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Research Article

Application of RSM in Design Improvement of Honeycomb Sandwich Panel

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Abstract

The honeycomb structure shape and size have significant effect on its structural characteristics. The objective of current research is to evaluate the structural response of honeycomb structure under impact loading conditions using techniques of Finite Element Analysis. The impact analysis of honeycomb structure is conducted using ANSYS explicit dynamics. The equivalent stress distribution varies with impact velocity of the bullet. The maximum equivalent stress is obtained at the inner center region of honeycomb structure. The honeycomb structure enables to reduce the velocity of bullet significantly.

Keywords: *Sandwich honeycomb, impact analysis, explicit dynamics*

1. Introduction

Honeycomb structures can be manmade or naturally present in the nature. In natural form it is seen in honeybee homes. The industrial use of honeycomb structure involves marine, aerospace and industrial applications. The general hexagonal type honeycomb structure is shown in figure 1. The honeycomb structure enables to significantly reduce the weight of the structure and material requirement.

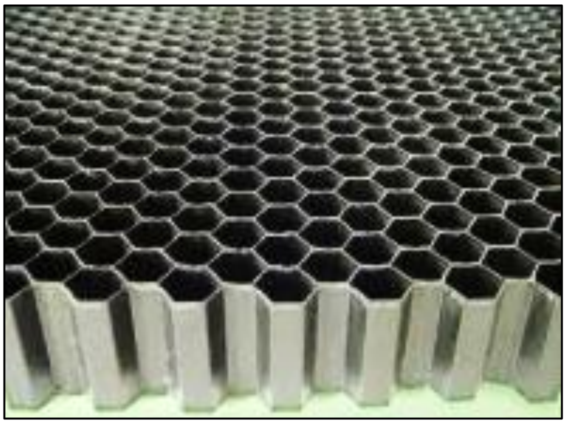

Figure 1: Honeycomb structure

The honeycomb structure encompasses array of cell structures which may be of hexagonal shape, octagonal shape and this structure is placed between two horizontal flat plates. This shape enables to absorb the impact energy. A "honeycomb shaped structure provides a material with minimal density and relatively high out-of-plane compression properties and out-of-plane shear properties. Man-made honeycomb structural materials are commonly made by layering a honeycomb material between two thin layers that provide strength in tension" [1,2,3].

2. Literature Review

Song *et. al.* [4] have presented analytical model on the energy absorption characteristics of honeycomb structure. The analytical model presented are based on buckling of plates which didn't considered nonlinear effect. However, the analytical model presented is on pure shear behaviour.

Camata *et al.* [5] have presented FEA investigation on aluminium material honeycomb structure to evaluate its orthotropic behaviour. The analysis is conducted considering initial imperfections on honeycomb structure. From the FEA analysis, the critical buckling load and stiffness is evaluated.

Bianchi *et al.* [6] have presented a nonlinear FEA analysis on honeycomb structure. The analysis presented shear behaviour of honeycomb structure which was in close agreement with experimental results.

3. Objective

The objective of current research is to evaluate the structural response of honeycomb structure under impact loading conditions using techniques of Finite

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Element Analysis. The impact analysis of honeycomb structure is conducted using ANSYS explicit dynamics.

4. Methodology

The explicit dynamic analysis process involves different stages i.e. CAD modeling, meshing, boundary condition and solution stage. The modeling process involves creation of honeycomb structure with plates and bullet as shown in figure 2.

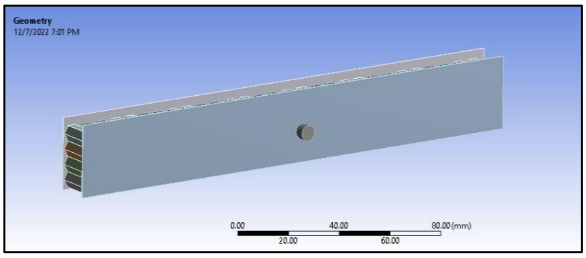

Figure 2: CAD modeling of honeycomb structure

The model of honeycomb structure is discretized using combination of hexahedral and brick elements. The model is meshed with fine relevance and growth rate of 1.2 along with normal inflation.

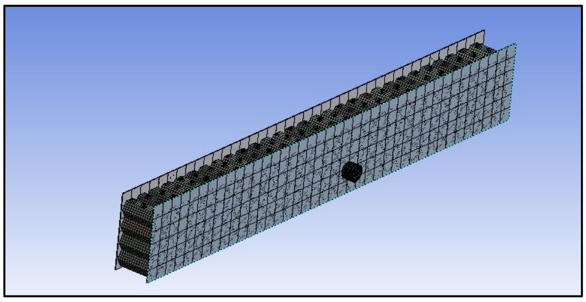

Figure 3: Meshed model of honeycomb structure

The model of honeycomb structure is applied with explicit dynamic conditions which include applying fixed support along with initial velocity to the bullet. The applied explicit boundary conditions are shown in figure 4.

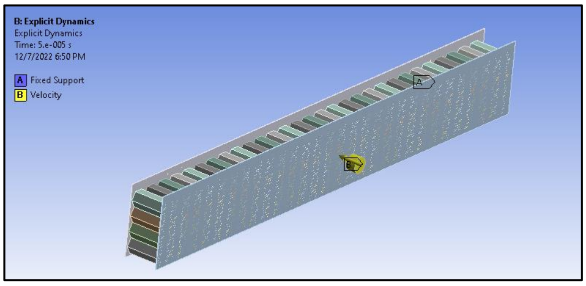

Figure 4: Impact boundary conditions

After applying specified boundary conditions, the solver is run. The solver running process involves setting up solver type, formulation of element stiffness matrix and determination of results for each node.

5. Results and Discussion

From the explicit dynamic analysis, the equivalent elastic strain and equivalent stress is determined at different time intervals. As the bullet pierces through the honeycomb structure, the equivalent stress induces at the zone of impact.

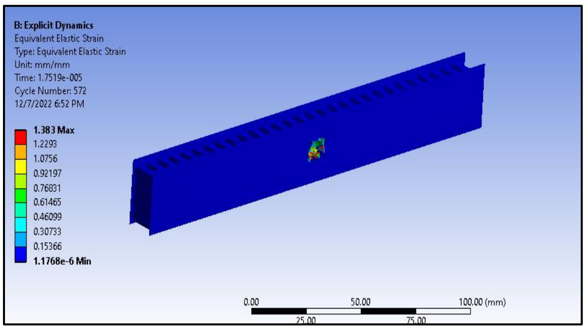

Figure 5: Equivalent elastic strain at .0000175secs

The equivalent elastic strain at .0000175secs is higher at the center of honeycomb structure with magnitude of more than 1.0756mm/mm. The elastic strain reduces along other zones of honeycomb structure.

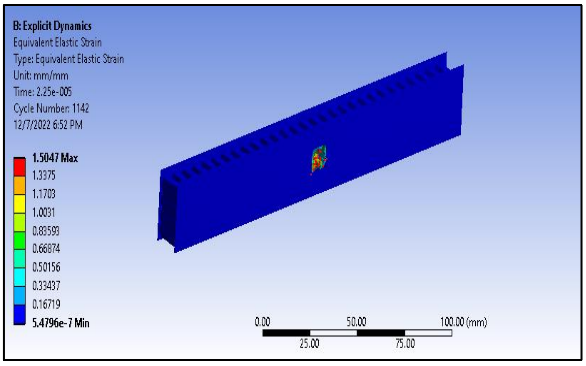

Figure 6: Equivalent elastic strain at .0000225secs

The equivalent elastic strain at .0000225secs is higher at the center of honeycomb structure with magnitude of more than 1.337mm/mm. The elastic strain reduces along other zones of honeycomb structure.

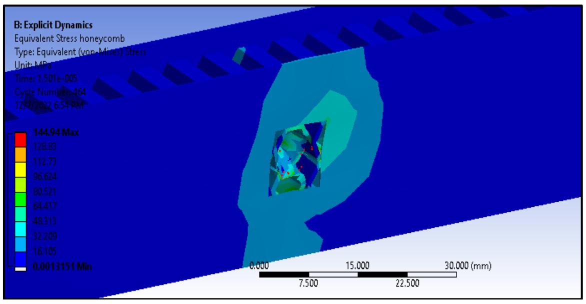

Figure 7: Equivalent stress at .0000150secs

The equivalent stress distribution plot is obtained for honeycomb structure at different time intervals. The equivalent stress is observed to be higher at the center and nearby zones of honeycomb structure as shown in light green and red colored regions.

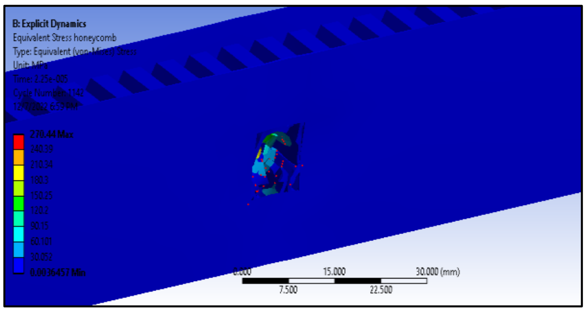

Figure 8: Equivalent stress at .0000225secs

The equivalent stress at .0000225secs shows higher stress at the inner regions of hole created due to piercing of bullet. The equivalent stress obtained is more than 240.3MPa.

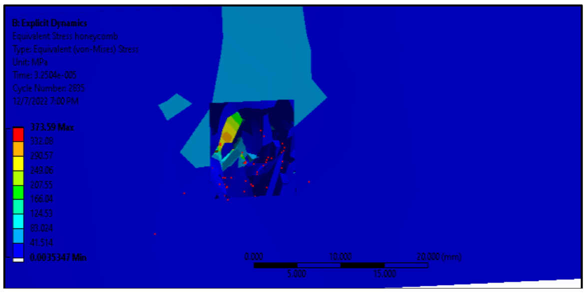

Figure 9: Equivalent stress at .0000325secs

The equivalent stress at .0000325secs shows higher stress at the inner regions of hole created due to piercing of bullet. The equivalent stress obtained is more than 290.57MPa.

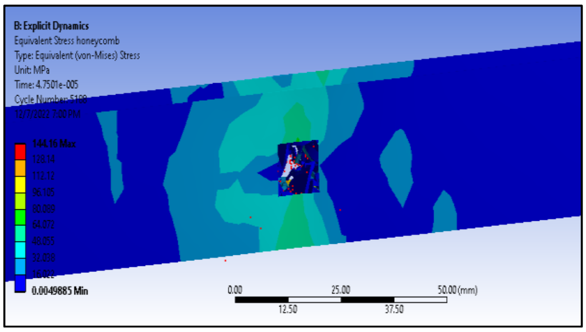

Figure 10: Equivalent stress at .0000475secs

The equivalent stress at .0000475secs shows higher stress at the inner regions of hole created due to piercing of bullet. The equivalent stress obtained is more than 128.14MPa. At this time the bullet pierces out of the honeycomb structure.

Conclusion

The structural characteristics of honeycomb structure is conducted to determine critical regions of high stresses and deformation. The equivalent stress distribution varies with impact velocity of the bullet. The maximum equivalent stress is obtained at the inner center region of honeycomb structure. The honeycomb structure enables to reduce the velocity of bullet significantly.

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