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# Numerical Investigation on Flexural Behaviour of Geogrid-Reinforced RCC Beams using ANSYS

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**ABSTRACT:** This study presents a numerical investigation on the flexural behaviour of reinforced concrete (RCC) beams reinforced with uniaxial polypropylene geogrid using Finite Element Analysis (FEA) in ANSYS. Four beam configurations were analyzed, namely Conventional Beam (CB), Fully Wrapped Beam (FWB), U-Wrapped Beam (UWB), and Layer in Tension Zone Beam (LTB). The numerical modelling was carried out to evaluate deformation behaviour, stress distribution, and load-carrying capacity under static loading conditions. Proper material properties, boundary conditions, meshing, and loading arrangements were defined to accurately simulate the experimental setup. The results revealed that geogrid reinforcement significantly improved the flexural performance of RCC beams compared to the conventional beam. Among all specimens, the LTB configuration exhibited the highest ultimate load-carrying capacity of 122.13 kN, followed by FWB with 107.67 kN. The stress distribution and deformation behaviour obtained from ANSYS confirmed improved stiffness, crack resistance, and energy absorption in geogrid-reinforced beams. The numerical results showed good agreement with experimental findings, with Numerical-to-Experimental (N/E) ratios ranging between 1.15 and 1.18.

**KEYWORDS:** Geogrid reinforcement, RCC beam, Finite Element Analysis, ANSYS, Flexural behaviour, Numerical analysis, Coal Bottom Ash; paver blocks; fine aggregate replacement; compressive strength; flexural strength; split tensile strength; IS 15658:2021; sustainable concrete

## I. INTRODUCTION

Reinforced concrete (RCC) beams are among the most important structural elements used in modern civil engineering construction due to their ability to resist compressive and flexural loads effectively. RCC beams are extensively employed in buildings, bridges, industrial structures, pavements, retaining structures, and transportation infrastructure because of their high strength, durability, and adaptability. However, despite the advantages of reinforced concrete, conventional RCC beams often suffer from several structural limitations such as crack initiation, crack propagation, excessive deflection, reduced ductility, and brittle failure under flexural loading conditions. These problems become more critical when structures are subjected to repeated loading, overloading, environmental deterioration, and long-term service conditions.

Concrete is inherently strong in compression but weak in tension. Under flexural loading, tensile stresses develop in the bottom region of the beam, resulting in the formation of cracks. As loading increases, these cracks propagate rapidly, reducing stiffness and load-carrying capacity and eventually leading to structural failure. Although steel reinforcement is commonly provided to resist tensile stresses, conventional reinforcement alone may not always provide sufficient crack resistance and post-cracking ductility, particularly in structures subjected to severe loading conditions. Therefore, there is a growing need for alternative reinforcement techniques capable of improving the flexural behaviour, crack resistance, and overall structural efficiency of RCC beams.

In recent years, geosynthetic materials have gained considerable attention in structural and geotechnical engineering applications due to their lightweight nature, high tensile strength, corrosion resistance, ease of installation, and cost-effectiveness. Among various geosynthetic materials, geogrids have emerged as an effective reinforcement material for enhancing the mechanical behaviour of concrete structures. Geogrids are polymeric grid-like materials consisting of interconnected ribs and apertures capable of providing tensile reinforcement and confinement action within the concrete matrix. The interlocking behaviour between geogrid and concrete improves stress transfer, crack control, and energy absorption capacity.

Geogrids are generally manufactured using polymeric materials such as polypropylene (PP), polyester (PET), and high-density polyethylene (HDPE). Depending on the direction of tensile strength development, geogrids are classified as uniaxial, biaxial, and triaxial geogrids. In structural applications, uniaxial polypropylene geogrids are widely used because of their high tensile strength in one principal direction, which makes them suitable for resisting flexural tensile stresses in RCC beams.

The incorporation of geogrid reinforcement in reinforced concrete members has shown promising improvements in structural behaviour. Previous experimental studies reported that geogrid reinforcement enhances crack resistance, improves stiffness, delays crack propagation, increases energy absorption capacity, and improves ductility and load-carrying performance of RCC beams. The geogrid acts as secondary reinforcement within the concrete matrix, helping in stress redistribution and confinement of concrete under loading. Different geogrid configurations such as full wrapping, U-wrapping, and placement in the tension zone significantly influence the structural response of beams.

Several researchers have investigated the behaviour of geogrid-reinforced concrete beams through experimental studies. The results consistently indicate that geogrid confinement delays crack initiation and improves post-cracking behaviour. Fully wrapped beams exhibit improved confinement and ductility, while geogrid placement in the tension zone provides better resistance against flexural tensile stresses and enhances load-carrying efficiency. However, experimental investigations alone may not provide a complete understanding of stress distribution, deformation characteristics, and structural response within the beam specimens.

Finite Element Analysis (FEA) has become one of the most efficient numerical tools for evaluating the structural behaviour of reinforced concrete members under various loading conditions. Numerical simulation helps in understanding deformation behaviour, stress concentration, strain distribution, and load transfer mechanisms with good accuracy. ANSYS software is widely used in civil engineering applications for modelling and analysing structural components such as beams, slabs, columns, and composite systems. The use of FEA allows researchers to study structural behaviour in detail and compare numerical predictions with experimental observations.

In the present study, Finite Element Analysis was carried out using ANSYS software to numerically investigate the flexural behaviour of geogrid-reinforced RCC beams under static loading conditions. Four beam configurations were considered in the analysis, namely Conventional Beam (CB), Fully Wrapped Beam (FWB), U-Wrapped Beam (UWB), and Layer in Tension Zone Beam (LTB). The numerical modelling included geometry creation, material property definition, meshing, boundary condition application, and loading simulation to accurately represent the experimental setup.

The primary objective of this numerical investigation was to evaluate the effect of different geogrid reinforcement configurations on the structural behaviour of RCC beams. Important parameters such as deformation behaviour, stress distribution, flexural response, stiffness characteristics, and ultimate load-carrying capacity were analysed using ANSYS. The obtained numerical results were compared with experimental findings to validate the effectiveness and reliability of the developed finite element model.

The study aims to provide a better understanding of the role of geogrid reinforcement in improving the structural efficiency of RCC beams and to establish the suitability of finite element modelling for predicting the flexural behaviour of geogrid-reinforced concrete structures.

## II. LITERATURE REVIEW

Several researchers have investigated the effectiveness of geogrid reinforcement in improving the structural performance of reinforced concrete members under different loading conditions. The available literature indicates that geogrid reinforcement significantly enhances flexural strength, crack resistance, stiffness, ductility, and energy absorption behaviour of concrete structures.

R. Siva Chidambaram et al. (2015) investigated the flexural and shear behaviour of reinforced concrete beams strengthened using geogrid confinement and steel fibre reinforced concrete. The study reported that geogrid confinement delayed crack initiation, reduced crack propagation, and enhanced load-carrying capacity. The combined action of steel fibres and geogrid reinforcement significantly improved toughness, energy absorption, and post-cracking behaviour of the beam specimens.

Hayssam Itani et al. (2016) carried out experimental and numerical investigations on geogrid-reinforced concrete overlays. The study showed that geogrid reinforcement improved the bond behaviour between the overlay and concrete substrate, reduced reflective cracking, and enhanced load transfer efficiency. The numerical analysis also confirmed improved stress distribution and strain compatibility within the reinforced system.

Sivakamasundaria et al. (2017) studied the flexural behaviour of steel fibre reinforced concrete beams confined with biaxial geogrid. The experimental results indicated that the inclusion of geogrid layers in the tension zone improved stiffness, delayed crack formation, and reduced crack widths. The study also reported enhanced flexural strength, ductility, and energy absorption due to the combined action of geogrid and steel fibres.

Hakan Yalciner et al. (2018) evaluated the influence of geogrid reinforcement and polypropylene fibres on the flexural and shear behaviour of reinforced concrete beams. The study concluded that geogrid confinement improved crack distribution, enhanced ductility, and increased load-carrying capacity. The addition of polypropylene fibres further improved tensile resistance and delayed crack propagation.

X. Meng et al. (2019) experimentally investigated the flexural performance of pervious concrete beams reinforced with geogrid. The results demonstrated that geogrid reinforcement significantly enhanced flexural strength, stiffness, crack resistance, and deformation behaviour. The reinforced beams exhibited improved stress transfer and stable post-cracking response compared to unreinforced specimens.

Haiqiu Zhang et al. (2019) introduced a geogrid-confined pervious geopolymer concrete system integrated with FRP-PVC confinement. The study revealed that geogrid confinement improved compressive strength, flexural performance, and crack control while maintaining the permeability characteristics of the concrete system.

R. Siva Chidambaram and Pankaj Agarwal (2019) investigated the shear resistance behaviour of geogrid-confined reinforced concrete members under static and cyclic loading conditions. The study showed that geogrid confinement enhanced stiffness, shear strength, ductility, and energy dissipation characteristics. The reinforced specimens exhibited delayed crack formation and improved post-cracking resistance.

Aljawhari et al. (2020) experimentally and numerically evaluated reinforced concrete columns internally confined with biaxial geogrids. The results showed considerable improvement in compressive strength, axial load capacity, deformation behaviour, and ductility. The numerical analysis exhibited good agreement with experimental observations.

Soheil Abharian et al. (2021) investigated the effect of geogrid reinforcement on the compressive strain behaviour of reinforced concrete beams. The study reported that geogrid reinforcement improved stress transfer, delayed concrete crushing, enhanced stiffness, and improved crack resistance. The reinforced beams showed higher compressive strain capacity and improved structural efficiency.

Ghali M. et al. (2022) experimentally investigated the flexural behaviour of geogrid-reinforced RCC beams. The study concluded that geogrid reinforcement significantly improved load-carrying capacity, stiffness, crack resistance, and

energy absorption behaviour. The reinforced specimens exhibited improved post-cracking performance and higher ductility compared to conventional beams.

Yuqiu Ye et al. (2022) studied the pullout resistance behaviour of geogrid and steel reinforcement in lightweight cellular concrete. The study indicated that geogrid reinforcement exhibited improved interfacial bonding and stress distribution characteristics compared to conventional reinforcement systems.

Aliaa K. Hanan et al. (2023) compared the flexural behaviour of concrete beams reinforced with steel, geogrid, and GFRP mesh systems. The results showed that geogrid-reinforced beams exhibited improved crack control, better stress redistribution, enhanced ductility, and higher energy absorption capacity.

Mohamed S. Moawad et al. (2023) investigated the combined effect of geogrid reinforcement with steel fibres and glass fibres in concrete beams. The experimental investigation demonstrated that geogrid reinforcement significantly improved flexural strength, toughness, crack resistance, and deformation behaviour. The hybrid reinforcement system exhibited superior post-cracking performance and ductility.

Soheil Abharian et al. (2023) experimentally and numerically studied the tensile behaviour of high-strength self-compacted concrete reinforced with geogrid. The study confirmed that geogrid reinforcement improved tensile strength, delayed crack initiation, reduced crack widths, and enhanced energy absorption behaviour.

Abbas S. A. Al-Hedad et al. (2024) investigated the influence of geogrid reinforcement on pavement systems. The study showed that geogrid reinforcement improved load distribution, reduced surface deflection, delayed reflective cracking, and enhanced overall structural durability.

Mohammed A.Y. Hafez et al. (2024) studied the impact resistance behaviour of geogrid-reinforced green concrete subjected to projectile loading. The results demonstrated that geogrid reinforcement significantly improved impact resistance, energy absorption, and crack resistance while reducing brittle failure.

Zhiqiang Wang et al. (2024) evaluated the interlayer shear behaviour of carbon fibre geogrid-reinforced asphalt concrete systems. The study reported improved bonding strength, enhanced shear resistance, and better fatigue performance under repeated loading conditions.

Ruba H. Bashir et al. (2024) examined the effectiveness of internal and external geogrid confinement techniques in reinforced concrete columns. The results showed improved load-carrying capacity, ductility, crack resistance, and energy absorption characteristics in geogrid-confined specimens.

Ban Abd Abbas Khudhair and Hayder Mohammed Al-Khafaji (2025) investigated the flexural performance of hybrid internally reinforced concrete beams incorporating steel bars, FRP bars, geogrid layers, and GFRP mesh. The study concluded that the hybrid reinforcement system significantly enhanced load-carrying capacity, ductility, crack control, and energy absorption behaviour.

M. Pandieswari et al. (2026) experimentally investigated the structural behaviour of fibre reinforced concrete beams with partial replacement of conventional stirrups using geogrid reinforcement. The study demonstrated that geogrid reinforcement effectively contributed to shear resistance, improved crack distribution, enhanced load-deflection behaviour, and increased energy absorption capacity.

From the literature review, it is evident that geogrid reinforcement considerably improves the flexural performance, crack resistance, ductility, and structural efficiency of reinforced concrete beams. Previous investigations also indicate that numerical analysis using finite element methods provides reliable prediction of structural behaviour and validates experimental findings with good accuracy. However, limited studies are available on the numerical investigation of different geogrid wrapping configurations using ANSYS software. Therefore, the present study focuses on evaluating the numerical behaviour of RCC beams reinforced with different geogrid configurations under static flexural loading conditions using Finite Element Analysis.

### III. FINITE ELEMENT MODELLING

#### A. Numerical Analysis Using ANSYS

Finite Element Analysis (FEA) was carried out using ANSYS software to evaluate the structural response of conventional and geogrid-reinforced RCC beams under static loading. The numerical model was developed to simulate realistic structural behaviour by defining geometry, material properties, meshing, support conditions, and loading arrangements.

The numerical investigation focused on important structural parameters such as:

- ❖ Ultimate load-carrying capacity
- ❖ Total deformation
- ❖ Stress distribution
- ❖ Flexural response
- ❖ Structural stiffness

The numerical results were compared to evaluate the influence of different geogrid reinforcement configurations on beam performance.

#### B. Beam Configurations

Four beam specimens were modelled in ANSYS:

BEAM	DETAIL
CB	Conventional Beam
FWB	Geogrid - Fully Wrapped Beam
UWB	Geogrid -wrapped in U-shape Beam
LTB	Geogrid- Provided as a Layer in Tension Zone Beam

The CB specimen was considered as the control beam without geogrid reinforcement, while the remaining beams were reinforced using different geogrid arrangements.

#### B. Modelling of Beam Specimens

The modelling of beam specimens was carried out in ANSYS Workbench based on the actual dimensions and reinforcement details adopted during the experimental investigation. The finite element models were developed carefully to accurately simulate the structural response of conventional and geogrid-reinforced RCC beams under static flexural loading conditions.

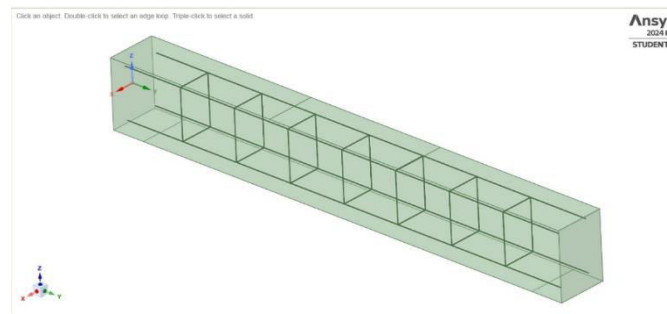
Initially, the beam geometry was created using the design modeller module in ANSYS. Four separate beam models were developed representing the Conventional Beam (CB), Fully Wrapped Beam (FWB), U-Wrapped Beam (UWB), and Layer in Tension Zone Beam (LTB). The overall dimensions of the beam specimens, reinforcement arrangement, support conditions, and geogrid placement were incorporated precisely to replicate the actual experimental setup.

The conventional beam model was developed without geogrid reinforcement and considered as the control specimen for comparison. The remaining beam models were developed with different geogrid reinforcement configurations. In the Fully Wrapped Beam (FWB), geogrid reinforcement was provided around the entire beam section to achieve complete confinement. In the U-Wrapped Beam (UWB), the geogrid was wrapped around three sides of the beam section excluding the top surface. In the Layer in Tension Zone Beam (LTB), the geogrid layer was placed only at the tension zone near the bottom portion of the beam.

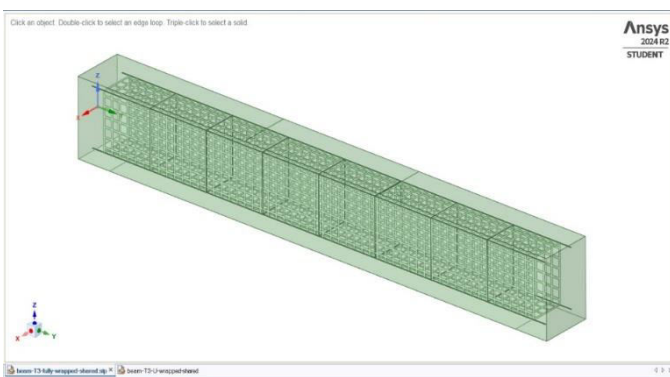
The concrete body was modelled as a solid structural element capable of resisting compressive and tensile stresses under loading conditions. Steel reinforcement bars were modelled and embedded within the concrete geometry to simulate actual reinforcement behaviour. The geogrid reinforcement was modelled as a separate reinforcement layer positioned according to the specified wrapping configuration.

Proper interaction between concrete, steel reinforcement, and geogrid layers was defined in the numerical model to ensure effective load transfer and realistic stress distribution behaviour. The modelling process was carried out carefully to avoid geometric discontinuities and ensure compatibility between different material components.

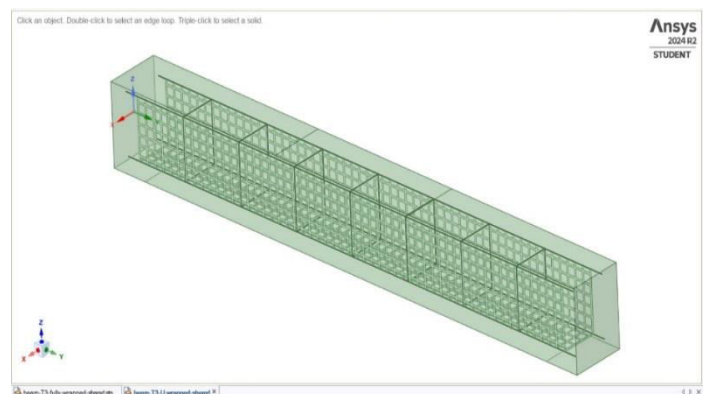
The developed finite element models were then used for meshing, application of boundary conditions, and numerical analysis. Accurate modelling of the beam specimens was essential for predicting realistic deformation behaviour, stress distribution, and load-carrying capacity under flexural loading conditions.



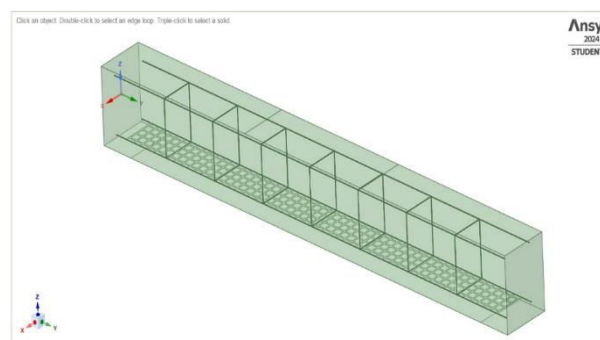
CB Model



FWB Model



UWB Model



LTB Model

### C. Material Properties

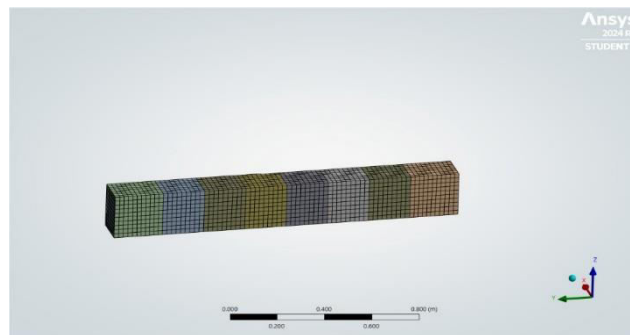
Material properties were assigned in ANSYS to accurately simulate the behaviour of concrete, steel reinforcement, and polypropylene geogrid. Important parameters such as modulus of elasticity, density, Poisson's ratio, and strength characteristics were defined for all materials.

The proper definition of material properties was essential for predicting realistic deformation and stress behaviour under applied loading.

### D. Meshing

Meshing was performed to divide the beam models into smaller finite elements for numerical computation. A uniform mesh size of 20 mm was adopted throughout the beam specimens to achieve a balance between computational efficiency and analysis accuracy.

The meshing process ensured proper representation of beam geometry, reinforcement detailing, and geogrid placement. Accurate meshing helped in obtaining reliable stress distribution and deformation results.



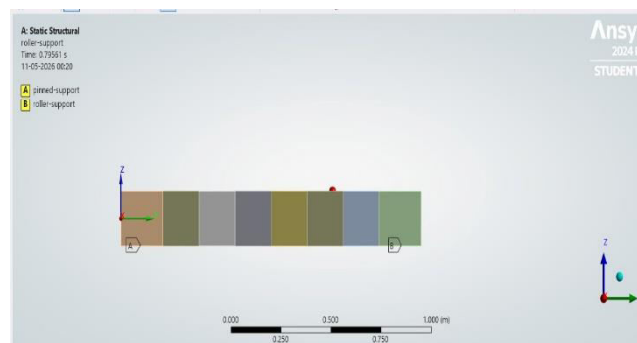
### E. Boundary Conditions

Boundary conditions were applied to simulate the actual support conditions used during beam testing. The beam specimens were modelled as simply supported beams.

- One support was restrained against both horizontal and vertical displacement.
- The opposite support was allowed limited horizontal movement while restricting vertical displacement.

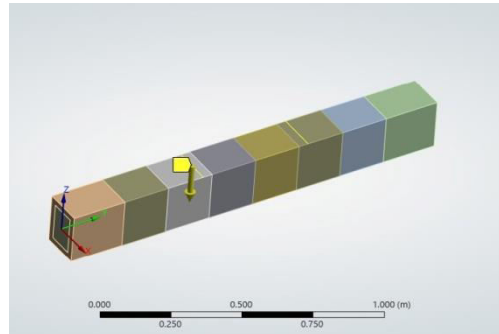
This arrangement enabled realistic bending behaviour during numerical analysis.

### F. Loading Conditions



The load was applied at two points on the top surface of the beam to simulate two-point flexural loading conditions. The loading arrangement created a constant bending moment region at the mid-span portion of the beam.

The load was gradually applied to evaluate deformation behaviour, stress development, and ultimate load-carrying capacity of all beam specimens.



#### IV. NUMERICAL RESULTS AND DISCUSSION

##### A. Numerical Results

The numerical analysis results obtained from ANSYS are presented in Table 1.

Table 1 Numerical Results of Beam Specimens

Beam Specimen	Ultimate Load (kN)	Deflection (mm)
CB	78.42	27.884
FWB	107.67	35.027
UWB	86.11	32.429
LTB	122.13	44.108

The numerical investigation clearly showed that geogrid reinforcement improved the overall flexural performance of RCC beams. All geogrid-reinforced specimens exhibited higher load-carrying capacity compared to the conventional beam.

Among all beam configurations, the Layer in Tension Zone Beam (LTB) exhibited the highest ultimate load capacity of 122.13 kN. The improvement in load-carrying capacity can be attributed to the effective placement of geogrid in the tensile zone, which enhanced resistance against flexural tensile stresses and delayed crack propagation.

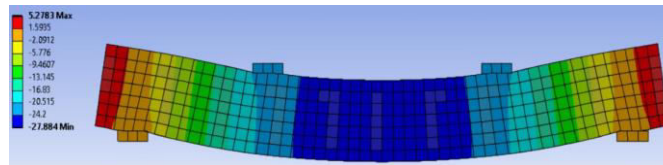
The Fully Wrapped Beam (FWB) also showed significant improvement with an ultimate load of 107.67 kN due to the confinement effect provided by complete geogrid wrapping around the beam section. The U-Wrapped Beam (UWB) exhibited moderate improvement because the geogrid confinement was provided only on three sides.

##### B. Deformation Behaviour

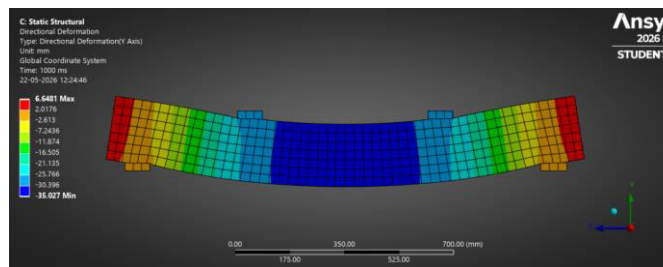
The deformation analysis revealed that geogrid reinforcement improved ductility and energy absorption behaviour of RCC beams. The conventional beam showed lower deformation capacity and comparatively brittle behaviour.

The FWB and LTB specimens exhibited larger deformation values before failure, indicating improved ductility and gradual failure behaviour. The higher deformation observed in geogrid-reinforced beams confirms improved post-cracking resistance and better stress redistribution within the concrete matrix.

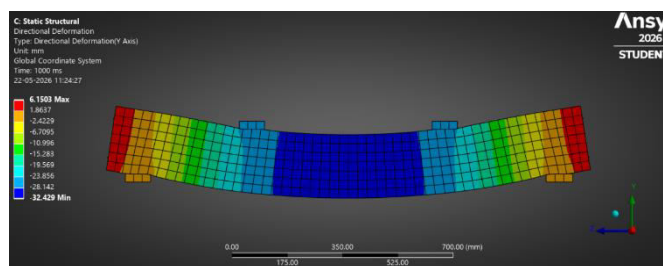
The LTB specimen recorded the highest deformation value of 44.108 mm, which indicates superior energy absorption and flexural performance.



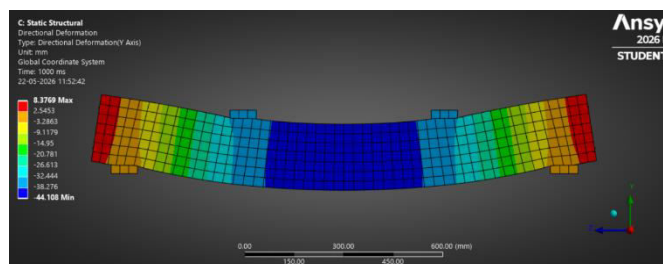
**Directional deformation of CB**



**Deformation of FWB**



**Deformation of UWB**



**Deformation of LTB**

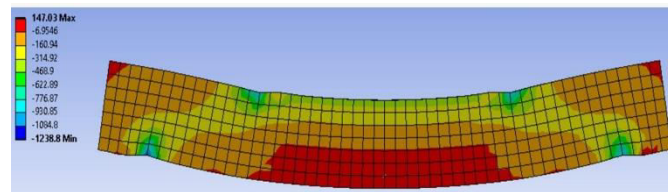
### C. Stress Distribution

Stress distribution analysis was performed in ANSYS to study the stress behaviour of beam specimens under applied loading conditions.

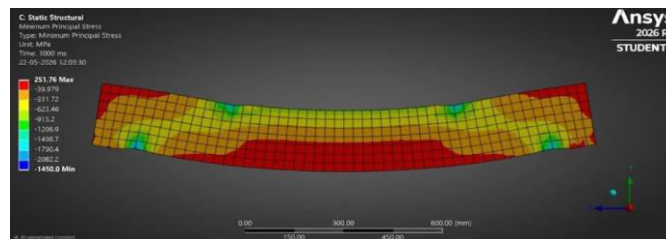
The stress contours indicated that compressive stresses were mainly concentrated in the bottom central region of the beams, while comparatively lower stresses were observed near the support zones. The stress distribution patterns were found to be nearly symmetrical for all beam specimens, confirming proper load transfer and realistic boundary condition application.

The geogrid-reinforced beams exhibited more uniform stress distribution compared to the conventional beam. The presence of geogrid improved stress redistribution and reduced stress concentration within the beam section.

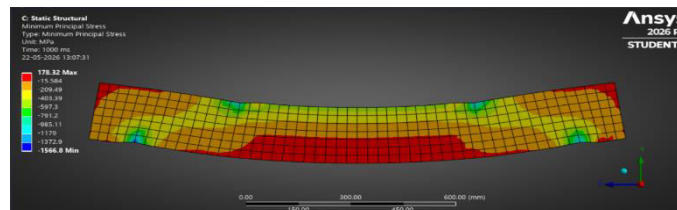
Among all specimens, the LTB and FWB beams exhibited better stress distribution behaviour due to effective geogrid confinement and tensile reinforcement action.



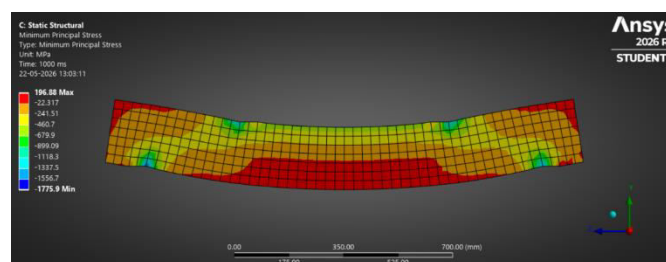
Stress distribution of CB



Stress distribution of FWB



Stress distribution of UWB



Stress distribution of LTB

## V. CONCLUSION

Based on the numerical investigation carried out using ANSYS, the following conclusions are drawn:

1. Geogrid reinforcement significantly improved the structural behaviour of RCC beams under flexural loading conditions.
2. The Layer in Tension Zone Beam (LTB) exhibited the highest ultimate load-carrying capacity of 122.13 kN, indicating superior flexural performance.
3. Fully Wrapped Beam (FWB) showed improved confinement, better stress redistribution, and enhanced ductility due to complete geogrid wrapping.
4. The U-Wrapped Beam (UWB) exhibited moderate improvement in strength and stiffness because confinement was provided only on three sides.

5. Geogrid-reinforced beams showed improved deformation capacity, delayed crack propagation, enhanced stress distribution, and better energy absorption compared to the conventional beam.
6. The finite element model developed in ANSYS showed good agreement with experimental results, with Numerical-to-Experimental ratios ranging between 1.15 and 1.18.
7. The numerical analysis confirmed that geogrid reinforcement is an effective technique for improving the flexural behaviour, stiffness, and structural efficiency of RCC beams.

#### REFERENCES

- [1] R. Siva Chidambaram and Pankaj Agarwal, "Flexural and Shear Behaviour of Geogrid Reinforced Concrete Beams," Journal of Structural Engineering, 2019.
- [2] Ghali M., et al., "Experimental Investigation on Flexural Behaviour of Geogrid Reinforced RCC Beams," Construction and Building Materials, 2022.
- [3] Soheil Abharian, et al., "Numerical and Experimental Study on Geogrid Reinforced Concrete Beams," Engineering Structures, 2023.
- [4] Aliaa K. Hanan, et al., "Flexural Performance of Concrete Beams Reinforced with Geogrid and GFRP Mesh," Materials Today Proceedings, 2023.
- [5] Mohammed A.Y. Hafez, et al., "Impact Resistance of Geogrid Reinforced Green Concrete," Journal of Building Engineering, 2024.



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