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STUDY ON FLEXURAL BEHAVIOUR OF RC BEAM STRENGTHENED WITH FRP

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ABSTRACT

Strong with fibers In the building of several buildings, polymer plays a significant part. The research examined the failure modes and ultimate flexural limit, which yielded fruitful outcomes when reinforced with FRP material. One of the methods that were employed to avoid cracks was the use of FRP. Fiberglass is an umbrella term for a wide range of goods that are often used as reinforcements and are created from individual glass fibers assembled into different shapes. The cost of repairs may be reduced using this strategy. Researchers found that the load-carrying capacity of beams increased and that the frequency of first fractures decreased after FRP strengthening. In order to increase the flexural strength of RC structures, FRP is one of the most popular approaches utilized for strengthening. FRP is a simple approach to reinforce buildings and provides a comparatively low-effort alternative to traditional methods. Results in deformation and stress analysis were superior in the analytical work done using ANSYS software for both conventional and GFRP strengthening. Beam strength and ductile behavior are both improved by GFRP, as is evident from the data. FRP, Ansys, Reinforced Concrete Beam

INTRODUCTION

Because reinforced concrete (RCC) and similar constructions have relatively low ductility and tensile strength, reinforcement with better tensile or ductility characteristics is added to make up the difference. Rebars, which are normally made of steel, are passively inserted into the concrete before to its setting in order to provide reinforcement. Changing out weak reinforcements with stronger ones used to be a dirty and time-consuming process for reinforcing concrete structures. This included beams, columns, and other structural components. As an example of a contemporary advanced composite material, fiber reinforced polymer (FRP) composites have allowed for the external binding of FRPcomposites to concrete components, substantially increasing their strength. The technological advantages and cost-effectiveness of FRP over conventional ways of reinforcing concrete structures include its low weight, resilience to corrosion and fatigue, ease of installation, and minimum modification to structural geometry. Additionally, the creation of FRP allows us a whole new realm of form and shape possibilities, in contrast to conventional steel materials. Despite the relatively high cost of the resins and fibers used in FRP systems, installation expenses for these systems are often lower than those for traditional reinforcing materials. Use of FRP systems is viable in areas where access is an issue, making the use of more traditional approaches impractical. Because of the lack of data on the structural behavior of concrete buildings that have been strengthened using fiber-reinforced polymers (FRP) composites, their use in preexisting concrete structures has not lived up to expectations. Reinforcing concrete structures using fibers necessitates

have a thorough familiarity with the subject matter, its unique regulations, and the readily available, user-friendly technologies. Beams are the primary structural elements that undergo bending, twisting, and shearing in any building. Similarly, columns can support axial loads without bending and are used as piers or abutments in many different types of constructions, including buildings and bridges. Consequently, there is an international push to study the feasibility of replacing concrete beams and columns with externally bonded FRP composites. Several researchers used concrete beams and columns that had been retrofitted with carbon fiber reinforced polymer (CFRP)/glass fiber reinforced polymer (GFRP) composites to study the effects of confinement, durability, enhancement of strength and ductility, experimental investigations, and the preparation of design guidelines. Research on the enhancement of basic metrics including strength/stiffness, ductility, and longevity of structural parts retrofitted with externally bonded FRP composites has shown encouraging results; nevertheless, there are still some limitations to these findings. Additional investigation into FRP composites is necessary before they can be considered a viable, failsafe structural component. One simple way to make a structure stronger and last longer is to repair it using FRP. Concrete buildings damaged by de-icing salts and other environmental factors are ideal candidates for this repair process. It provides a protective covering for concrete components, making them more resistant to corrosion and increasing their strength-to-weight ratio. The presence of ambient components and previous salts do not cause harm to FRP. Corrosion may easily spread over the outside girth of a bridge. ders. All of this points to the possibility that environmental conditions, de-icing chemicals, water spray, and other surface contacts can have detrimental effects. Encasing these girders not only makes the design last longer, but it also protects them from surface attacks. FRP may be tailored to several uses. Foam reinforced plastic (FRP) has the potential to improve a wide range of building types. Fencing and fastening FRP sheets to concrete parts is a breeze. A lot of money is made by it.

FLEXURAL STRENGTHENING OF BEAMS

External post tensioning, plate bonding, and near surface mounted (NSM) systems are just a few of the many alternatives available for flexural strengthening. Among the many structural reinforcing choices, advanced fiber-reinforced polymer composites (GFRP) bonding to the outside is among the most common. Because of its many useful properties, glass fiber reinforced plastic (GFRP) composites have become more popular in this field in the last ten years.

materials. Research on the structural behavior of Reinforced Concrete (RC) has been extensive, both in theory and practice. That being said, RC beams may now be reinforced with Glass Fibre Reinforced Polymer (GFRP) thanks to technological advancements in the last few years.

LITERATUREREVIEW

Several literature evaluations in this chapter have focused on RC beams that have been strengthened using FRPs.

Sharif, Al-Sulaimani, Basunbul, Baluch, and Ghaleb investigated the reliability of RC beams that had been previously loaded using various FRP plate repair processes (1994). Changing the plate thickness allowed us to detect the premature failure of the plate curtailment zone. Various anchoring and repair approaches were used to eliminate these undesirable failures and ensure ductile behavior. Repair beam behavior was investigated by the authors using load-deflection curves and several failure circumstances. Following their investigation, they reached the following verdicts: Plate separation and concrete rip-off happened due to increased shear and normal loads at the extremities of the plates, which were produced by increasing plate thickness; restored beams showed enough ductility, showing the efficacy of the FRP plates.

In 1996, ACI Committee 440 released their most current findings about fiber-reinforced plastic (FRP) for concrete structures. The article included useful information on the interior and exterior uses of FRP for reinforcement, as well as design and implementation guidelines. Parametric study was conducted by Arduini and Nanni (1997) on beams strengthened with externally bonded FRP. Adhesive strength, stiffness, and stiffness were all factors considered in the study. A high-ultimate-elongation adhesive and a FRP bonded length as long as possible were both suggested by the authors.

Norris, Saadatmanesh, and Ehsani (1997) conducted an analytical and experimental examination of the shear and flexure behavior of damaged concrete beams that had CFRP sheets connected to them. On top of the pre-cracked beams, three separate CFRP systems were attached. Depending on the orientation of the fibers, the scientists observed different failure modes and improvements in ultimate strength.

Ross, Jerome, Tedesco, and Huges reported the results of analytical and experimental research into the flexural strengthening of RC beams using the external bonding of FRP laminates (1999). The authors used non-linear finite element analysis and inelastic section analysis to predict the behavior of additional retrofitted beams under different loads and displacements. Weakly reinforced beams may attain a significant increase in flexure strength, according to the researchers, and the reaction of the beam was significantly affected by the binding strength of the concrete and composite plate.

The flexural behavior of RC beams reinforced with various types of FRP laminates was examined by Grace, Sayed, and Ragheb (2002). They experimented with different epoxy kinds, reinforcing patterns, and quantities of FRP layers to see how the beam would react. Among the topics covered was the impact of strengthening on strain, ductility, deflection, failure load, and failure mode. The authors discovered that employing both horizontal and vertical sheets with the proper epoxy substantially enhanced the beams' ultimate load bearing capabilities, and they also noted that all of the reinforced beams brittlely failed, necessitating a higher design safety factor.

A study was conducted by Ferrier, Avril, Hamelin, and Vautrin (2003) to examine the mechanical behavior of RC beams reinforced with externally bonded CFRP sheets. The effectiveness of externally bonded CFRP in reinforcing structures constructed from damaged concrete has been the subject of research. The reduction of fracture widths was the primary effect of service loads.

When a dual crack width occurs in reinforced beams, it influences the crack growth. Henrik Thomsen, Enrico Spacone, Suchart Limkatanyu, and Guido camata (2004) conducted an investigation into the failure mode analysis of reinforced concrete beams increased in flexure utilizing externally bonded fiber-reinforced polymers. Using a non-linear RC beam element model that included bond-slip between the concrete and the FRP plate, the researchers examined how variables such plate width, length, stiffness, and loading type impacted the failure processes of RC beams that were simply supported. Parametric studies confirmed the results of the experimental research by demonstrating that the most common failure mechanism due to the loss of composite activity was affected by material properties and plate shape. Beams subjected to point loads, as opposed to scattered loads, are more likely to have plate debonding in the region of maximum bending moments, according to their findings.

In 2005, it was reported by Huang Yue-lin, Hung Chien -hsing, Yen Tsong, Wu jong-hwei, and Lin Yiching that an experimental examination was conducted on reinforced concrete beams employing prestressed glass fiber-reinforced polymer (PGFRP). The ultimate loads and deflections of reinforced concrete beams reinforced with glass fiber reinforced plastic (GFRP) and polypropylene (PPGFRP) sheets were investigated and contrasted. Results showed that PGFRP-reinforced beams could withstand higher ultimate loads than GFRP-reinforced beams. While both types of beams were exposed to the same environmental forces, those with PGFRP sheets exhibited much less deflections. The ductility of the over-strengthened beams was significantly reduced.

Lee, Avila, and Montanez presented a numerical study of sprayed fiber reinforced polymer's strengthening and retrofitting capabilities in 2005. Using composites in a spraygun is an innovative strategy that has just shown encouraging trial outcomes for many uses.

constructing and repairing structures. Fiber reinforced polymer (SFRP) that was sprayed over concrete structures greatly improved their load capacity, ductility, and energy absorption capacity. The writers published the results of numerical investigations into damaged reinforced concrete beams and superstructures of bridges covered with SFRP. By combining a damage constitutive model with a finite element code, a computational model may be developed to forecast the performance of concrete structures that have been retrofitted with SFRP. Tarek Almusalam (2006) studied the load-deflection behavior of RC beams reinforced with GFRP sheets in different environmental situations. This study required the production of eighty-four beam specimens. The first set of subjects was kept in a strictly controlled laboratory environment, whereas the second set of subjects were left to their own devices in an outdoor setting with wet-dry alkaline water and UV protection paint. In every set, you may find both unreinforced and reinforced beams. The specimens from different wet-dry environments were subjected to a two-week time cycle, with one week spent in the solution and the other week outdoors. After 6, 12, and 24 months, different environmental conditions were tested. Under either of those situations, the author could not find any impact on the flexural strength of the beams. An analytical study on neural networks for assessing the performance of RC beams coated with polymer and reinforced with glass fiber was published in 2008 by Pannirselvam, Raghunath, and Suguna. In order to predict yield load, ultimate load, yield load deflection, ultimate load deflection, and deflection, they presented a computational model that uses General Regression Neural Networks (GRNNs). the ductility and energy ductility of beams strengthened with concrete using glass fibers. The experimental results were highly concordant with the model's predictions.

Issa and R. Al-Rousan (2017) A substantial impact on the permanent deflectional mid-span is described in this research.

when the stresses are redistributed, resulting in a sharp decrease in concrete stresses and a rise in steel and The life of CFRP sheets was depleted. It was also noted that there was no notable change when performing fatigue cycles with a low frequency. Researchers discovered that ultimate load, stiffness, and the number of CFRP layers all rise as the contact area between CFRP and concrete increases, and that mid-span permanent deflection decreases significantly as a result. It demonstrates that substantial serviceability issues arise from excessive permanent deformations caused by a decrease in beam stiffness during fatigue cycle loading.

The name is Sattainathan. Adhana Sharma, Shoban Prashant, Solomon Sharma Samson Sachin, Supriya Malik. This year (2019) The majority of constructions designed to hold water employ steel fibers. This demonstrates that the ductility performance of RC beams may be enhanced by varying the volume percentage of steel fibers. Steel fiber beams reinforced with glass fibers have higher flexural strength and deflection than standard beams and crimped GFRP beams.

SUMMARY OF LITERATURE REVIEW

A plethora of data about the load-deflection behavior of RC beams with FRP plating has been produced by study using ductility, strength, and deflection as research criteria. The research mainly concerned RC beams that have FRP laminate reinforcements. A number of researchers in the field have published mathematical models that aim to predict the research parameters of FRP-reinforced RC structural components. Few studies have examined the reliability of beams reinforced with fiber-reinforced plastic (FRP) in concrete. Most studies have not conducted a comprehensive investigation into the relationship between the load bearing capacity, deflection, and ductility of GFRP reinforced concrete beams. Therefore, further research is necessary to address this information gap. Because it boosts the beams' rigidity and flexural behavior, Fiberglass Reinforced Plastic (FRP) wrapping is the preferred method of reinforcing them. The beam's load bearing performance is enhanced by using GFRP strengthening technology. Research was carried out to assess the efficacy of externally bonded CFRPin strengthening deteriorated concrete structures. The primary effect of applying service loads was to cause cracks to shrink. More research is needed to even begin to understand FRP materials and how they behave.

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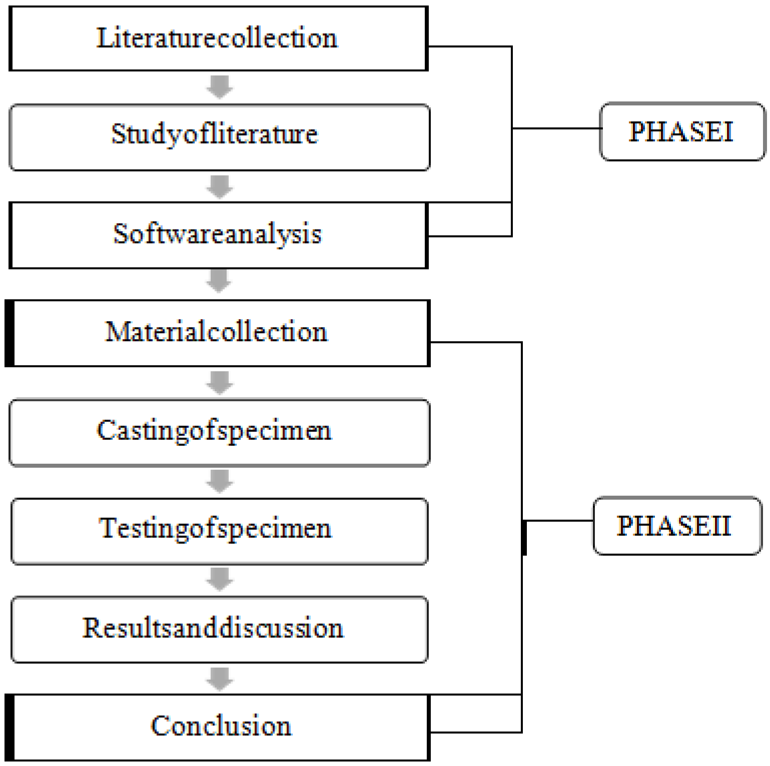
METHODOLOGY

Inthischapter,itdescribesabouttheworkflowoftheprojectasfollows:



SOFTWAREANALYSIS

An intuitive, front-end tool for finite element analysis, the ANSYS 17.0 Workbench environment works well with CAD programs and Design modeler. It is possible to do structural, thermal, and electromagnetic analyses inside the ANSYS 17.0 Workbench environment. The primary focuses of this course include solving finite element models, building and optimizing geometry, attaching geometry, and reviewing results. The course will teach students not only how to use the code, but also the fundamentals of finite element simulation and how to understand and use the findings. Engineers in the domains of electromagnetics, vibration, fluid dynamics, heat transfer, and physics use the general-purpose application ANSYS17.0 to simulate interactions. You may import CAD data and produce geometry using ANSYS17.0's "pre-processing" features. The same pre-processor also generates the computational mesh, also called a finite element model. Following the definition of loadings and study execution, the results might be represented numerically or graphically. With ANSYS, advanced engineering studies may be safely and effectively carried out using its time-based loading features, nonlinear material models, and variety of contact techniques. Combining parametric computer-aided design (CAD) tools with simulation technology, ANSYS 17.0 Workbench offers outstanding automation and performance. What makes ANSYS17.0 Workbench so powerful is the team's extensive experience with ANSYS solver algorithms. Product enhancement and verification in a simulated setting is what ANSYS Workbench is all about.

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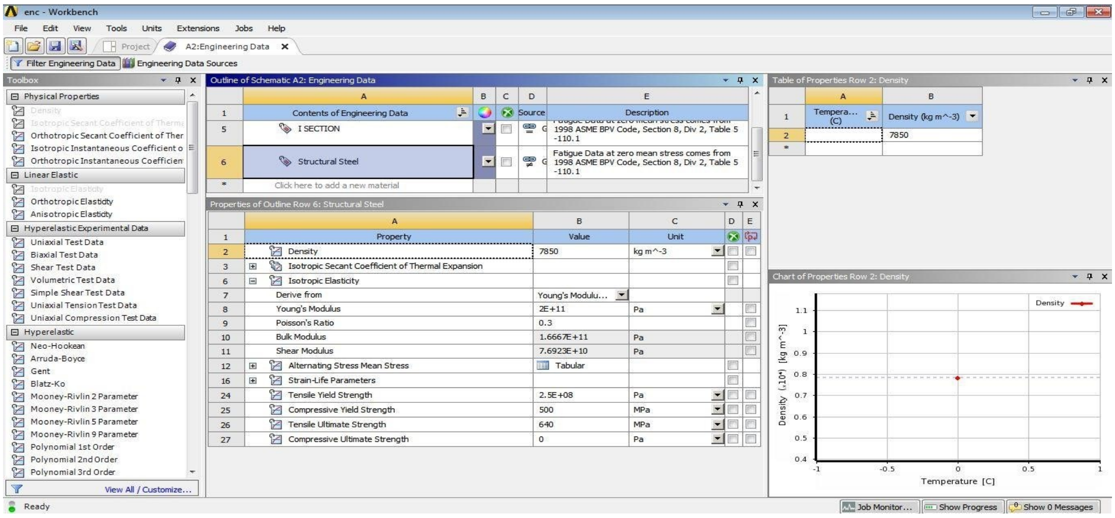
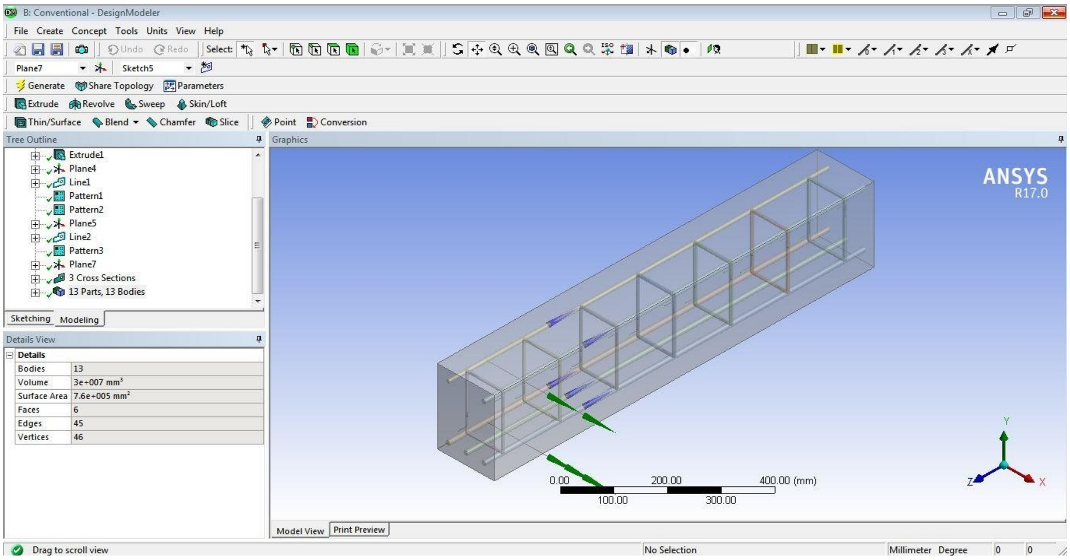


Engineering Data

GEOMETRYCREATION

The model I made has a cross section of the beam measuring 150x200x1000 m, with primary reinforcement measuring 12 mm, stirrups measuring 8 mm, and all of this is represented in figure 6.2.



Reinforcement Provision

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ASSIGNINGTHESECTIONPROPERTIES

Using sections, describe the attributes of a part. One of the two following ways may be used to assign a newly created section to the portion in the current viewport.

- Choose a portion to attach to the area you choose in the component.
- Assign the portion to the set and use the set tool to build a homogenous set that contains the area.

Establishing the Fixed Element Model

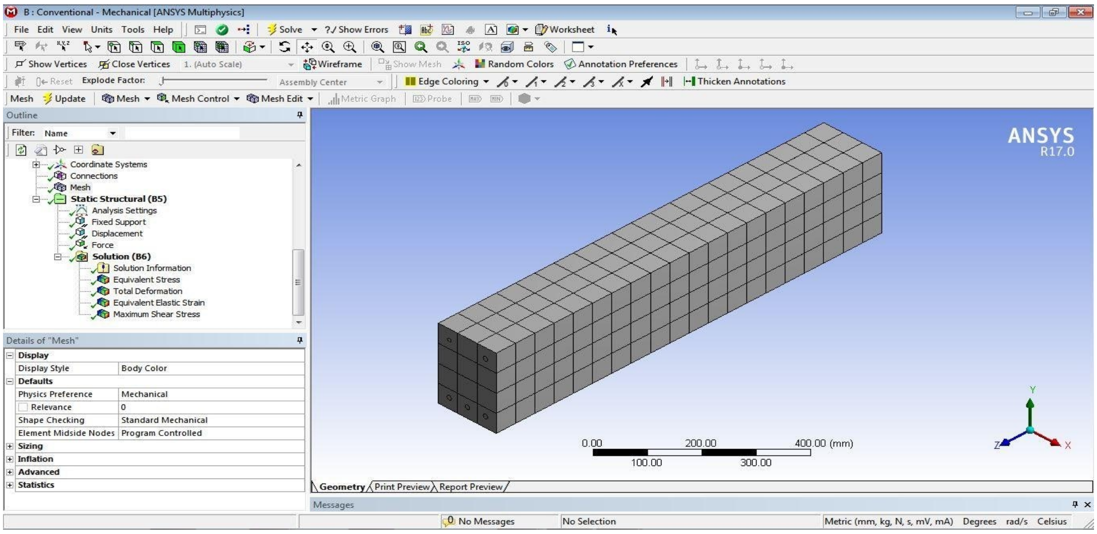
I have moved on to the modeling step after finishing the geometry design and assigned all the material attributes. Next, I created a mesh that would aid in solving the model using the finite element approach. The results will be shown appropriately in the figure below. 5.3 The material properties and 6.1.4
The software's library is used to import the material attributes into the workbench data table.

Table6.1MATERIALPROPERTIES

Material	**Density**	**Modulusof Elasticity**	**Poisson ratio**
Concrete	2400 kg/m3	32Mpa	0.2
Steel	7850 kg/m3	2x105Mpa	0.3
GFRP (UDC) 1mm (Tk)	1921 kg/m3	73Gpa	0.26

MESHGENERATION

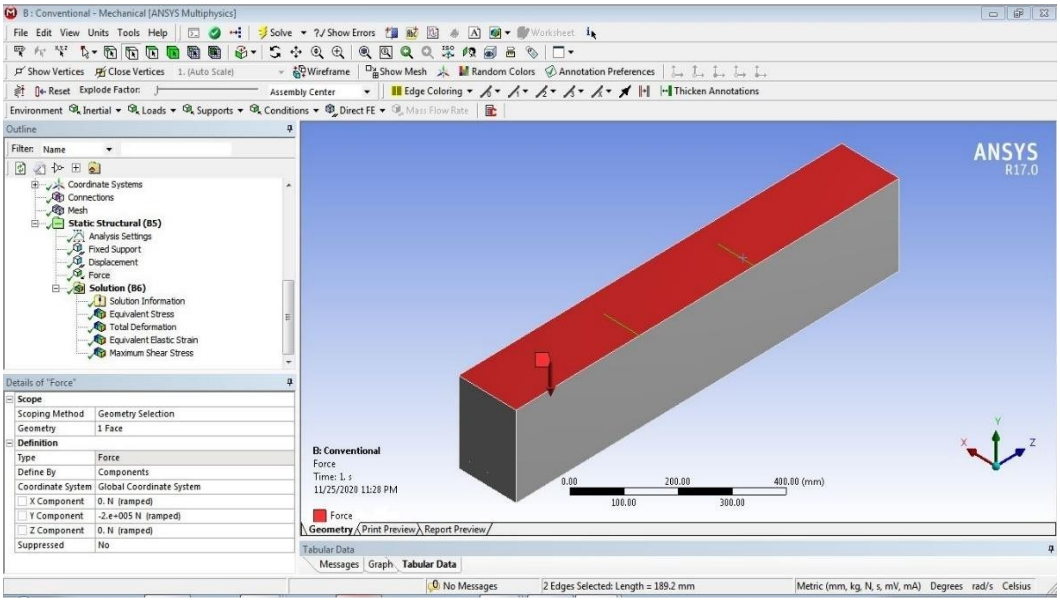
To transform bigger particles into a certain number of nodes, the mesh generation is used. Discretization describes the procedure used to create the nodes. As seen in Figure 6.3, this procedure aids in applying the loads within each node, therefore distributing the load across the structures.



MeshGenerationofControlbeam

LOADINGPATTERN

Figure 6.4 shows the results of applying two point loads to the RC beam in order to study failure mechanisms and strength improvement.



Loadingpattern

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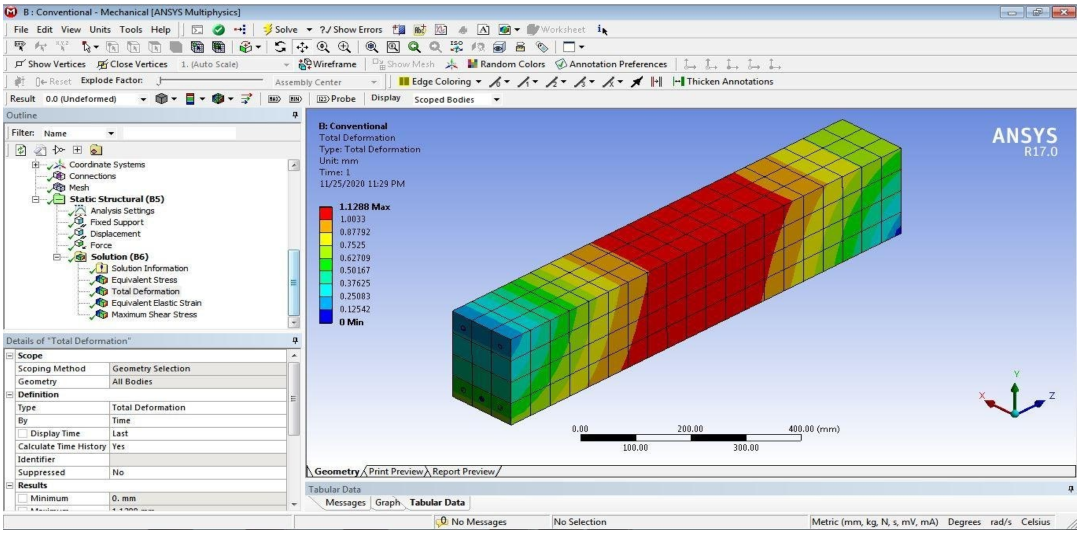
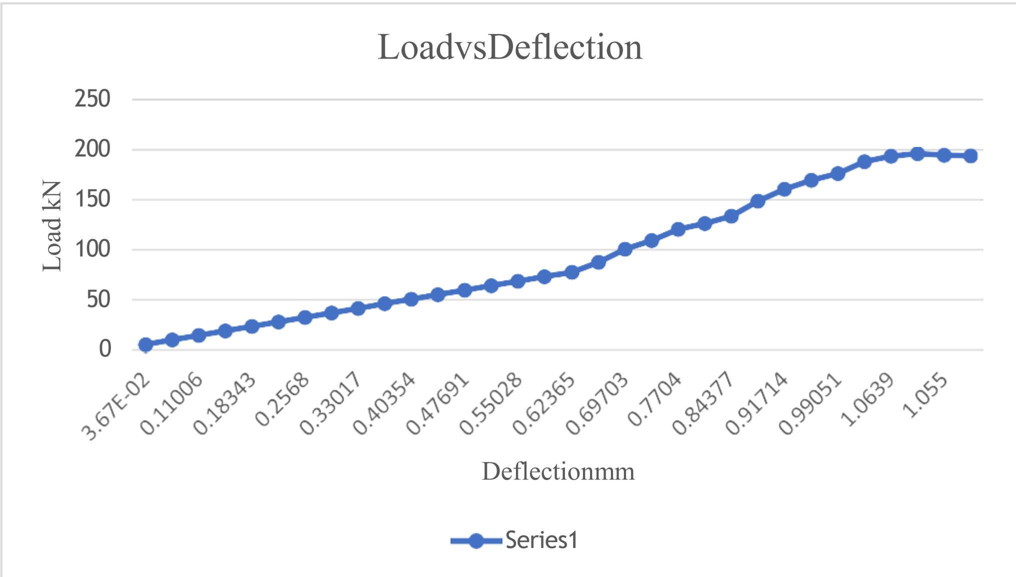
TOTALDEFORMATION

As the control beam's greatest deformation is shown in figure 6.5, the deformation value thus achieved is 1.12.



DeformationviewofRCbeam

LoadVsDeflectioncurve



LoadVsDeflection

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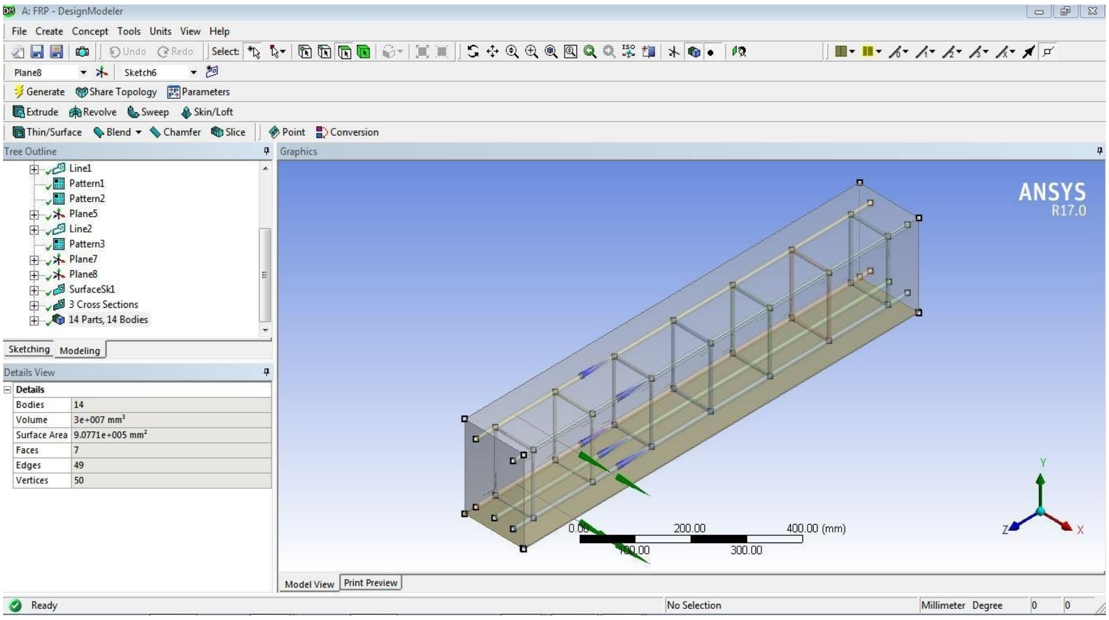
THREELAYEROFGFRPSTRENGTHENING(3mmThickness)

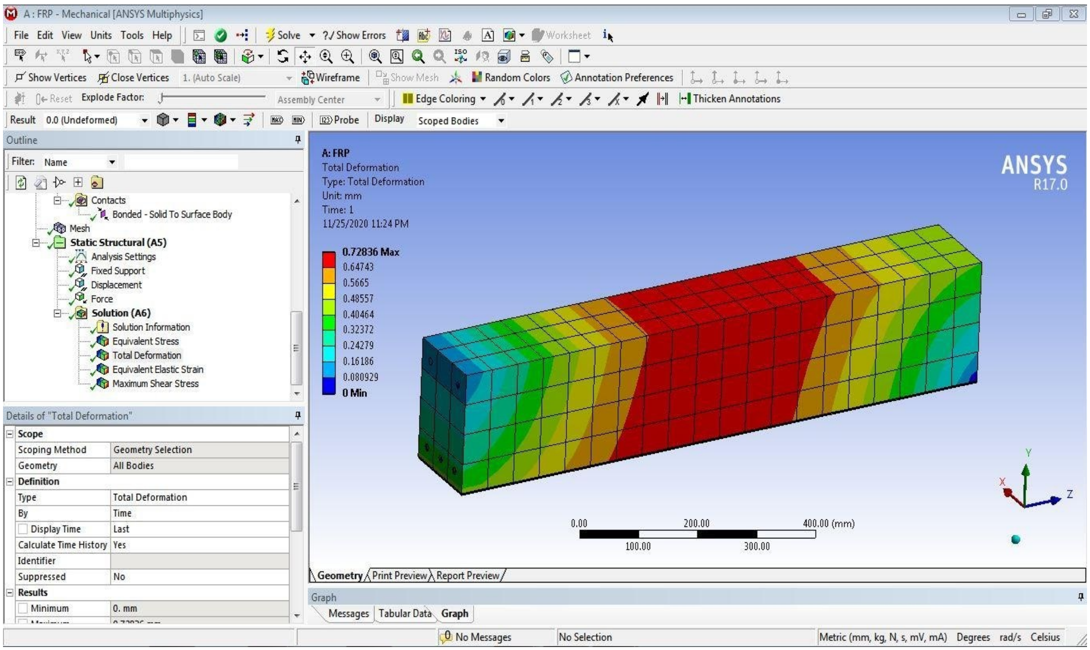
findings that were achieved after applying three layers of GRFP to the bottom surface, each with a thickness of 3 mm.



ReinforcementProvision

TOTALDEFROMATION

displays the data showing the specimen's deformation after three layers of GFRP strengthening.



Deformation of beam with GFRP strengthening

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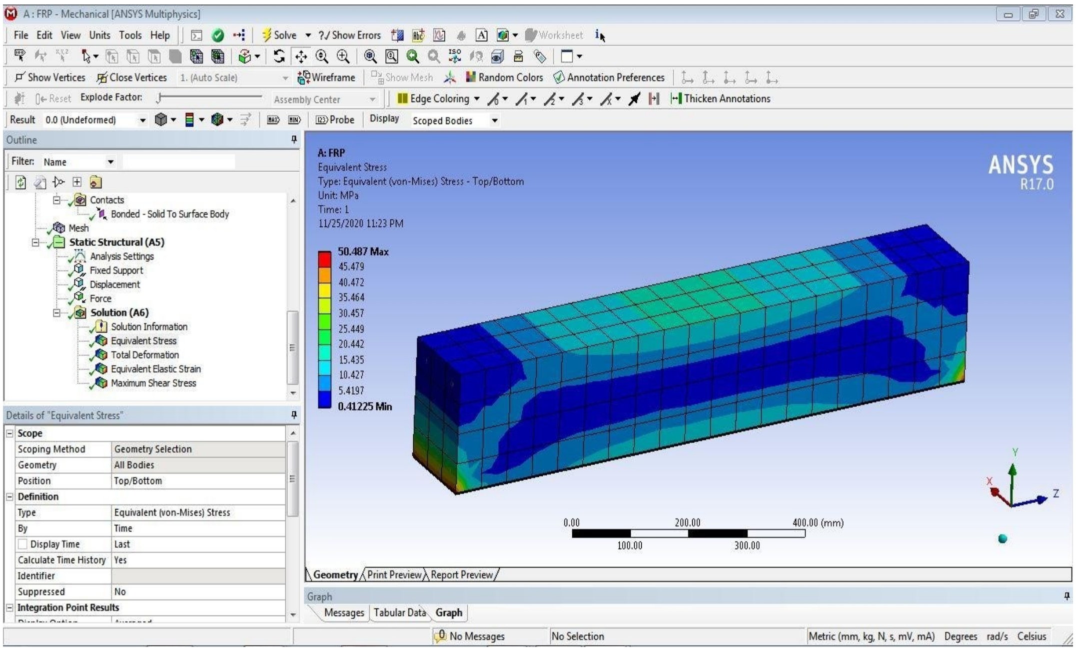
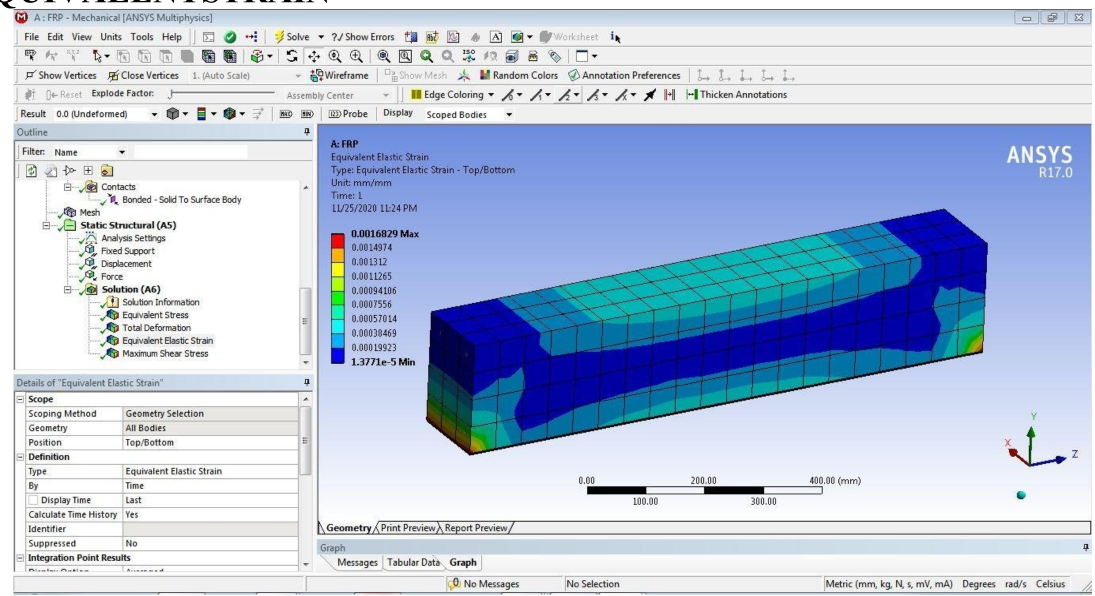
EQUIVALENTSTRESS



Equivalent stress of beam with GFRP strengthening

EQUIVALENTSTRAIN



Equivalent strain of beam with GFRP strengthening

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CONCLUSION

Compared to the standard reinforced concrete beam, the one reinforced with FRP offers several advantages. In order to obtain a feel for the FRP materials, our study combed through a number of literatures. We received the findings of a software study of FRP reinforced beams of varying thicknesses. After conducting a two-point load test on the beams, flexural fractures were found. According to the research, using GFRP improves the beam's stiffness under service loads and boosts its flexural capacity. Both ways, it helps to reduce the reflection. Further research is required to comprehend the behavior of RC beams reinforced with FRP by means of design, construction, instrumentation, and testing. Additionally, adjustments to existing design specifications should be developed to accommodate the properties of FRP reinforcements. This proves that GFRP is an efficient material for strengthening concrete beams by reducing cracks and enhancing their load-carrying capability. It has been noted from this study that GFRP strengthening is a cost-effective solution that also minimizes the beam's flexural failure. Increased load bearing capability as a result of GFRP strengthening is shown by the value thus acquired. We need to do more experiments to compare the analytical and experimental values and find the best one.

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