beams can hold 20KN of load. Type 3, 5, 7, and 8 beams have a lower load capacity. These weaker beams can't be used in most places.

We found flexural failure in fiber reinforced concrete beams, indicating critical points of stress and highlighting the need for improved reinforcement strategies.

5.2 **Recommendation**

The above discussion suggests that better swelling will be obtained if steel replacement is used with textile reinforcement. Textile reinforcement is useful for low-load projects like slabs, septic tank slabs, and sunshades. Twisting three textile reinforcements together might improve results, but more research is needed.

For a more sustainable option, materials like bitumen or other chemicals could be tested. More studies are also needed to improve how textile reinforcement bonds with concrete. These efforts will help make future textile reinforcement designs stronger and more eco-friendly.

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APPENDIX

Table 6: Load displacement pure concrete

Load (KN)	Displacement (MM)
0	0
5	0.01
10	0.225

Table 7: Load displacement steel

Load (KN)	Displacement (MM)
0	0
5	0.275
10	0.55
15	0.825
20	1.1
25	1.375
30	1.65
35	1.925
40	2.2
45	2.475
48	2.75

Table 8: Load displacement (for 2 nose 12mm) cotton fiber reinforced

Load (KN)	Displacement (MM)
0	0
5	0.02
10	0.19
15	0.60

Table 9: Load displacement (for 3 nose 12mm) cotton fiber reinforced

Load (KN)	Displacement (MM)
0	0
5	0.205
10	0.375
20	0.55

Table 10: Load displacement (for 2 nose 12mm) polyester fiber reinforced

Load (KN)	Displacement (MM)
0	0
5	0.25
10	0.40
15	0.48

Table 11: Load displacement (for 3 nose 12mm) polyester fiber reinforced

Load (KN)	Displacement (MM)
0	0
5	0.47
10	0.60
15	0.70

Table 12: Load displacement (for 2 nose 12mm) nylon fiber reinforced

Load (KN)	Displacement (MM)
0	0
5	0.16
10	0.25
15	0.60

Table 13: Load displacement (for 3 nose 12mm) nylon fiber reinforced

Load (KN)	Displacement (MM)
0	0
5	0.03
10	0.35
15	0.55
20	0.70

Table 14: Load-displacement (for combine

Load (KN)	Displac e-ment (mm) Beam - 1	Displac e-ment (mm) Beam - 2	Displacement Cotton Fibre Beam		Displacement Nylone Fibre Beam		Displacement Polyester Fibre Beam	
			2-12mm	3-12mm	2-12mm	3-12mm	2-12mm	3-12mm
0	0	0	0	0	0	0	0	0
5	0.01	0.5	0.02	0.205	0.16	0.03	0.25	0.47
10	0.225	0.4	0.19	0.375	0.25	0.35	0.40	0.60
15		0.71	0.45	0.60	0.60	0.55	0.48	0.70
20		0.93	0.55			0.70		
25		1.18						
30		1.44						
35		1.745						
40		2.195						
45		2.30						
48		2.75						

Table 15: Sand aggregate

No. of Sieve (mm	Weight of Retained (gm)	% Retained	Cumulative % Retained	Percent Passing	% Finer
#4	0.0	0	0	100	F.M=159.6/ 100 =1.596
#8	1.5	0.3	0.3	99.7	
#16	1.5	0.3	0.6	99.4	
#30	8.0	1.6	2.2	97.8	
#50	307.0	61.4	63.6	36.4	
#100	146.5	29.3	92.9	29.3	
Pan	35.5	-	-	-	
Total	500	-	159.6		

Table 16: Coarse aggregate

No. of Sieve (mm)	Weight Retained (gm)	Cumulative% Retained	% Retained	Percent Passing
37.5	0	0	0	100
25	18	3.6	3.6	96.4
19.5	114.5	22.9	26.5	73.5
12.5	240.5	48.1	74.6	25.4
6.3	118.7	23.74	98.34	1.66
2.36	6.7	1.34	99.68	0.32
Pan	1.6	0.32	100	0
Total	500	-		