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Dynamic Analysis of Honeycomb Structure using MMC

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Abstract: The sandwich composite structures are used in various applications which demands high energy absorption characteristics. The objective of current research is to evaluate the energy absorption characteristics of honeycomb structure using explicit dynamics. The CAD modelling and explicit dynamic analysis of honeycomb structure is conducted in ANSYS simulation software. The energy absorption characteristics, deformation characteristics and equivalent stress characteristics are evaluated. The use of honeycomb structures enabled to reduce the kinetic energy of bullet significantly. The maximum equivalent stress is observed at the zone of bullet impact and at the vicinity of this zone.

***IndexTerms* – Sandwich honeycomb, impact analysis, explicit dynamics**

I. INTRODUCTION

Honeycomb structures are a lattice of hollow, thin-walled cells with relatively high compression and shear properties out-of-plane while boasting a low density. Honeycomb structures are a lattice of hollow, thin-walled cells with relatively high compression and shear properties out-of-plane while boasting a low density.

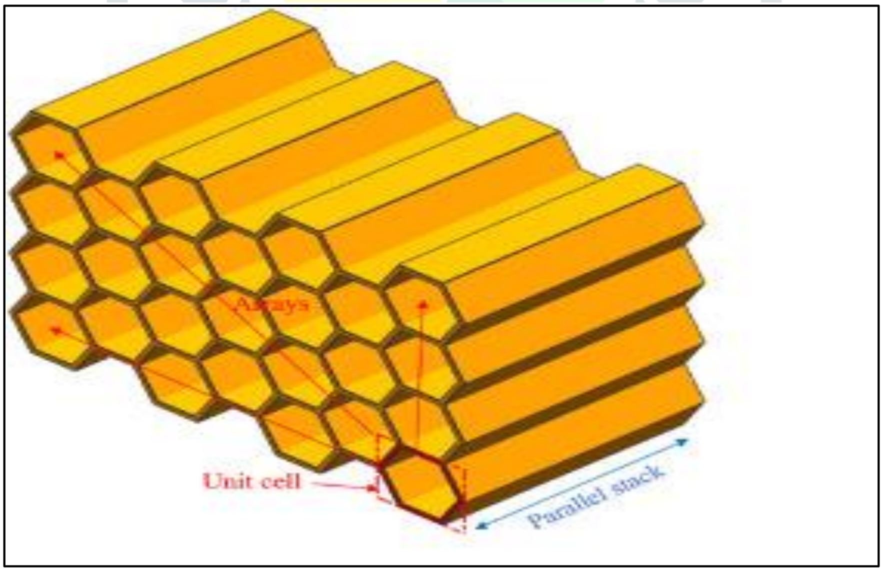

Figure 1: Honeycomb lattice structure

The "behaviour of thin walled structures such as tubes of different material and cross sections, honeycomb core with the different cross-section, lattice structure and foams of metal and non-metals have been studied due to their high strength to weight ratio and high stiffness" [1–7].

II. LITERATURE REVIEW

Mcfarland et. al. [8] have conducted experimental evaluation on crushing stress of hexagonal cell structures. The analytical model pertaining to shear deformation, energy absorption is presented. The crushing stress of hexagonal cell structures, trapezoidal cell structures at different loads are evaluated.

Wierzbicki et. al. [9] have presented an analytical model to determine crushing strength and plasticity behavior of honeycomb structure. The model studied included Y shaped unit cell and formula for energy absorption is presented with respect to cell wall thickness "t" and cell width "t". The model is named as "Mcfarland" type.

Liaghat et al. [10,11] have conducted experimental investigation on honeycomb structure elements. The elements type investigated is "folding" type. The effect of honeycomb cell angle on panel plasticity behaviour and energy absorption behaviour is investigated. The research findings have shown that cell angle of 120^0 is best for honeycomb panel applications.

Yin et al. [12] have conducted experimental investigation on honeycomb panel structure to evaluate mean crushing force. The crushing force is evaluated using folding mechanism into two different folding modes. The research findings have shown that Y shaped lattice cell have best crushing force absorption characteristics.

Gibson et al. [13–15] have conducted experimental investigation on cell geometry of honeycomb structure. The buckling behaviour, energy absorption behaviour of honeycomb structures are evaluated. The research findings have shown that cell angle of 65^0 is best for higher energy absorption characteristics.

III. OBJECTIVES

The objective of current research is to evaluate the energy absorption characteristics of honeycomb structure using explicit dynamics. The CAD modelling and explicit dynamic analysis of honeycomb structure is conducted in ANSYS simulation software.

IV. METHODOLOGY

The methodology steps encompass 3 different stages i.e. pre-processing, solution and post-processing stage. In pre-processing stage, the CAD model of honeycomb lattice structure is developed in ANSYS design modeler.

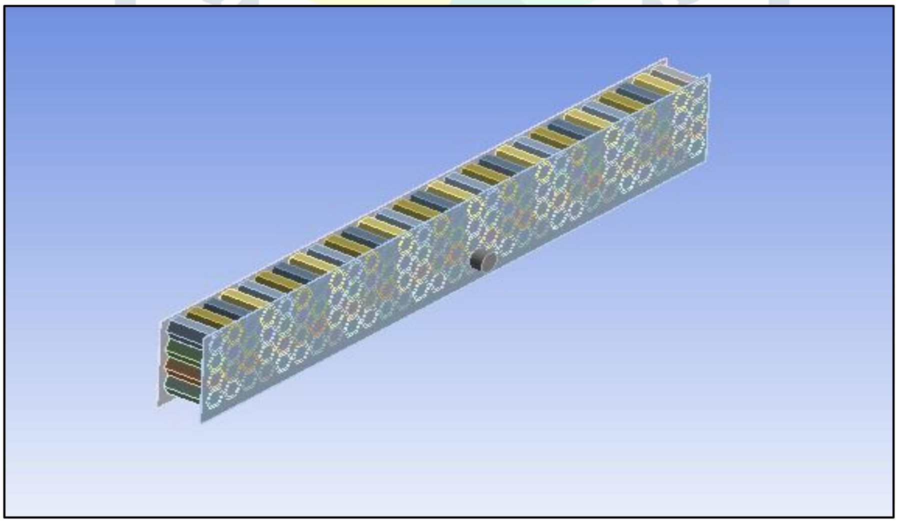

Figure 2: CAD design of honeycomb structure

The honeycomb structure is checked for geometric errors like surface imperfections, hard edges etc. The mode of honeycomb structure is then meshed with both hexahedral and tetrahedral element type. The meshed model of honeycomb structure is shown in figure 3.

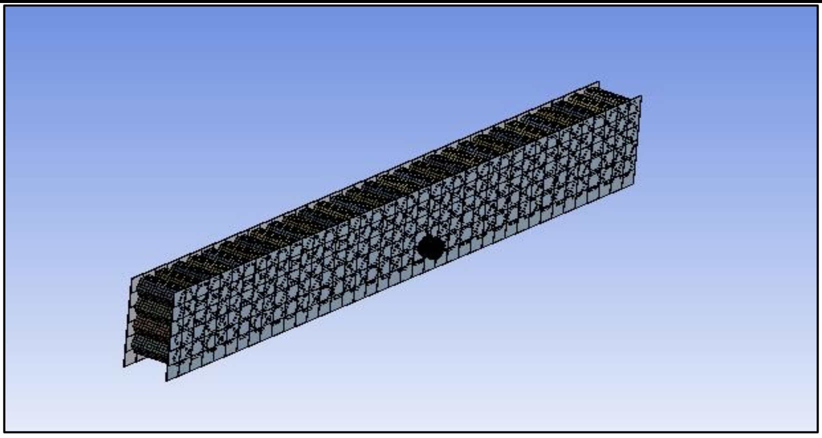

Figure 3: Meshed model of honeycomb structure

The meshing of honeycomb structure involves setting of relevance, growth rate and inflation. The growth rate for meshing is set to 1.2, inflation set to normal and relevance set to fine type.

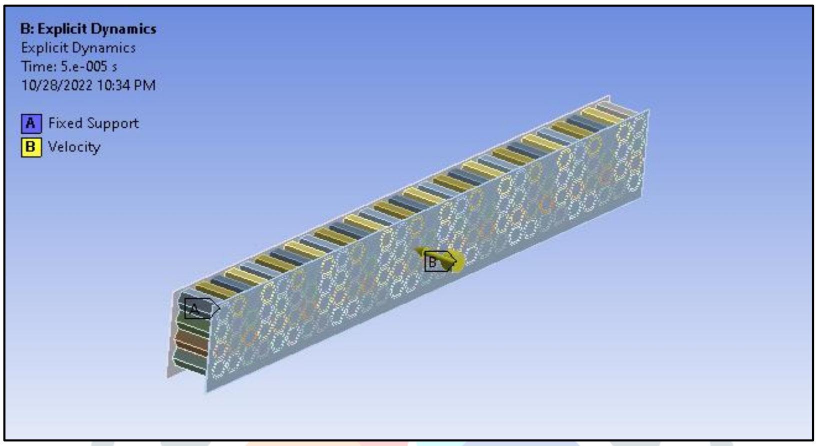

Figure 4: Loads and boundary conditions

The boundary conditions are defined for honeycomb structure as shown in figure 4 above. The boundary conditions involve applying fixed support at the rear end of honeycomb structure and bullet is applied with initial velocity. The bullet penetrates the honeycomb structure and honeycomb structure reduces energy of bullet.

VI. RESULTS AND DISCUSSION

After running explicit dynamic analysis, the contour plots of deformation are obtained. As the bullet penetrates the honeycomb structure, the kinetic energy of bullet reduces and is absorbed by honeycomb structure.

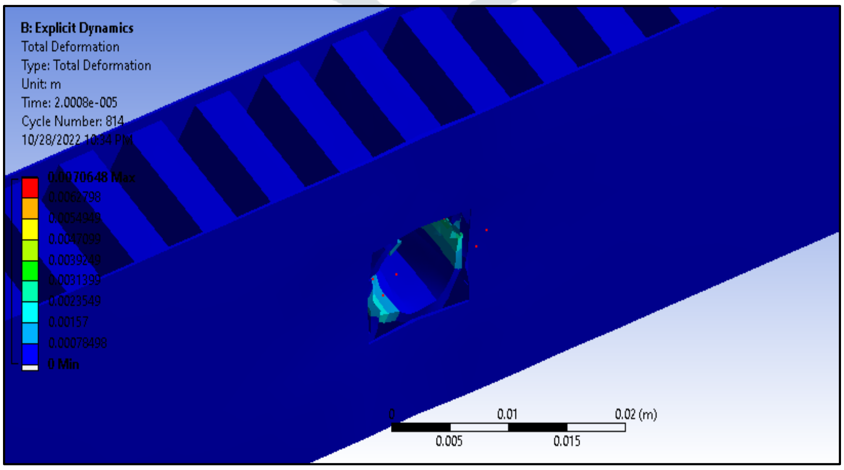

Figure 5: Total deformation at .00002secs

The deformation obtained for honeycomb structure at .00002secs is .0070648m. The deformation at other region of honeycomb structure remains unaffected.

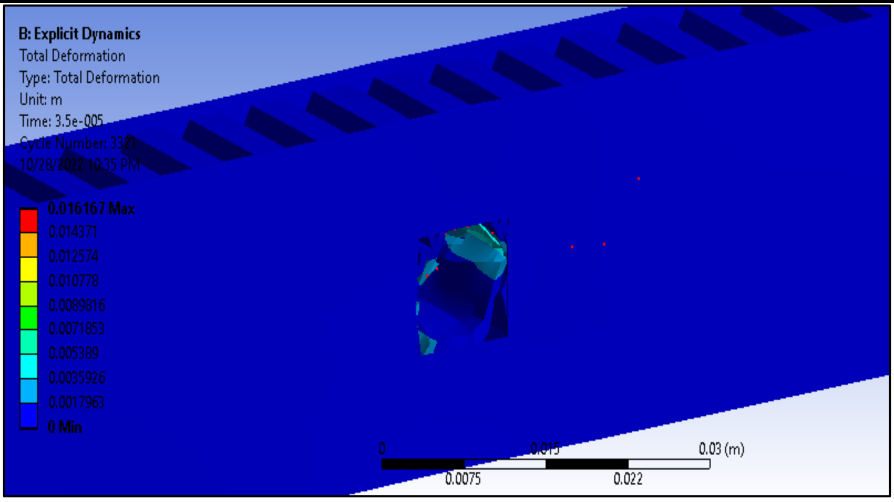

Figure 6: Total deformation at .000035secs

The total deformation plot is obtained for .000035secs. The deformation obtained for honeycomb structure is .016167m which is at the center of honeycomb structure. The deformation at other locations is almost uniform.

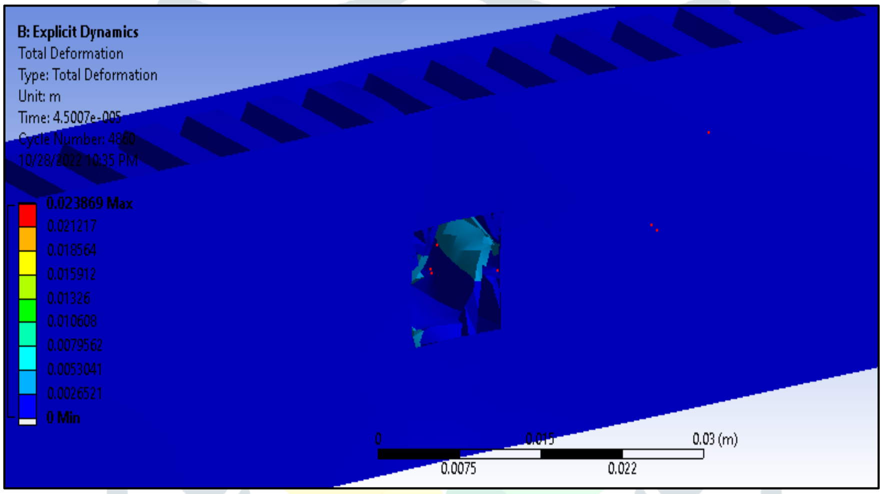

Figure 7: Total deformation at .000045secs

The total deformation of .000045secs is shown in figure 7 above. The maximum deformation is obtained at the center of honeycomb structure wherein the deformation is more than .023869mm. The deformation at other zones are almost negligible.

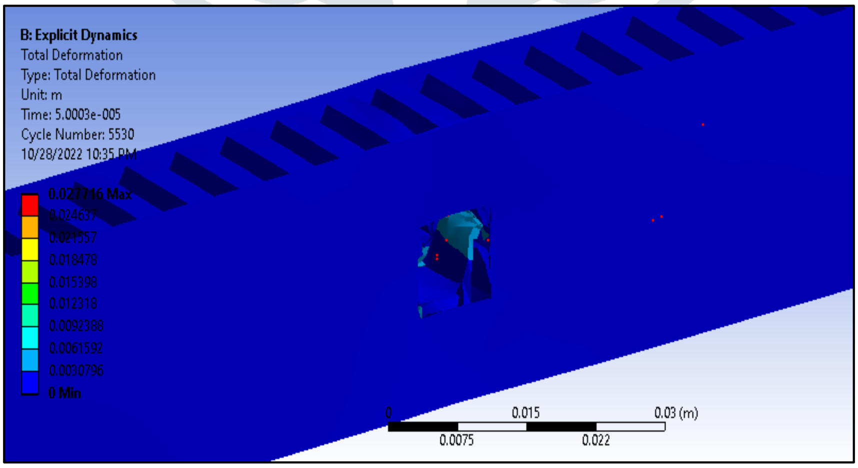

Figure 8: Total deformation at .00005

The total deformation of .00005secs is shown in figure 8 above. The maximum deformation is obtained at the center of honeycomb structure wherein the deformation is more than .027716mm. The deformation at other zones are almost negligible.

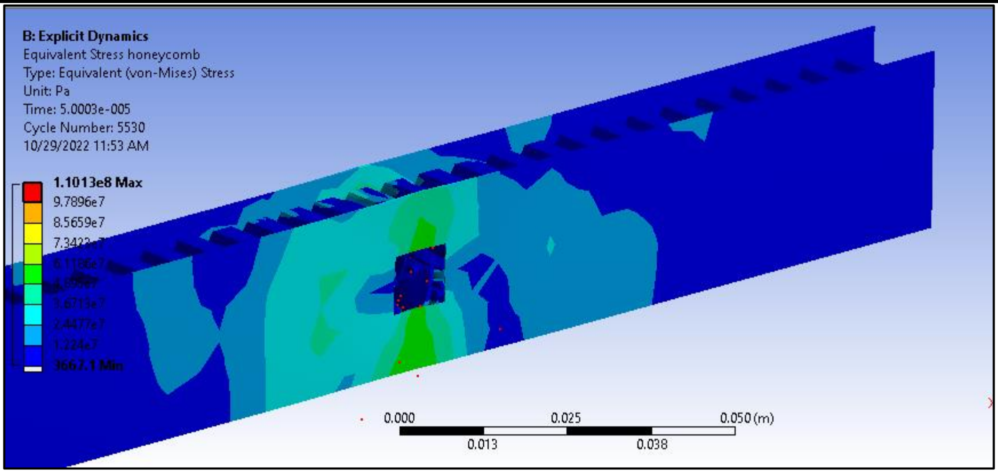

Figure 9: Equivalent stress distribution plot

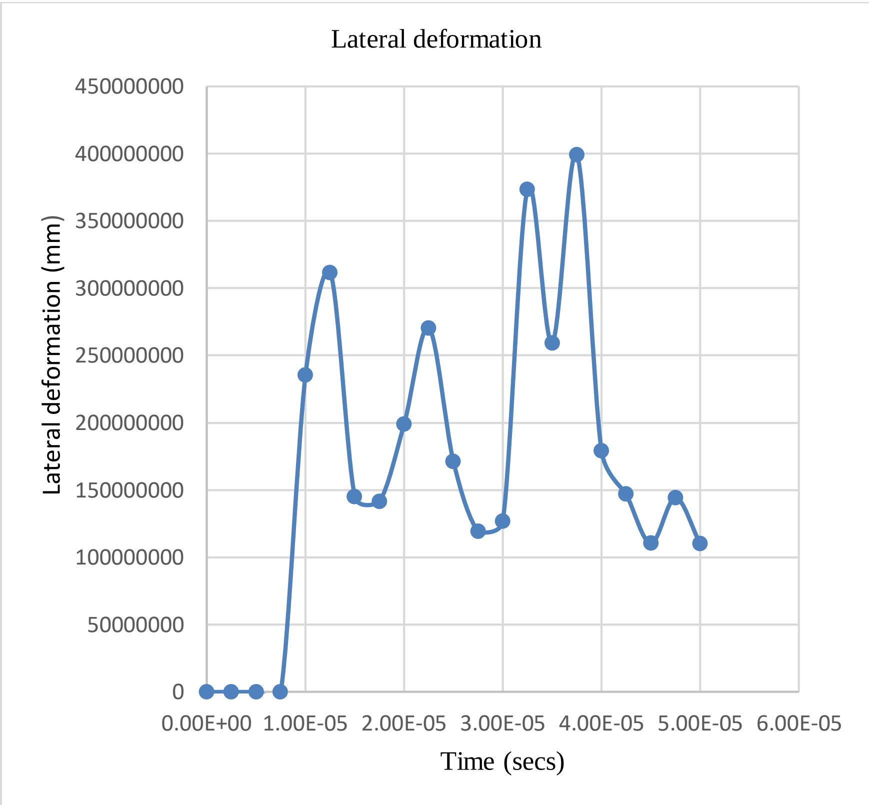

Figure 10: Equivalent stress curve w.r.t time

The equivalent stress is evaluated for honeycomb structure at different time intervals. The equivalent stress is maximum at the zone of bullet impingement. The equivalent stress value doesn't show uniform trend and varies gradually with time. The maximum equivalent stress is observed at .00004secs and then reduces gradually.

VII. CONCLUSION

The explicit dynamic analysis enabled to determine the energy absorption characteristics of honeycomb structure. The energy absorption characteristics, deformation characteristics and equivalent stress characteristics are evaluated. The use of honeycomb structures enabled to reduce the kinetic energy of bullet significantly. The maximum equivalent stress is observed at the zone of bullet impact and at the vicinity of this zone.

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