Analytical Study on Profiled Steel Sheet – Concrete Composite Sandwich Panel under Axial Load

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Abstract: *Steel-concrete composite panels have been proposed and developed for applications in various types of structures A sandwich panel is a typical structural form with good structural performance and excellent material advantages, such as high-specific strength, stiffness, light weight, high thermal insulation, and better performance under shock absorption. The project investigated the response of profiled steel sheet – concrete composite sandwich panel subjected to axial loading. Steel-concrete-steel sandwich structures consisting of two steel face plates infilled with concrete composite material has been developed. Sandwich panel consists of profiled steel sheet as the outer skins(face) and concrete as the infill, connected by using through bolts and the concrete portion is called core. Further, numerical study has been conducted to assess the integrity of the connection between skin and core and to find the effectiveness of connection on overall strength of the panel. Three-dimensional finite element (FE) simulation model is created for the parametric study to investigate the effect of several parameters on overall strength of the panel. Parametric studies are performed and numerical analysis using ANSYS Workbench results are analysed including failure mode, load–deflection curves and strength capacity.*

Keywords: Steel-concrete composite panel, high-specific strength, axial loading

I. INTRODUCTION

Sandwich materials are the most important applications of technological composites. Composite material is a structure formed by combining macroscopic meaning of several basic materials for a specific purpose. Sandwich materials are again in accordance with this definition, and different structures are combined without dissolving in order to provide various desired mechanical properties. Since this bonding process is provided with an adhesive layer, sandwich materials can be examined within the concept of bonding bonded composites. In recent years, a new type of composite structures, which called as steel plate–concrete (SC) structures, has developed to apply the construction of high-rise buildings, The SC structures are composed of steel plate, concrete and shear connectors to combine inhomogeneous two materials. A number of researchers are actively studying on SC structures. The research of SC structures have been focused on the structures using high strength steel and concrete to apply the special structures such as nuclear power plant and high-rise buildings. They have better structural performance than that of bare steel or reinforced concrete structures. There are many advantages in SC structures such as the possibility of prefabricated production and modular construction. These advantages provide to excellent potential for the use of the SC structures in mid to low-rise general buildings. However, the number of past test specimens subjected to compressive loading is limited because they have used the ordinary or high strength concrete in SC structures. Typical steel-plate concrete (SC) composite walls are composed of steel faceplates, infill concrete, headed steel studs anchoring the faceplates to the infill, and tie rods connecting the two faceplates through the infill. Fig.1.1 presents a cut-away view of a typical SC wall panel. The considerable interest in the use of steel-plate concrete (SC) composite shear walls in safety-related nuclear facilities has motivated Japanese, Korean, Canadian and US researchers to investigate the inplane behaviour of SC walls. Much of the early work focused on shear critical walls, namely, those walls with boundary columns and flanges and those rectangular walls and rectangular walls with low aspect ratios.

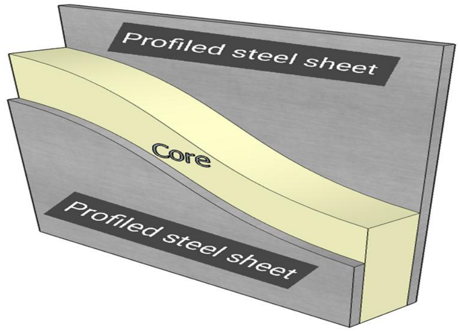

Fig.1. Profiled Steel Sheet – Concrete Composite Sandwich Panel

The double skin composite system exhibits many structural and economic advantages against the conventional double layer reinforced concrete structures. By filling the concrete, the structure provides high structural performance in terms of resistance, ductility and stiffness. The smooth exterior steel surfaces of structure can be easily inspected and protected so that the structure can maintain the required level of structural integrity throughout its service life. At construction stage, the steel plates form a permanent concrete formwork to eliminate temporary formwork, thereby saving time and costs. Pre-fabrication of large panels in the factory and rapid installation on-site translate into further time and cost savings. Using double skin composite system filled with lightweight material, the seismic action may be reduced and the installation, transportation efficiency may be improved due to the weight reduction and high strength-to-weight ratio. Lightweight and high strength material is more tam attractive to by engineers to serve for the building constructions.

II. DESIGN METHODOLOGY

The length width and thickness of the composite sandwich panel is 300mm x 300mm x 10mm. Finite element simulation of sandwich panels were performed using ansys. The core cell were modelled using an isotropic elastic-perfectly plastic material model available in ansys with following material parameters: Young's modulus=8.5E+07 Pa ,Poisson's ratio=0.3,Bulk modulus=7.0833E+07 Pa ,Shear modulus=3.2692E+07 Pa . The elastic behaviour of the foamed concrete core was modelled using uniaxial compression elastic modulus and yield stress from Table 3, ν=0.1 and density of 1000 kg/m3. The Unidirectional Epoxy Infusion Resin Carbon fiber fabric were modeled as a Orthotropic elastic material with the following parameters: Young's modulus in X direction=1.15E+13 Pa , Young's modulus in Y,Z direction=6.43E+09 Pa , Poisson's ratio in XY,YZ,XZ=0.3 ,Shear modulus XY=6E+09 Pa , Shear modulus YZ=6E+09 Pa , Shear modulus XZ=6E+09 Pa.

III. ANALYTICAL MODEL

3.1. Mesh Model

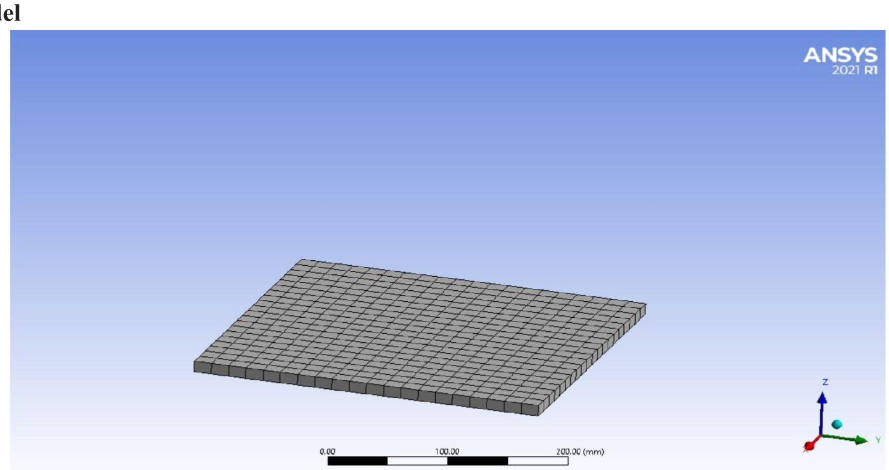

Fig.2.Meshing of Sandwich composite sheet

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3.2 Fibre Direction

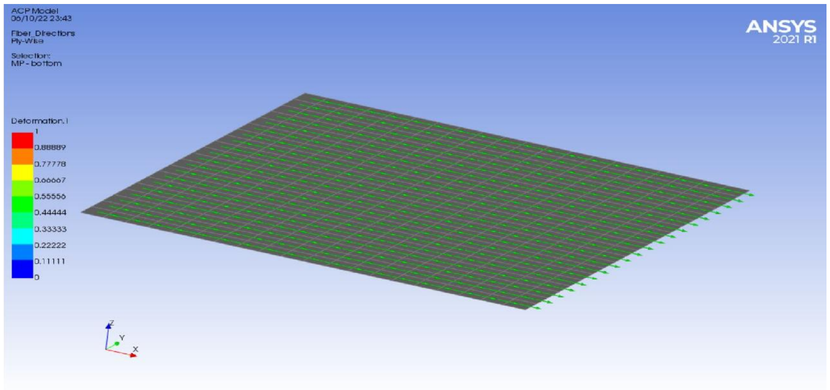

Fig. 3 Fibre direction

IV. RESULTS

4.1. Directional Deformation

As a result of analysis, the directional deformation of the composite sandwich panel is determined in Fig.4

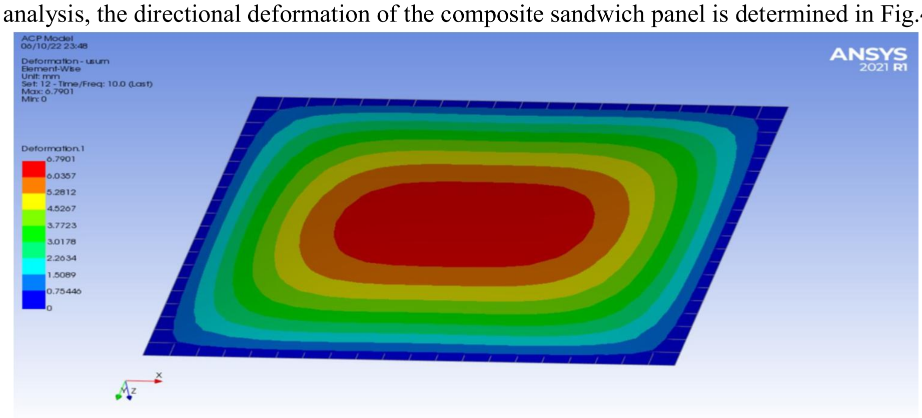

Fig.4.Directional deformation of the composite sandwich panel

4.2. Failure Post Process

As a result of the analysis, failure post process is determined in fig.5 as per the failure criteria considered.

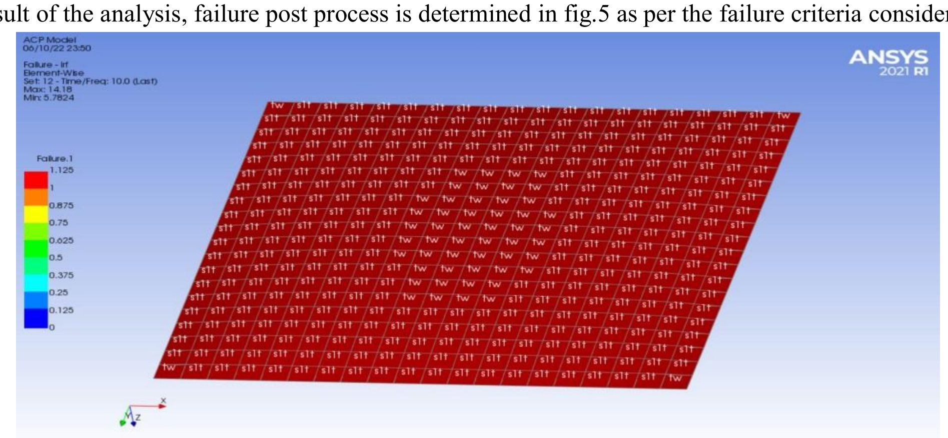

Fig .5. Failure post process

4.3 Maximum Principal Stress

As a result of analysis, the maximum principal stress is determined in Fig.7

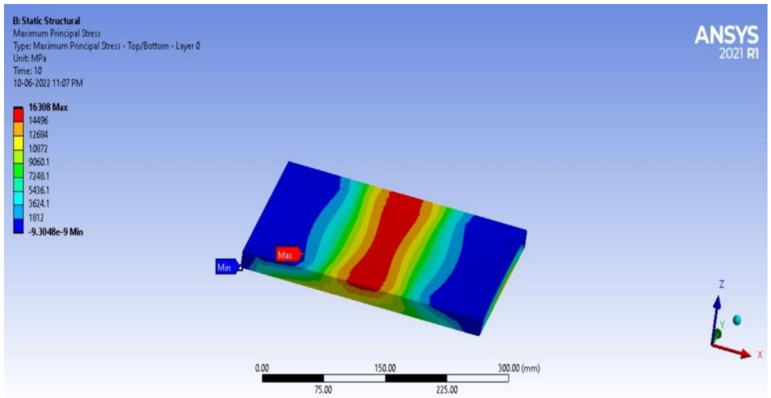

Fig. 7. Maximum principal stress

4.4 Maximum Principal Strain

As a result of analysis, the maximum principal strain is determined in Fig.8

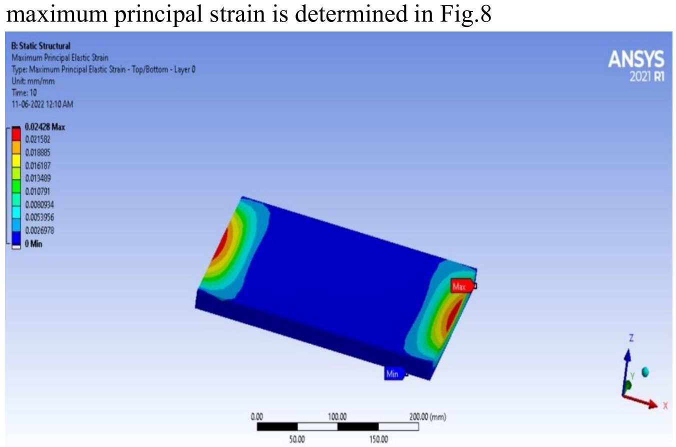

Fig. 8 Maximum principal strain

4.5 Load-Deflection Curve

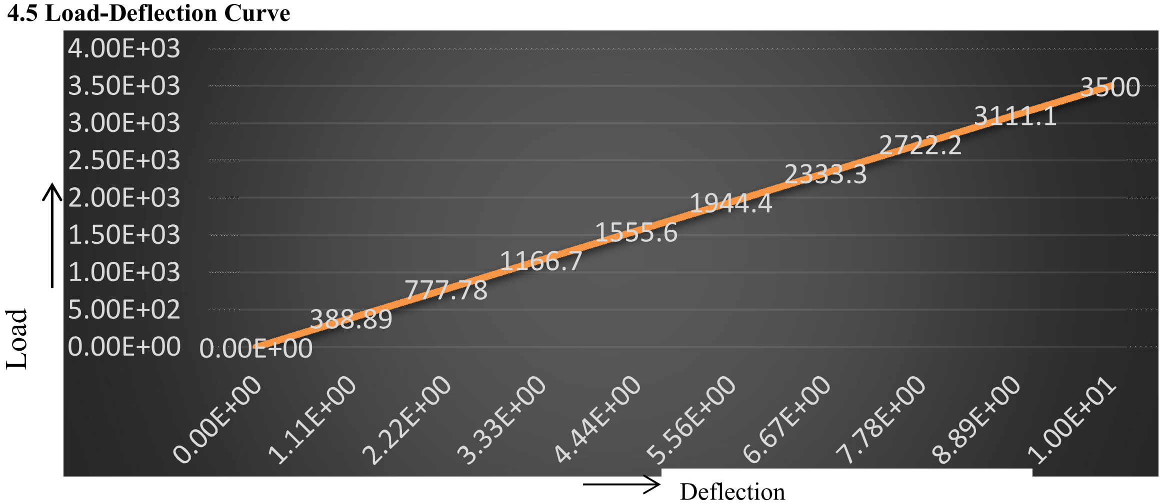

Fig .8.Load –deflection curve

4.6 Stress-Strain Curve

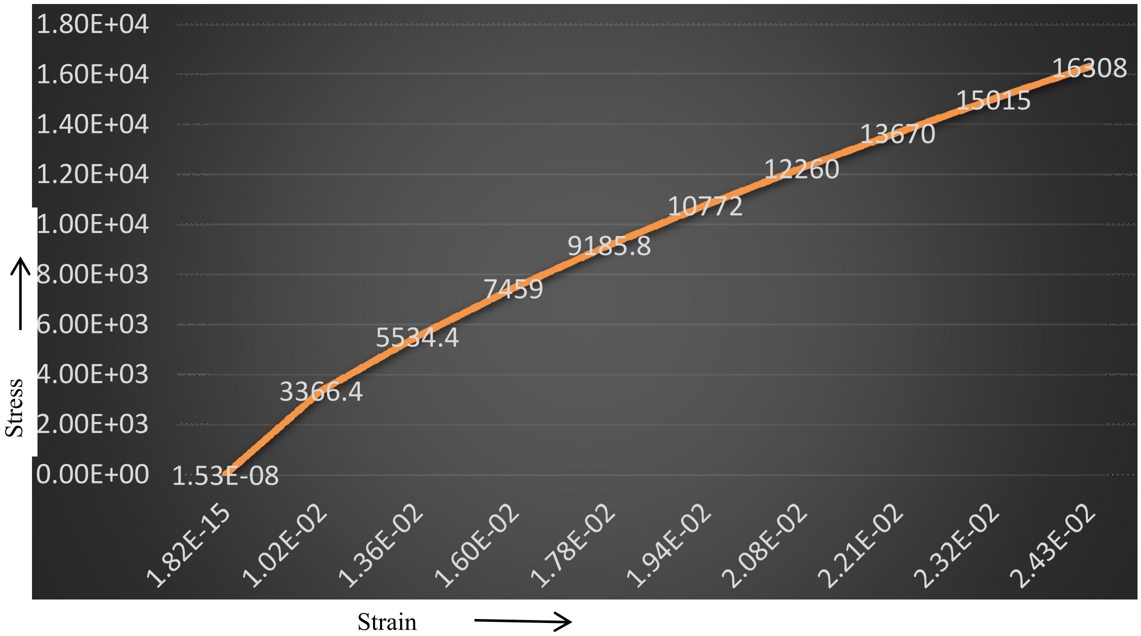

Fig .9.Stress-Strain curve

V. CONCLUSION

Following conclusions can be drawn from ANSYS analysis results discussed above.For concentrated load at center generates about double max equivalent stress as compared to distributed load. For concentrated load at center generates about double total deformation as compared to distributed load. Max deflection always occurs at center on plate which is in agreement with standard strength of material result. For panel having concentrated load at center max stress always generated at the location of application of load i.e. on the center of plate.

The strategy for modelling impact behaviour of composite sandwich panel , with their complex modes of damage, presented here has been shown to work very well. The analyses have shown that sandwich panel is a good absorber of impact energy. The sandwich panel has been shown to absorb energy by a combination of core crush under the impact and through-thickness shear yielding.

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