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Analyze the Behaviour of Reinforced Geo-Polymer Concrete and Reinforced Concrete Beam with the Help of Ansys

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ABSTRACT

we aim to demonstrate the significance of finite element (FE) modeling in structural element analysis, particularly in understanding the behavior of reinforced geo-polymer concrete beams until failure. We emphasize the importance of utilizing realistic material properties in FE models to accurately represent the behavior of the structure under various loading conditions.

Our study focuses on investigating the flexural strength, load-deflection characteristics, and failure modes of reinforced geo-polymer concrete beams. By incorporating the actual material properties into our FE model, we can simulate the behavior of the structure with high fidelity. Through comprehensive analysis, we intend to provide detailed insights into the critical distribution of stresses and effective strains within the members, including the steel reinforcement. Understanding these factors is crucial for assessing the structural integrity and performance of the beam under flexural loading.

The utilization of nonlinear models enabled by advanced computer software enhances the accuracy of our simulations. Nonlinear modeling accounts for material nonlinearities, such as stress-strain relationships, which are essential for accurately predicting the behavior of concrete structures, especially under large deformations and failure conditions. In this paper we take M25 grade of reinforced concrete and geo polymer based reinforce concert and calculate shear force, bending moment and deflection and we find geo polymer based concrete showing better result in compare to rcc concrete by using ANSYS softwere.

Key words: ANSYS, reinforced concrete and geo polymer based reinforce concert, shear force, bending moment, deflection

Introduction

Geo-polymer concrete, reinforced concrete (RC) beams, and normal RCC (Reinforced Cement Concrete) beams are all materials commonly used in construction, each with its own characteristics and advantages. Let's compare them:

Geo-polymer Concrete: It is made by mixing a geo polymer binder, aggregates, and water. The binder is usually made from industrial by-products like fly ash, silica fume, or slag.

Reinforced Concrete (RC) Beams: These beams are made by pouring concrete around steel reinforcement bars, often referred to as rebar’s, which provide tensile strength to the concrete.

Strength and Durability

Geo-polymer Concrete: It typically exhibits high compressive strength and durability. Its resistance to chemical attacks and harsh environments can be superior to conventional concrete.

RC Beams: The strength of RC beams depends on the quality of concrete and the reinforcement used. Proper design and construction can result in beams with high strength and durability.

Environmental Impact

Geo-polymer Concrete: It often has a lower carbon footprint compared to conventional concrete since it utilizes industrial by-products.

RC Beams: The production of steel reinforcement for RC beams contributes to a significant carbon footprint. However, proper design and construction can increase the lifespan of RC structures, reducing the need for reconstruction.

Cost

Geo-polymer Concrete: Initial costs may be higher due to specialized binders and production processes.

RC Beams: Costs can vary depending on the quality of materials and construction methods but are generally competitive.

Construction and Design Considerations

Geo-polymer Concrete: Requires specific expertise and careful quality control during mixing and curing due to its unique properties.

RC Beams: Construction follows standard practices for concrete casting and reinforcement placement. Proper design is critical to ensure structural integrity.

LITERATURE REVIEW

S. Venkatachalam et al (2021) he study described presents a detailed examination of the behavior of reinforced geo-polymer concrete beams, with a specific focus on their flexural behavior. Here are the key points highlighted in the study: The analysis employs three-dimensional Finite Element Method (FEM) to comprehensively examine the behavior of reinforced geo-polymer concrete beams under critical stress distributions and effective strains. This approach allows for a thorough investigation into various aspects of beam behavior. The primary focus of the study is on the flexural behavior of the beams. This includes studying failure surfaces and physical properties related to flexural cracking behavior. By understanding how these beams respond under flexural loading, engineers can better design and optimize their performance in practical applications. Results obtained from the FEM analysis are compared with analytical calculations following ACI (American Concrete Institute) codes. This comparison serves to evaluate the accuracy and reliability of the analytical approach in predicting the behavior of reinforced geo-polymer concrete beams. The investigation includes an evaluation of incremental loading conditions leading up to failure. This aspect provides insights into the time-dependent behavior of the beams, which is crucial for understanding their performance in real-world scenarios where loading conditions may vary over time. The study leverages computer analysis to delve into the flexural failure of reinforced geo-polymer concrete beams. Modern computer software allows for the implementation of nonlinear models, enabling a more realistic representation of the behavior of structural members under various loading conditions.

Nagraj jammi et al (2017) was providing information about concrete and the use of ANSYS software in analyzing structural aspects of construction materials. Concrete, as we mentioned, is a widely used construction material due to its versatility, strength, economy, and durability. It can be molded into various shapes and forms, making it suitable for a wide range of structures. ANSYS Mechanical software is utilized for finite element analysis (FEA), which is crucial for studying structural behavior and performance. It offers capabilities for linear, nonlinear, and dynamic studies, as well as thermal analysis and coupled-physics simulations. This software is trusted globally for solving complex structural problems efficiently.

In your project, you're using M60 grade concrete with different water-to-binder ratios for Geopolymer concrete (GPC) and Ordinary Portland concrete (OPC). The water-to-binder ratio affects the properties of the concrete, including its strength and durability.

OBJECTIVE OF PAPER

Calculate the share force, bending moment and deflection in reinforce concrete beam and geo polymer based reinforced concrete beam.

METHODS OF ANALYSIS

Computational Analysis using ANSYS

Shear Force Analysis

ANSYS software was employed to analyze the distribution of shear forces within the concrete structures. Finite element analysis techniques were utilized to simulate various loading conditions, allowing for a comprehensive understanding of shear force distribution and its effects on structural integrity.

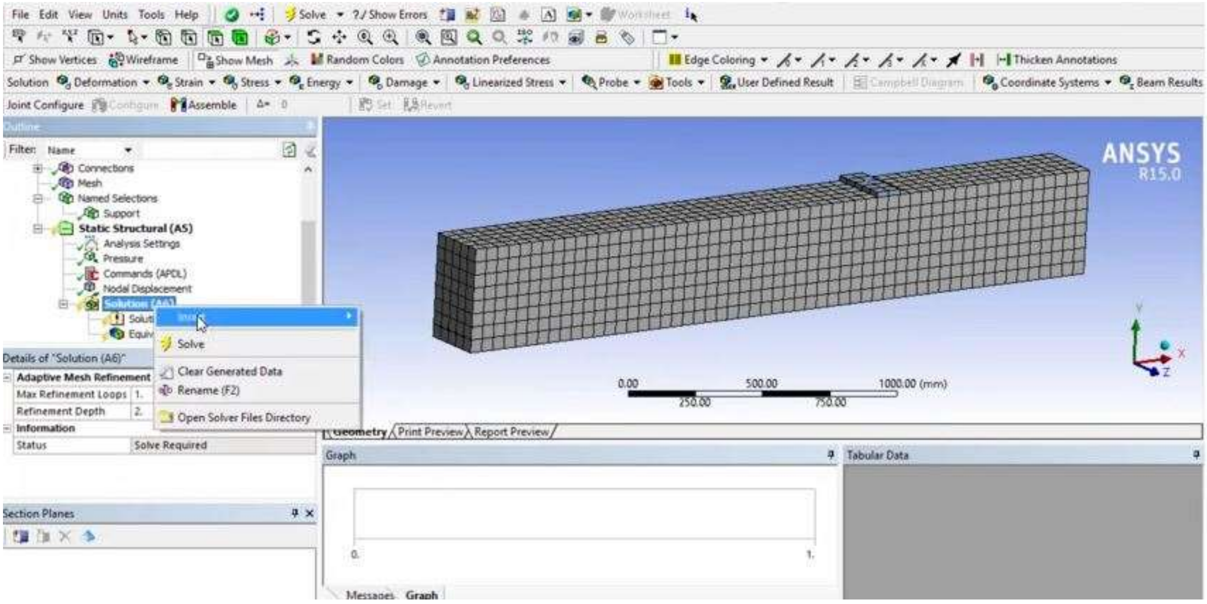
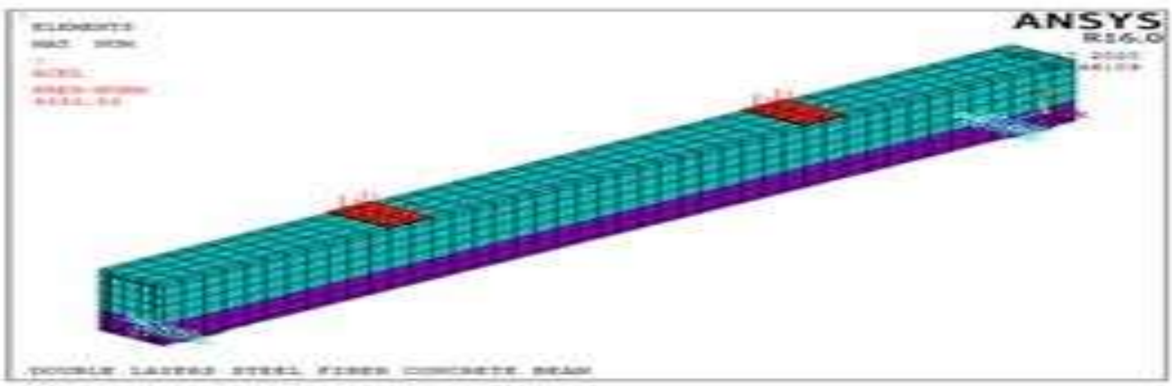


Figure 1 Mesh structure of bean in ANAYS



a) 2-layer beam model and boundary conditions

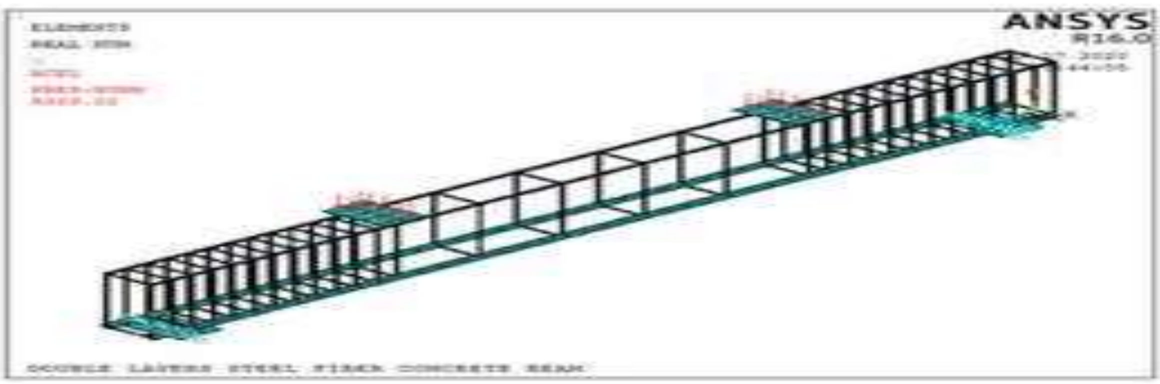


Figure 2 Rcc details in ANSYS

Bending Moment Analysis

The bending moment experienced by concrete elements under applied loads was investigated using ANSYS software. By modeling the structural geometry and applying appropriate boundary conditions, the distribution of bending moments along the members was elucidated, aiding in the design and optimization of concrete structures.

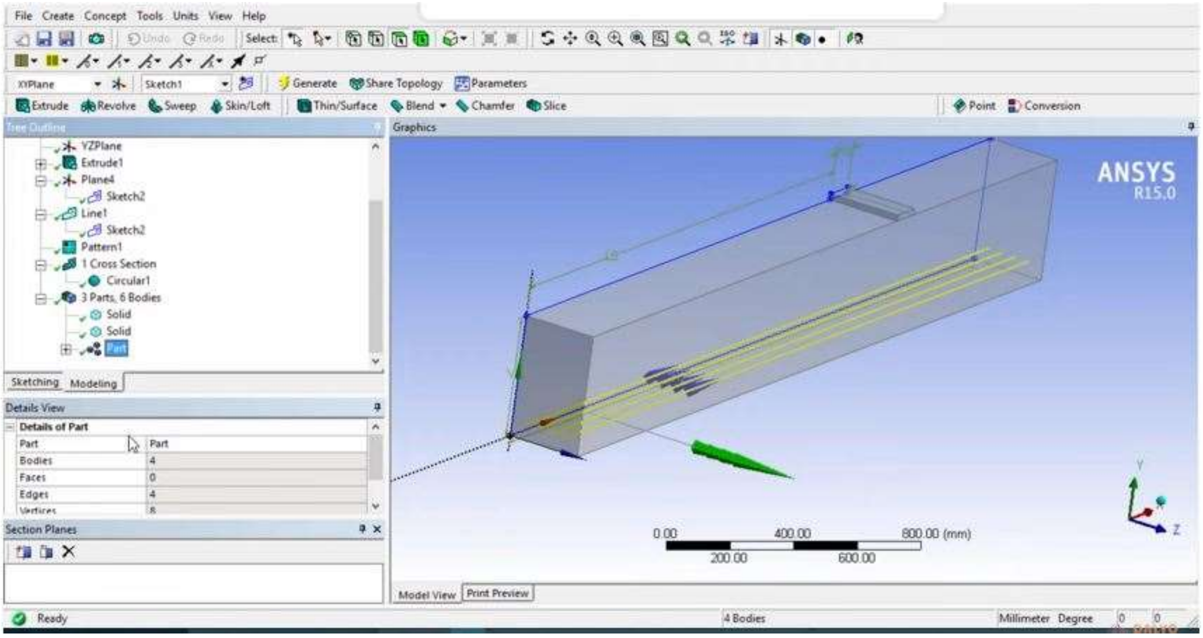


Figure 3 Bending moment along the direction of beam

Deflection Analysis

Deflection analysis was conducted to assess the deformation characteristics of concrete components under load. ANSYS simulations facilitated the visualization of deflection patterns and enabled the determination of critical deflection points, crucial for ensuring structural stability and performance.

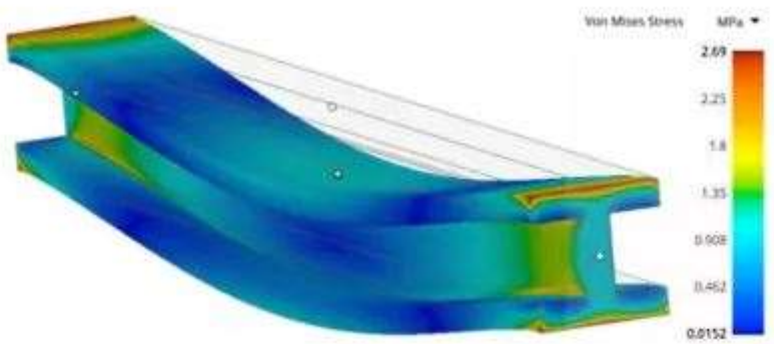


Figure 4 Deflection of beam in ANSYS

RESULTS AND DISCUSSION

We may have followed the best practices and utilized appropriate methods and materials, there may still be limitations inherent in the methodology itself. These limitations could impact the reliability or validity of the results. Sometimes, the result may not be in your favor because our understanding of the subject matter is still incomplete. Science is an iterative process, and new discoveries and insights can challenge previously held assumptions or beliefs. External factors beyond your control could also influence the outcome of the project. This could include changes in market conditions, shifts in consumer preferences, or unforeseen events that affect the context in which the project operates. The timing of the project implementation could also play a role in the outcome. Factors such as seasonality, economic cycles, or technological advancements may impact the results in ways that were not initially anticipated.

Shear Force

Shear force, in the context of mechanics and engineering, refers to the internal force that acts parallel to the surface of a material and tends to slide one part of the material over an adjacent part. It is a result of applied forces or loads on a structural member, such as beams, columns, or plates.

When an external force is applied perpendicular to the cross-section of a structural member, it induces internal forces, including shear force and bending moment. Shear force arises when the applied load causes one part of the material to slide past another along a plane parallel to the applied force.

This suggests that the geo polymer-based concrete may have advantages in terms of load-bearing capacity, possibly due to its unique properties or composition. However, the normal concrete beam may excel in shear force resistance, indicating differing strengths and weaknesses between the two materials in different aspects of structural performance.

Table 1 Showing the value of share force

Shear force in KN/m	
Normal R.C.C concrete	**Geo polymer Based Reinforced concrete**
582.32	498.36

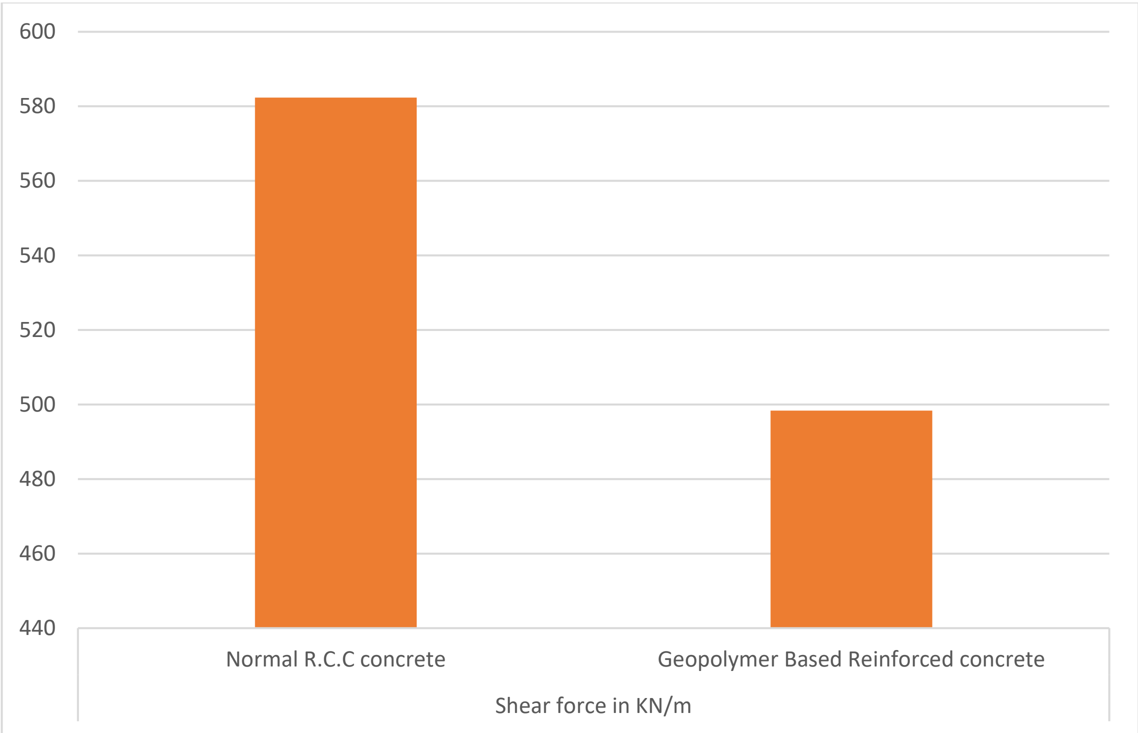


Figure 5 shear force compression

Bending Moment

Bending moment is a term used in engineering, specifically in structural analysis and design, to describe the internal moment that causes a beam, or any other structural element, to bend under loads. When a beam is subjected to external loads, such as forces or moments, it experiences internal forces and moments that resist deformation.

This is an interesting finding and suggests that the geo polymer-based concrete beams may have superior load-bearing capacity, while the normal concrete beams may exhibit higher susceptibility to bending under load.

Such results can have significant implications for construction and engineering practices, as they may indicate that geo polymer-based concrete could be a promising alternative for structures requiring high load-bearing capacity and resistance to bending

Table 2 Showing the value of bending moment

Bending moment in KN-m	
Normal R.C.C concrete	**Geopolymer Based Reinforced concrete**
276.32	245.51

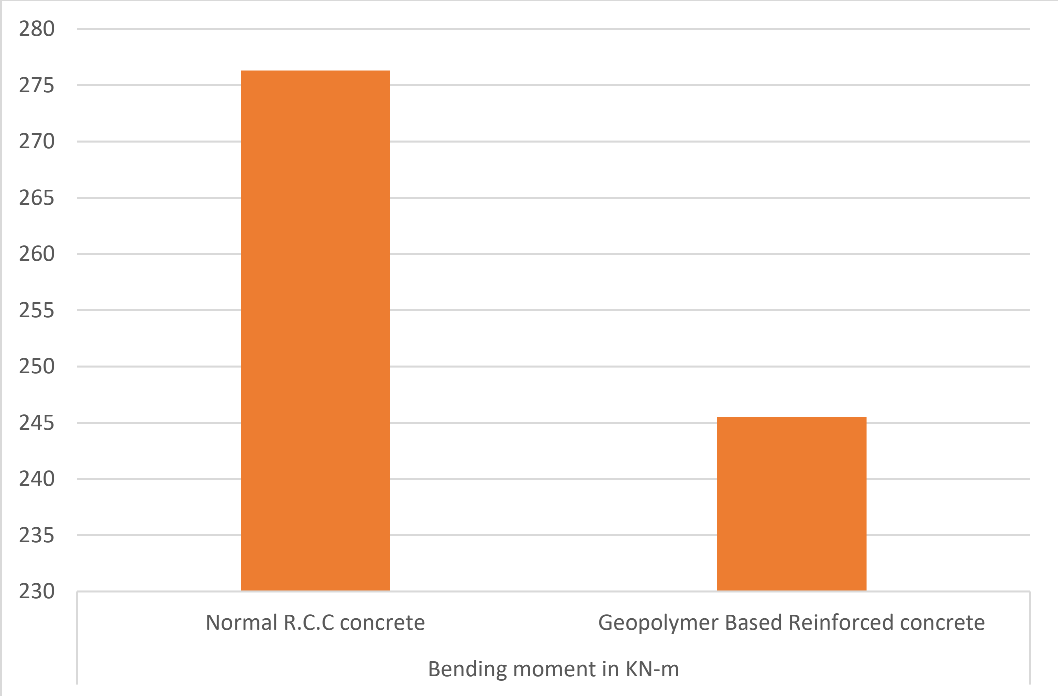


Figure 6 Bending moment compression

Deflection

Deflection calculations play a crucial role in building construction, particularly in the selection of materials and design of structural elements to ensure safety, stability, and functionality. Deflection analysis is an essential aspect of structural engineering in building construction, influencing material selection, design decisions, and compliance with safety standards. By accurately predicting and controlling deflection, engineers can ensure that buildings are safe, durable, and fit for their intended purpose. Different materials have varying stiffness and strength properties, which directly affect their deflection characteristics under load. Engineers need to choose materials that can withstand anticipated loads while minimizing deflection to acceptable levels. For example, steel and reinforced

Deflection analysis is crucial in assessing the structural performance of concrete elements, especially in terms of stiffness and load-bearing capacity. Geopolymer concrete, being an alternative to conventional Portland cement-based concrete, often exhibits different mechanical properties due to its unique composition and curing process.

The fact that you observed less deflection in the geo polymer-based concrete compared to normal concrete suggests that it may have higher stiffness or better resistance to deformation under applied loads

This finding underscores the potential benefits of geo polymer-based concrete in terms of structural performance, particularly in reducing deflection. It's essential to further investigate and validate these findings through experimental testing and possibly more advanced numerical simulations to gain deeper insights into the behavior of geo polymer concrete under various loading conditions. The deflection analysis of M25 grade based normal concrete and geo polymer based concrete with the help of Ansys software and found that geo polymer based concrete is showing less deflection in comparison to normal concrete.

Table 3 showing the value of deflection

Deflection in mm	
Normal R.C.C concrete	**Geo polymer Based Reinforced concrete**
11.32	6.31

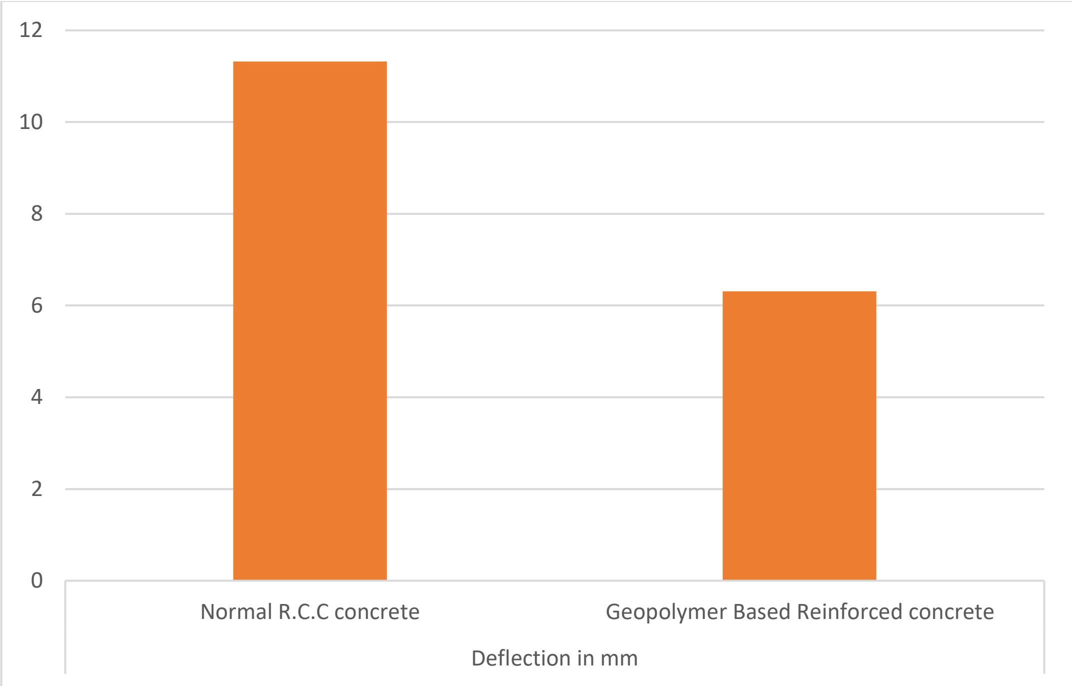


Figure 7 Deflection compression

CONCLUSION

The findings of this study unequivocally demonstrate the feasibility of developing accurate nonlinear material models using computer software. Furthermore, these models effectively capture the nonlinear behavior of reinforced concrete structural elements under loading conditions up to failure. The results obtained from the computational simulations realistically mirror those obtained through experimental testing. we completed a comprehensive project on geo-polymer concrete and its comparison with conventional concrete. You've successfully executed the mix design for geo-polymer concrete and casted concrete specimens based on this design. Various tests have been conducted on the concrete specimens to assess their properties and performance. The optimum grade of geo-polymer concrete has been determined, likely based on the results of the tests conducted. The predictions obtained from the finite element model were compared with experimental data obtained from testing the concrete beams. A specific model for geo-polymer concrete beams was created, likely using finite element analysis or other modeling techniques. All results obtained from testing, modeling, and analysis were compared with theoretical results. Theoretical values were likely obtained through calculations, possibly using coded methods, and supplemented with self-weighing.

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