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Investigation of the mechanical behavior of the T-shape profile composite beam structure subjected to a three-point bending test

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Abstract. In this study, Three-point bending tests have been employed to investigate the mechanical behavior of the composite structure. T-shape profiles have been employed to be investigated and analyzed. in this study, geometry has been modeled and meshed using Ansys Software. Mesh and predicted results have been converged using normal stress as a main indicator of the convergency procedure. A static structure tool has been employed to simulate the mechanical behavior of the composite structure. The numerical results have been carried out based on the normal stress and resultant of the total deformation due to the applied static load. The numerical results have stated that the maximum value of the stress is 0.4 MP a due to the 1000 N. The value of the total deformation of the entire body is 0.004 mm. Eventually, the output of the numerical results has been stated that the composite structure can resist due to the applied static force.

Keywords: *structural analysis, normal stresses, T-shape, bending test, and Ansys*

1. Introduction

Some of its benefits as a legitimate point of view in technical situations are as follows: Encased concrete and thin-walled exterior steel U-sections serve as a prop to postpone or even stop local buckling of the steel, in contrast to conventional Hybrid Composite Beams (HCB), which employ open H-sections of steel with a restricted width-to-depth ratio [1]. Concrete enclosures with exterior steel U-sections with thin walls

Additionally, cooperate to reduce brittle shear failure and enhance shear capacity [2]. While Concrete-encased U-section Composite Beam (CUCB) peak year was brief, its details and forms were extensive.

Both experimentally and theoretically [3]. Investigated composite profiled beams, where profiled sheets were used to create open box girders. These composite beams have remarkable shear capacity, ductility, little creep deformation, and low dead weight; nonetheless, they would require a significant number of site supports and personnel to sustain them under construction loads. Several CUCB-like layouts using a variety of external steel types have been completed since 2000. Cold-formed thin-walled steel U sections [4]. Top flanges for slabs and columns were easy to install and worked well in hogging regions. However, residual stress effects may appear in the welded light steel section due to the challenging production process and the significant amount of welding. The integral behavior of composite beams has a significant impact on mechanical properties (such deformability and bearing capacity) [5]. The CUCB has two weak interfaces: one between the encased concrete and the outer steel U-section, and another between the concrete slab and the structure's lower half. [6, 7] (includes reinforcement, steel U-section, and encased concrete).

The bending, vibration, and buckling response of composite structures reinforced with Boron Nitride Nanotubes BNNTs or Carbon Nanotubes CNTs is an important topic in structural mechanics. The mechanical and electrical properties of carbon nanotubes (CNTs) and boron nanotubes (BNNTs) were discussed. A piezoelectric polymeric shell reinforced by double-walled boron nitride nanotubes was examined for electro-mechanical torsional buckling. The researchers discovered that using stronger foam cores enhances the buckling strength substantially [8]. The structure and electrical characteristics of armchair bunts as a function of tube diameter were investigated using density functional theory. The Young's moduli and Poisson's ratio of boron-nitride crystals were determined using a continuum approach, and the findings were found to be consistent with both theoretical and experimental values.

The stability of BNNT reinforced piezoelectric polymeric composites was examined under electro thermomechanical loadings. Using a meshless approach, a sinusoidal shear deformation model, and Modified Shear Gap Theory (MSGT), the dynamic behavior of viscos-elastic double-bonded polymeric nano-composite plates reinforced by Functionally Graded Single-Walled Carbon Nanotubes (FGSWCNTs) was examined [9, 10].

Finite-element analysis was used to evaluate the buckling and free vibration of a tapered FGCNTRC micro Reddy beam while subjected to a longitudinal magnetic field. A Euler-Bernoulli composite beam model reinforced by FGSWCNT was studied for its nonlinear static and vibration properties. Composite

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Timoshenko beams reinforced with carbon nanotubes were tested on an elastic basis [11] for dynamic and buckling characteristics. When many moving loads are involved. Multiwalled carbon nanotubes with polystyrene walls were investigated for their dynamic behavior [12]. Piezoelectric nanocomposites with Functionally Graded Single-Walled Nanotubes FG-SWNT reinforcement for biaxial and bending tests. A modified strain gradient was employed in the Reddy rectangular plate model [13, 14]. Using DQM, MSGT micro-composite Reddy plates reinforced by FGSWCNTs under hydro-thermo-mechanical loadings were investigated for temperature-dependent material properties. The nonlocal biaxial stability of the CNT-reinforced polymeric nanocomposite plate has been examined in connection with surface stress and agglomeration [15]. In this study, Numerical analysis has been undertaken to calculate and predicted the total deformation and normal stresses of the constructed beam.

2. Research Methodology

2.1 Material properties

Composite material has been employed to fabricate the T shape beam structure and the mechanical properties of these structure have been collected as shown in table 1.

Table 1. The composite structure's mechanical characteristics.

No.	Properties	Composite materials
1	passion ratio	0.341
2	E (GPa)	622
3	Density (kg/m3)	1265

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2.2 Geometry and meshing

In this study, T shape profile beams have been drawn using AutoCAD. The geometry had been imported and modeled using Specialisms in Ansys Software. Ansys software can be used to research the case of this study. ANSYS is a well-known software that is used to model and simulate

Equations and generate the required solutions. Another software known as space claim is an ansys pre-processor that develops and applies the mesh on the geometrical depiction of the subject under inquiry. Ansys mechanical handles both the processing and post-processing processes. More difficult portions of the model, Tri-type paves are used, while in the rest of the model, Quad-type paves are used. With amorphous meshes, ANSYS enables complete mesh freedom, and the grid can be polished or roughened depending on the solution. After reading the grid into ANSYS as show in Fig. 1 for mesh elements.

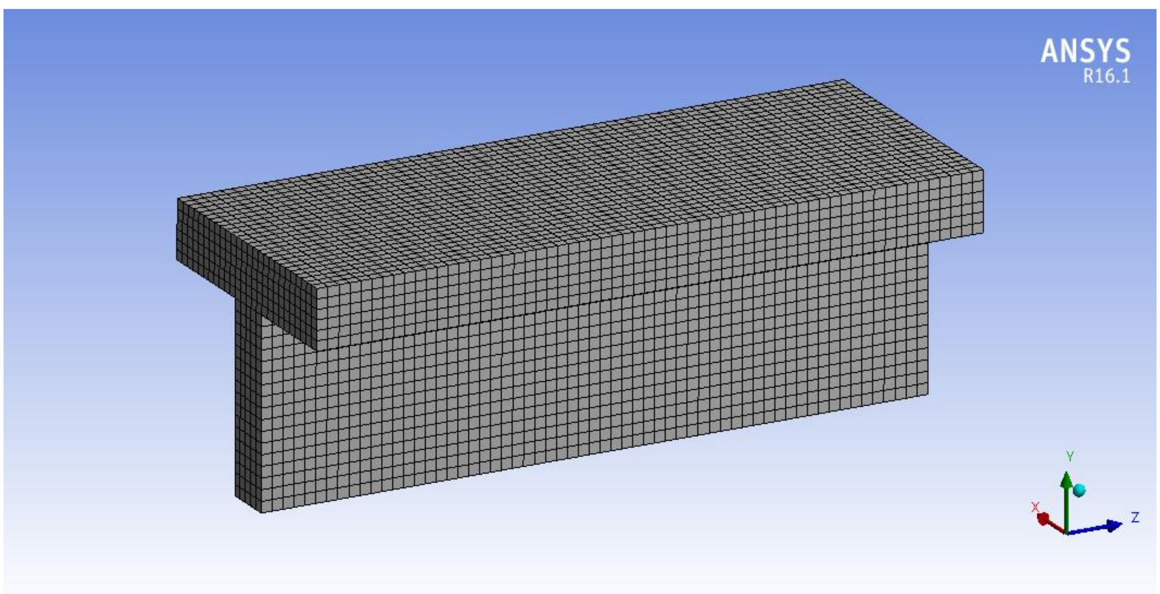

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Fig. 1. mesh representation of the composite structure's T-shape.

2.3 Boundary conditions

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In this study, the structure beam has been subjected to the three-point bending test. Based on the boundary conditions there are two fixed supported with central force. The type of force is static load with a magnitude is 1000 N. Fig. 2 also shows the general layout of the installation and force application areas for the model.

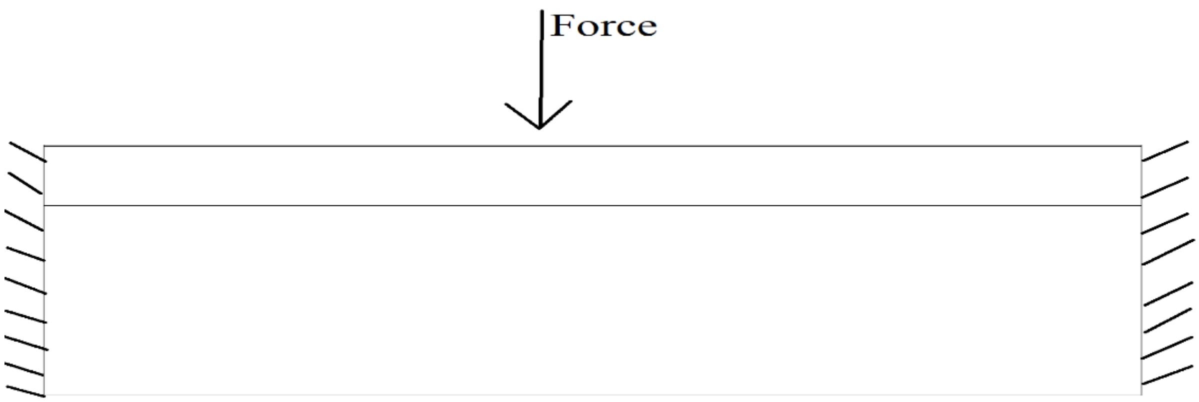

Fig. 2. The load that was imposed with fix support

3. Result and Discussion

3.1 Grid independent test

In this research number of elements has been 56445. the mesh of the current geometry has been converged accordingly. The analysis geometry has been meshed and converged accordingly. Normal stresses have been used as a main indicator of the convergence procedure.

3.2 Investigation normal stresses

Fig. 3 presented the graphical affection of the applied static load on the structural composite beam. The simulation process has reported the maximum resultant stresses at the middle of the composite structure. the maximum stress has reached 0.04 Mpa. The applied load was 1000 N. normal stress results were collected within X-axis within the global coordinate system.

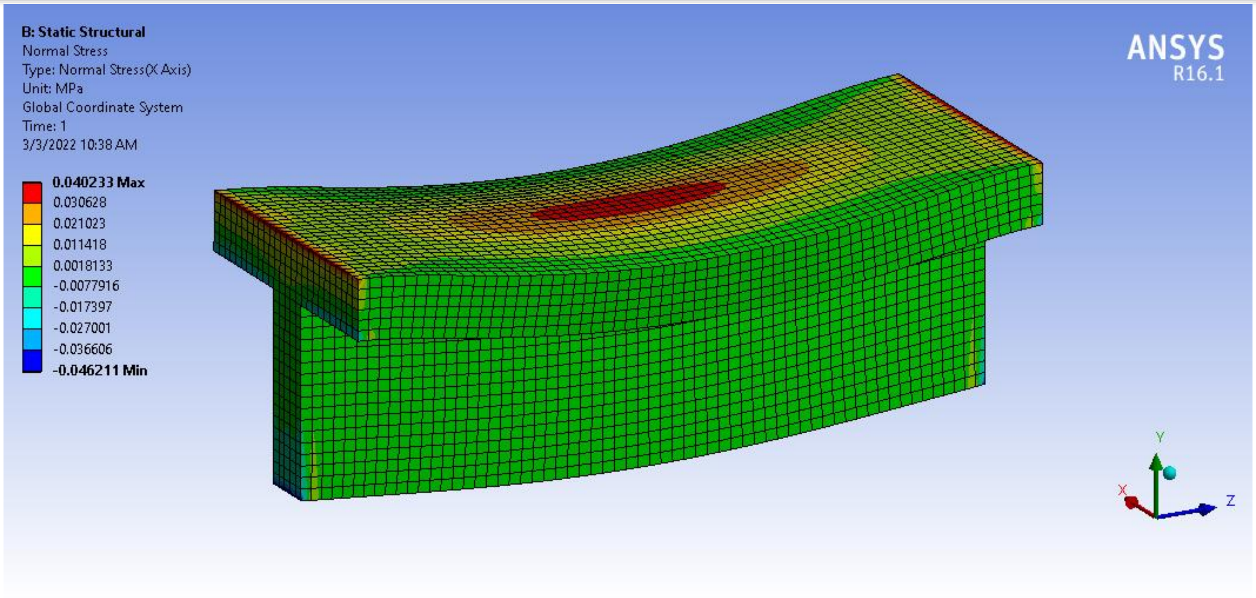

Fig. 3. Numerical results of the normal stresses

3.3 Investigation of total deformation

Total deformation has been predicted numerically as shown in the Fig. 3. Which shown the graphical affection due to the applied static load on the structural t-shape profile of the composite beam. The simulation process has reported the maximum resultant total deformation is 0.0014 mm at the middle of the composite structure. the maximum stress has reached 0.0014 mm. The applied load was 1000 N. Normal stress results were collected within X-axis within the global coordinate system. The minimum deformation is 5 *e-10 mm at the full body of the composite structure. As shown in Figure 4, the highest effect is concentrated in the middle on the sides indicated in red.

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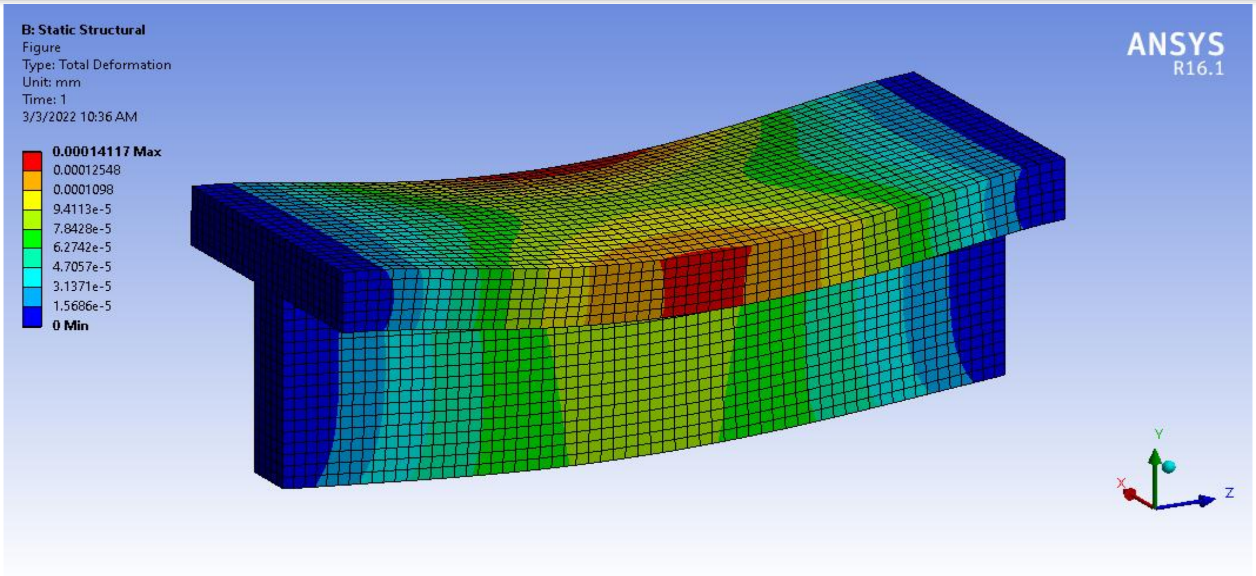

Fig. 4. Total deformation results

4. Conclusion

Three-point bending tests were used to explore the mechanical behavior of the composite structure in this study. T-shape profiles were used to study and interpret the data. Ansys Software was used to model and mesh the geometry in this investigation. Normal stress was used as a major indicator of the convergency technique to converge mesh and projected results. To simulate the mechanical behavior of the composite construction, a static structure tool was used. The numerical results were calculated using the normal stress and the total deformation as a result of the imposed static load. According to the numerical calculations, the maximum stress is 0.4 MPA owing to the 1000 N, and the total deformation of the complete body is 0.004 mm. Finally, the numerical results revealed that the composite structure can withstand the applied static force.

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