Research Article

Finite Element Analysis of Honeycomb Sandwich Composite Structures With Various Joints

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Abstract: This work focuses on the numerical investigation of mechanical properties of aluminium honeycomb sandwich composite structures with lap and butt joints. The joints are bonded using adhesive, welded and bolted which were designed using CATIA software. The static and dynamic structural analyses were performed to compute the mechanical properties of aluminium honeycomb composite structures with various joints using ANSYS software. Finally, the models were developed for estimating the failure strength of joints in honeycomb sandwich composite structures.

KEYWORDS: Sandwich panel; Composite structure; Joints; Numerical model; Mechanical strength.

Introduction:

In recent years, the usage of sandwich composite structures is continuously increasing due to their excellent compressive and out-of-plane shear properties [1]. Also, the sandwich composite structures are widely used in various manufacturing sectors such as marine, building, aerospace, automobile industries etc [2]. The typical sandwich composite structures consist of top and bottom face sheet which covered the central core materials. Generally, the central core material is made in the shape of truss, honeycomb and foam in sandwich composites. Materials such as Nomex, Aluminium and Polypropylene are regularly used as core in sandwich composites. The face sheet materials are carbon fiber reinforced plastics (CFRP), glass fiber reinforced plastics (GFRP) and aluminium are commonly used for fabricating sandwich composite structures.

However, the sandwich composite panels are used as various structural components ships, beams, cars and so forth. Further, the structures are not only difficult to fabricate and also very expensive in computational analysis to develop the models [3-5]. This is due to large and complex shapes of honeycomb core are used to construct the panels [6, 7]. In order to eliminate these limitations, the complex shape of core materials are replaced by a same volume of simple shape without changing the orthotropic properties of the composite panels can be manufactured [8-11].

The present work developed the methodology for analysis of honeycomb sandwich composites structures using homogenization technique. It is based on the strain energy criterion to develop the model for analysis the mechanical properties. Additionally, the sandwich structures consist of face sheet and hexagonal core were used for manufacturing composite panels. Also the model was developed for predicting the failure strength of different joints in sandwich composite panels [6, 8]. Moreover, the simple equivalent volume of core was used for finite element analysis. A single equivalent representative cell was considered for analysis to compute the effective elastic orthotropic properties [9]. Hence, the single element which repeats itself on the direction of in-plane and the elastic properties were obtained based on the single cell with equivalent volume [10]. The similar methodology was used for the analysis of sandwich beam. Four-point and three-point tests were simulated using 2D finite element analysis. Finally, the experimental and simulation results were validated for the failure strength in various joints of sandwich composite structures.

Modelling of sandwich panel

The composite sandwich panel is modelled by using CATIA software, the top and bottom panels are fully closed and inside the sandwich panel honeycomb structure is fixed the adhesive joints layer is modelled in-between the panels, for welded joints, welding part is modelled in top and bottom and for bolded joints are shown in Figs.1 and 2. The maximum deformation, stress, strain and impact strength of the aluminium honeycomb composite structures are shown in Figs. 3 to 14.

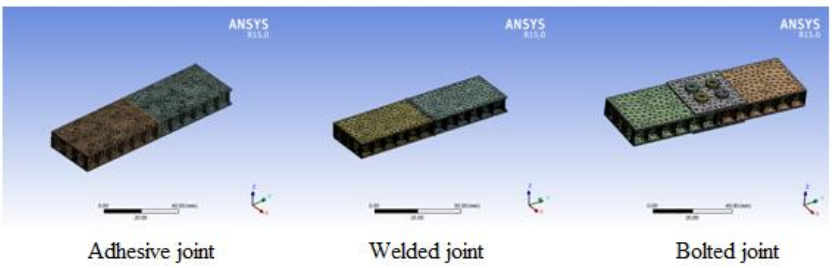


Fig.1: Different type of designed butt joints

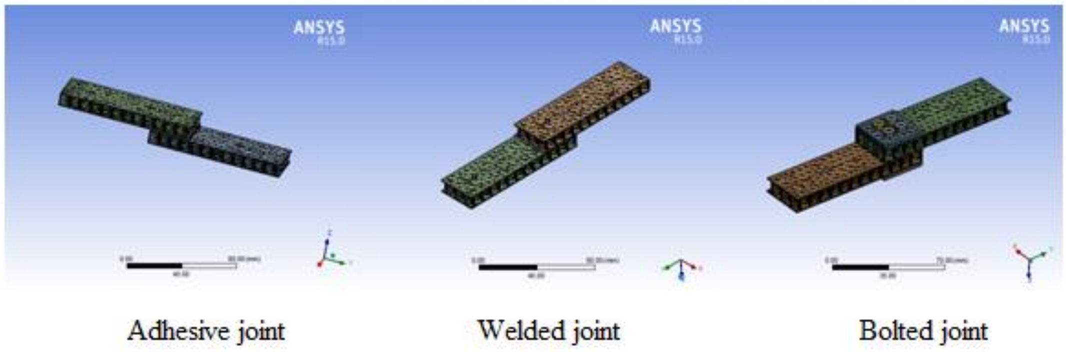


Fig.2: Different type of designed lap joints

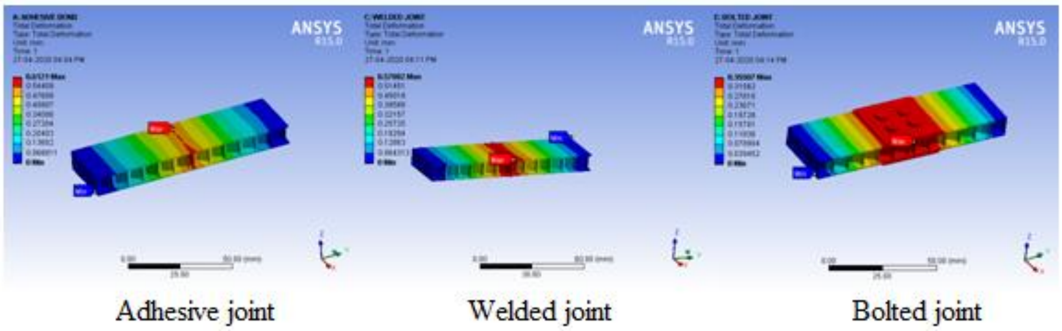


Fig.3: Analysis of deformation in different butt joints

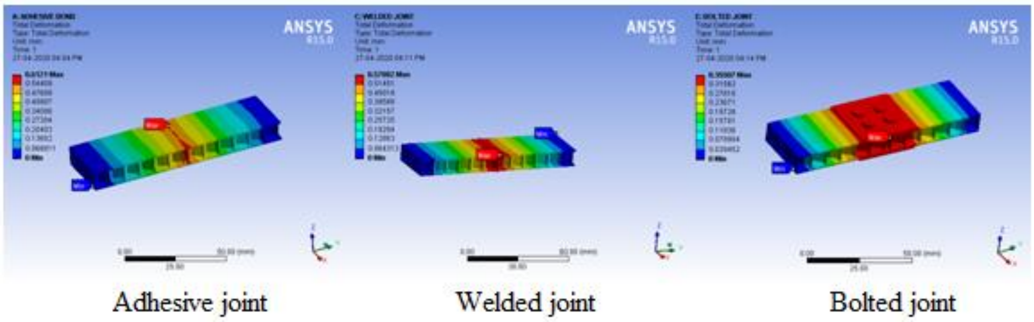


Fig.4: Analysis of deformation in different lap joints

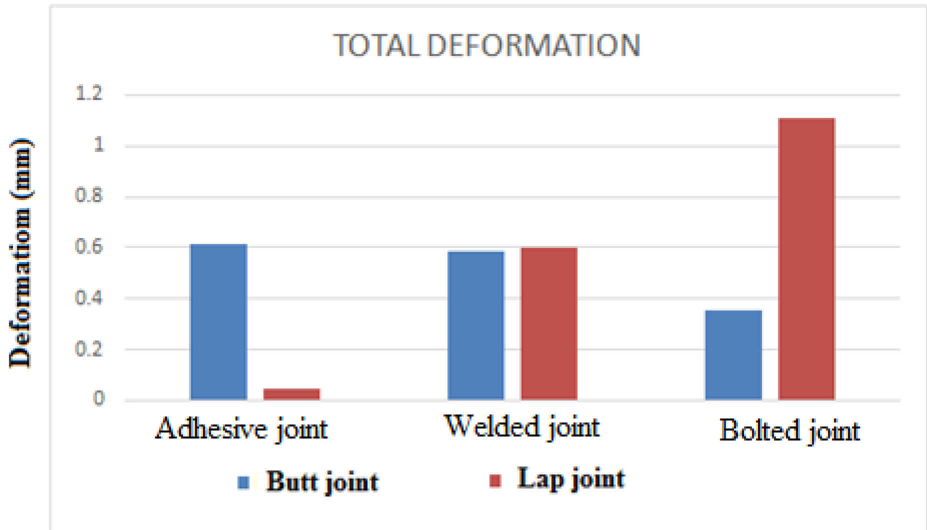


Fig.5: Comparison of deformation in various joints of aluminum honeycomb composite panels

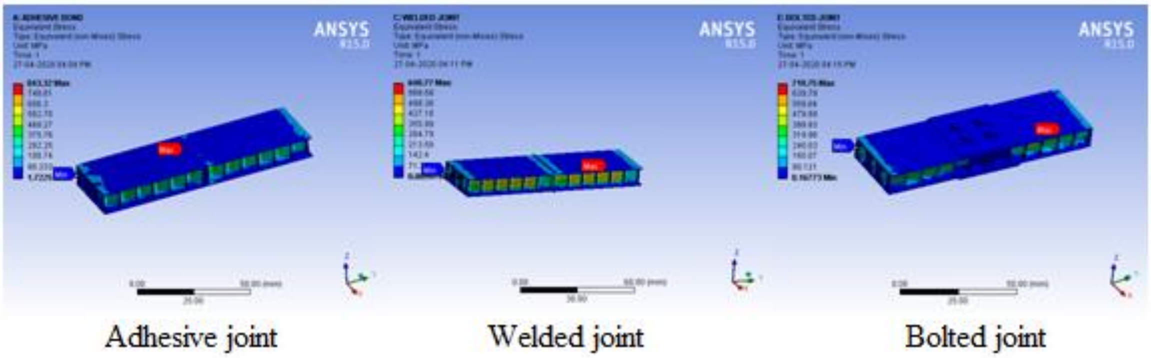


Fig.6: Stress analysis of different butt joints

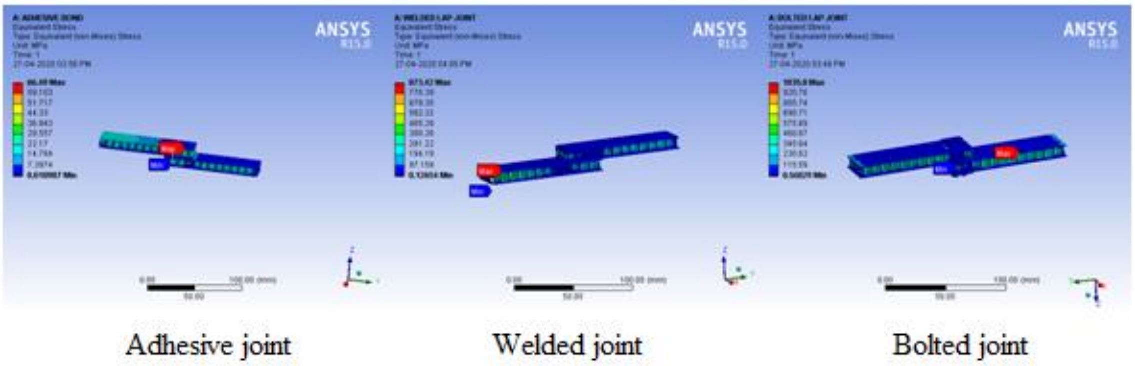


Fig.7: Stress analysis of different lap joints

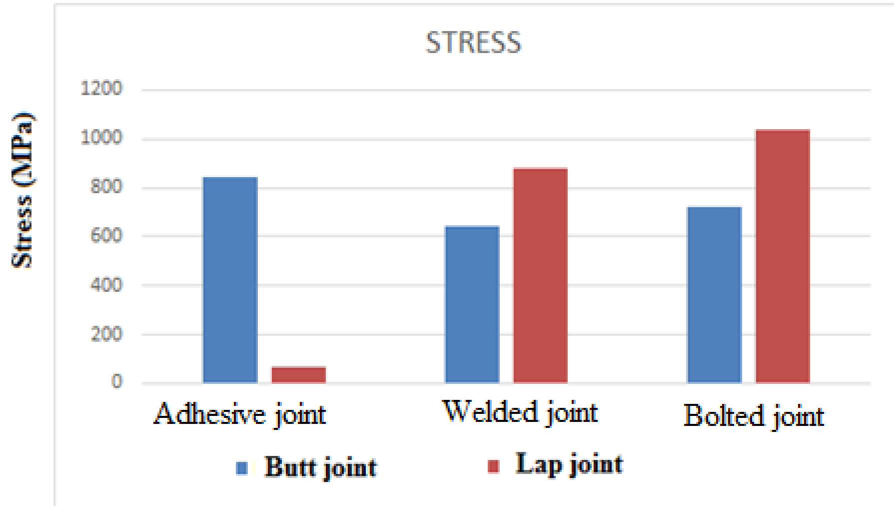


Fig.8: Comparison of stress in various joints of aluminum honeycomb composite panels

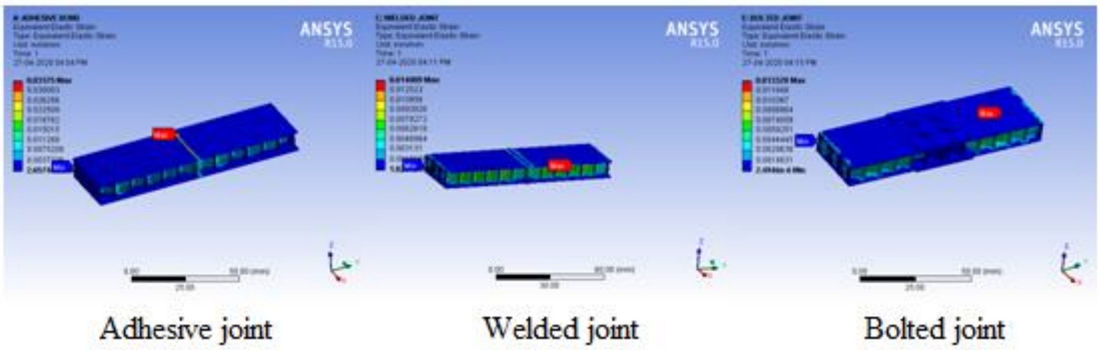
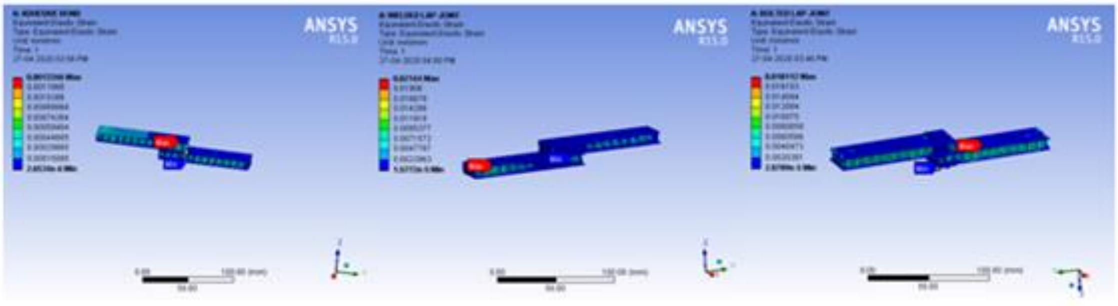


Fig.9: Strain analysis of different butt joints



Adhesive joint Welded joint Bolted joint

Fig.7: Strain analysis of different lap joints

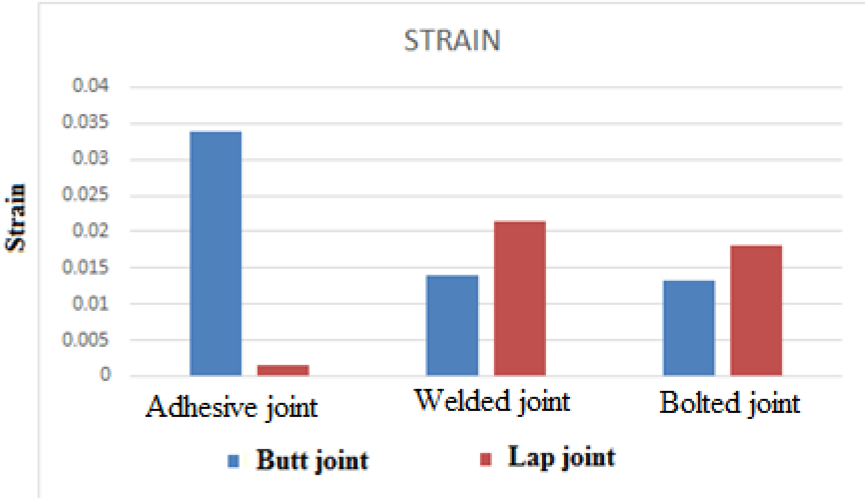
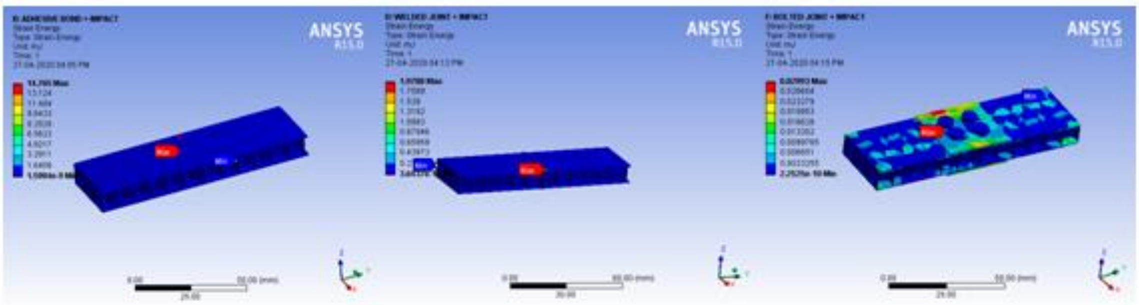
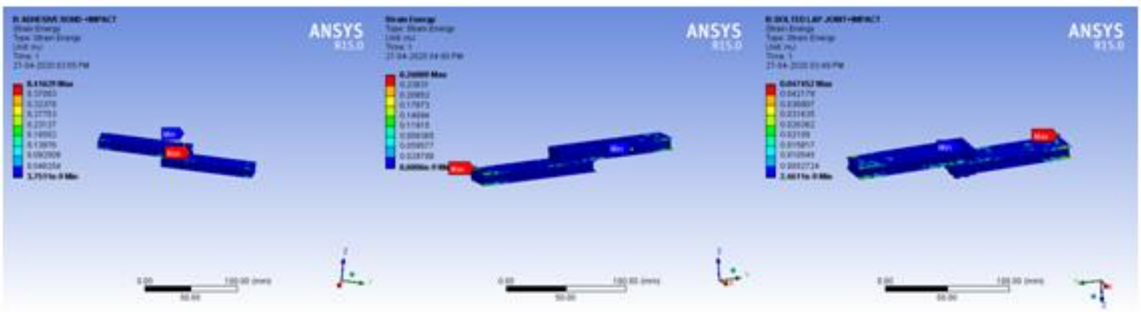


Fig.11: Comparison of strain in various joints of aluminum honeycomb composite panels



Adhesive joint Welded joint Bolted joint

Fig.12: Impact analysis of different butt joints



Adhesive joint Welded joint Bolted joint

Fig.13: Impact analysis of different lap joints

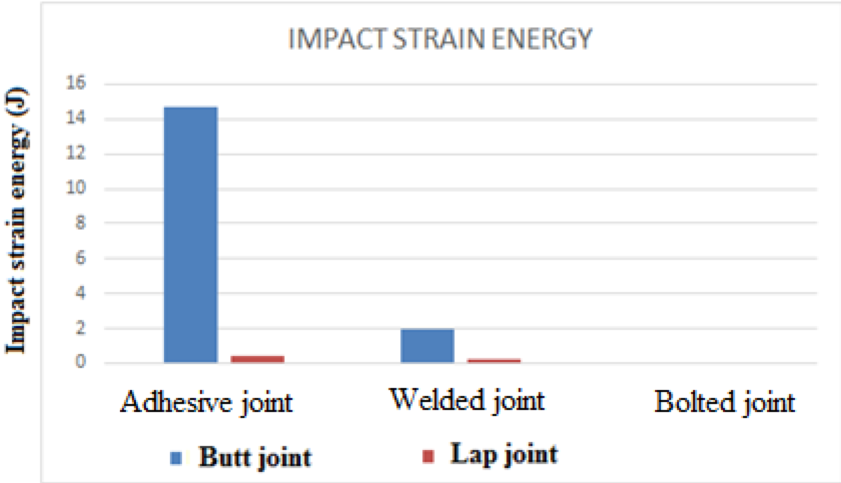


Fig.14: Comparison of impact energy absorption in various joints of aluminum honeycomb sandwich composite panels

Conclusion

The structural analysis of the sandwich panel composite material with various joints of lap joint and butt joints was performed using ANSYS workbench software. Aluminium honeycomb sandwich composite panels are fixed with different joints like adhesive, bolted and welded are subjected to static and dynamic load. The results such as total deformation, stress, strain and impact strain energy are compared for all joints. Higher impact strength and lower impact energy absorption was observed for bonded and bolted joints. Finally, this study concluded that the bonded and bolted joints can be used for making the joints in sandwich composite panels.

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