Metallic Sandwich Panels Subjected to Multiple Shocks and Combined Shock/Projectile Impact

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Introduction

There is an increasing demand in developing structures that can withstand extreme loadings including shocks and projectile impact that can be generated due to explosions and blast. For evaluating the performance of these critical structures different loading scenarios such shock loading followed by projectile impact, internal uncontrolled fire or subsequent shocks should be considered. Metal sandwich panels are shown to have superior performance compared to a solid plate of same mass under both shock and projectile loadings.

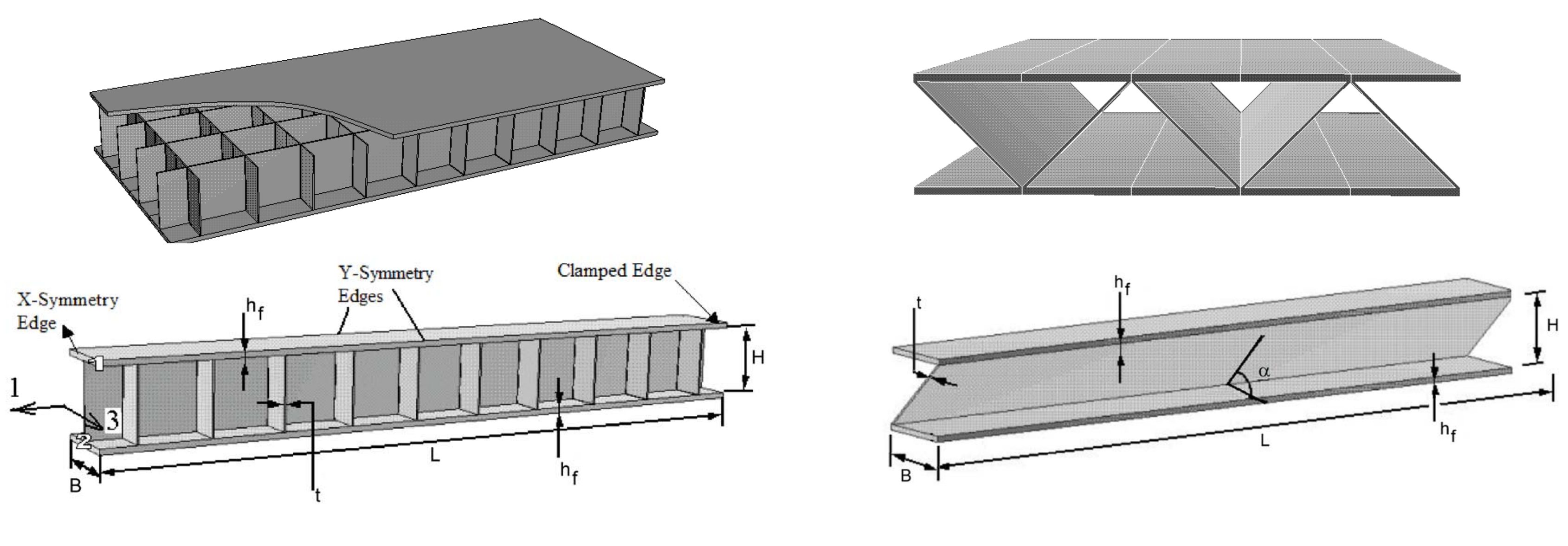

Fig 1.Schematic diagrams of metal sandwich plates configurations and the corresponding computational models for square honeycomb sandwich plate and folded sandwich plate. The width of the plates is 2L.

We specifically study the performance and failure of all metal sandwich panels with honeycomb and folded plate core under multiple shocks and combined shock/projectile impact.

Sandwich plates subjected to multiple intense shocks

In this section, detailed results on the deformation of square honeycomb and folded plate core sandwich plates are presented for plates made of HY80 steel. The shock loading was modeled as a uniform pressure history $P(t) = P_0 e^{-t/t_0}, t > 0$ that applied on the surface of top face sheet. Fig. 2 shows for normalized time between two shock greater than one response is independent of this parameter.

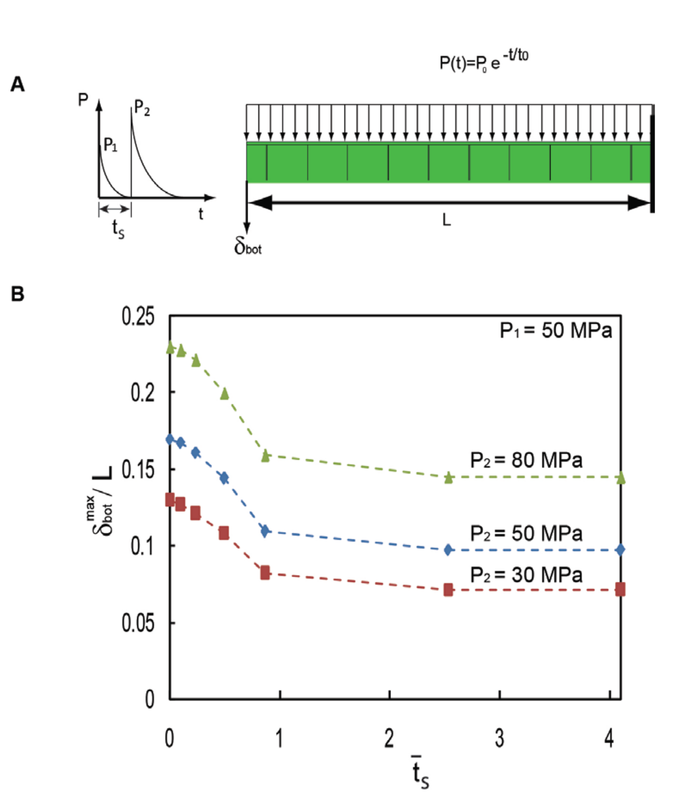

Fig. 2. (A) Schematic diagram of the half of metallic square honeycomb sandwich plate subjected to intense shock loading. (B) Normalized maximum deflection of bottom face of the square honeycomb sandwich plate with $\bar{\rho}_c = 0.04$ made of HY80 subjected to two shocks as dependent on the normalized shock time.

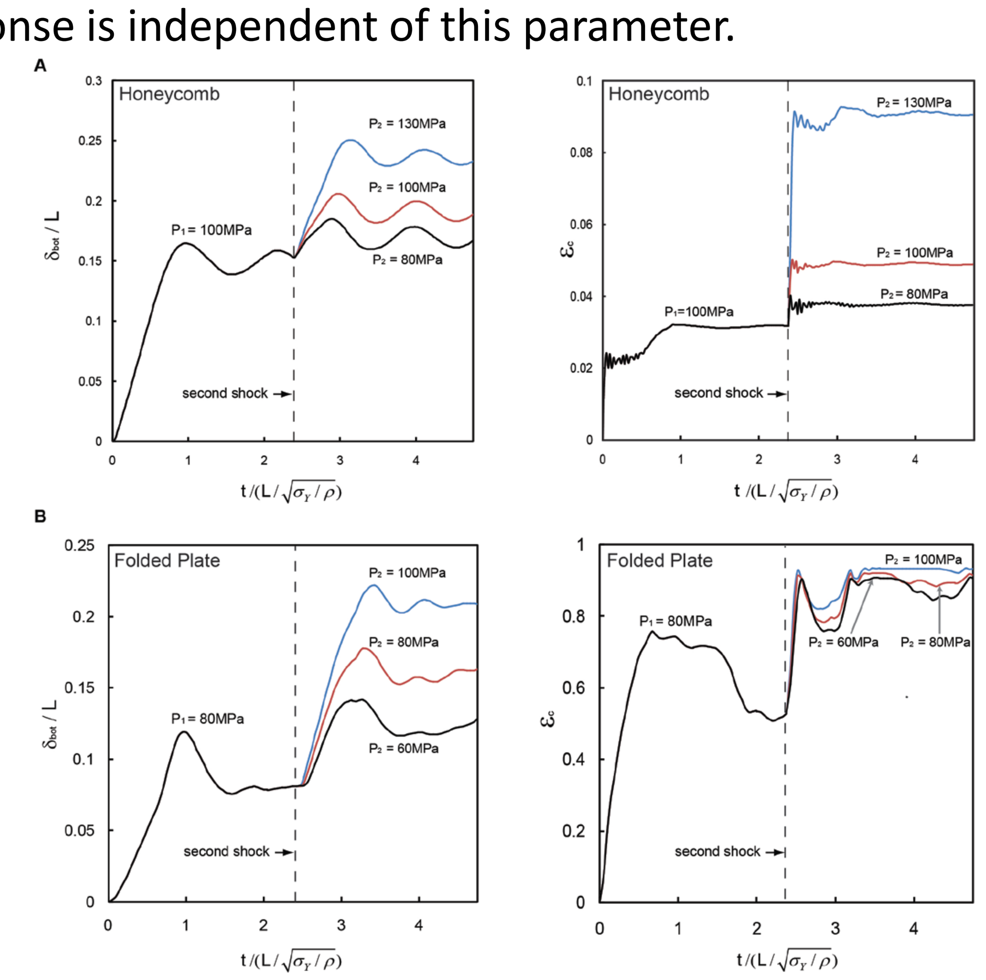

Fig 3. Normalized deflection of bottom face and crushing strain at the center of the plate of (A) the square honeycomb and (B)the folded plate sandwich panels with $\bar{\rho}_c = 0.04$ made of HY80 as a function of normalized time for three different sets of loading.

We carried out a parametric study on the effect of shock intensities on the maximum deflection and crushing strain of honeycomb core sandwich plates impinged by two consecutive shocks. Fig. 4 reveals that bottom face deflection increases approximately linearly as a function of P1 and P2, except near the point with highest peak pressure.

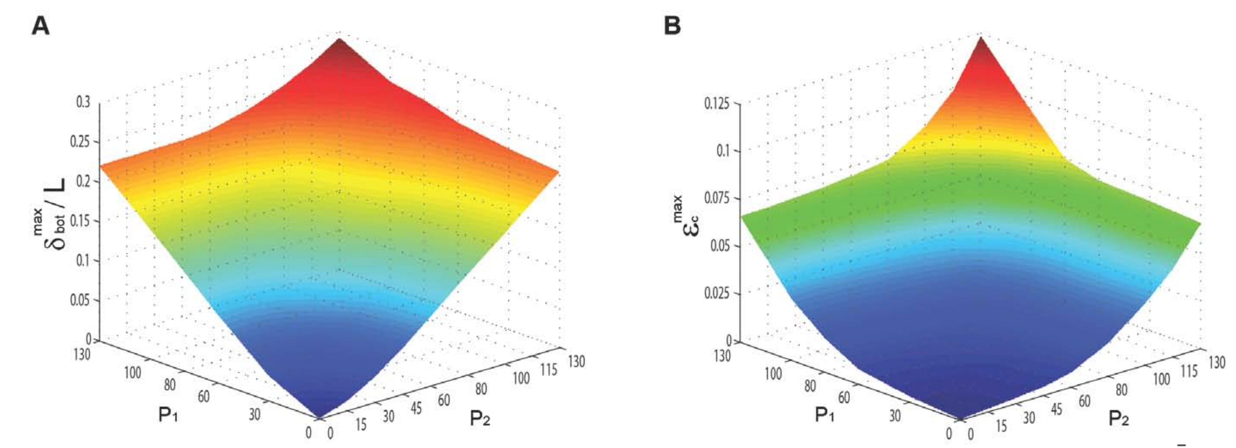

Fig 4. Normalized maximum deflection of bottom faces and maximum core crushing strain of the square honeycomb sandwich plate with $\bar{\rho}_c = 0.04$ made of HY80 subjected to two shocks as a function of over-peak pressures.

In optimizing the structural designs against shock loading, it is generally desirable to achieve superior performance (i.e. minimum deflection and fracture) at a constant mass. Simulations carried out on honeycomb core sandwich plate reveal that in relative density 4% to 5% it shows minimum deflection due multiple shock loading.

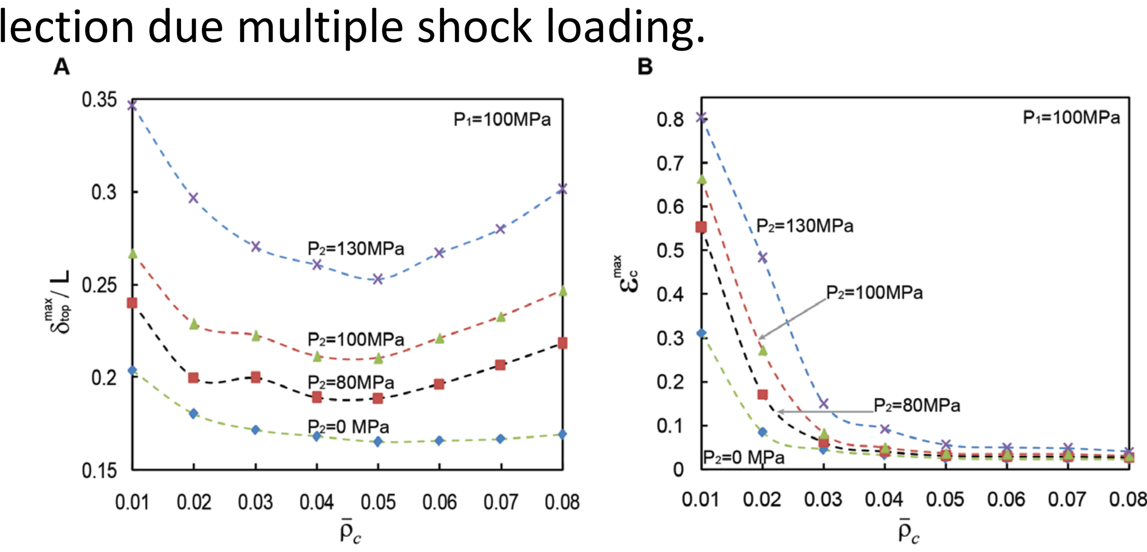

Fig 5. Normalized maximum deflection of top face and maximum core crushing strain of the square honeycomb core sandwich plate made of HY80 subjected to two shocks as dependent on the relative density of the core. Peak over-pressure of first shock is same for all four sets of loading.

Failure modes of honeycomb sandwich plate were also investigated under one, two and three consecutive shocks. Because fracture data on HY80 was not available, simulations are performed for three critical fracture strain assumed for this steel just to illustrate the role of ductility of HY80.

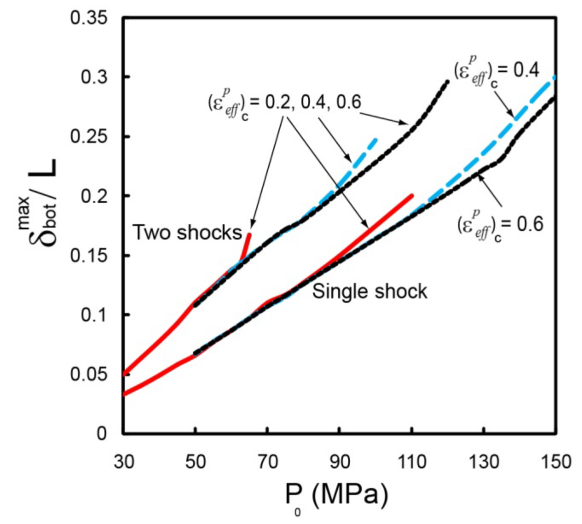

Fig 8. Maximum normalized deflection of bottom face of the square honeycomb sandwich plate made of HY80 after first and second shocks as a function of peak over-pressure for three critical fracture strain.

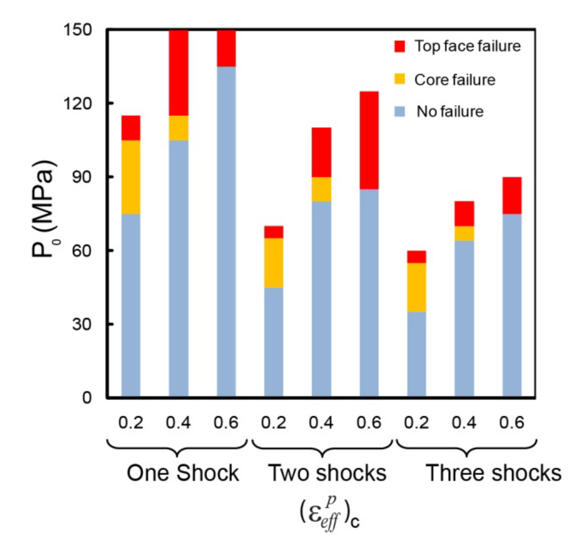

Fig 9. The failure map for HY80 square honeycomb plate subjected to one, two and three shocks as dependant on the critical effective plastic strain at fracture.

Sandwich plates subjected to combined shock/projectile impact

In this section results for combined shock/projectile impact loading are presented for honeycomb core sandwich plate made of AH36 . The below figure shows the sandwich plate response for four set of loading and also final deformed shape.

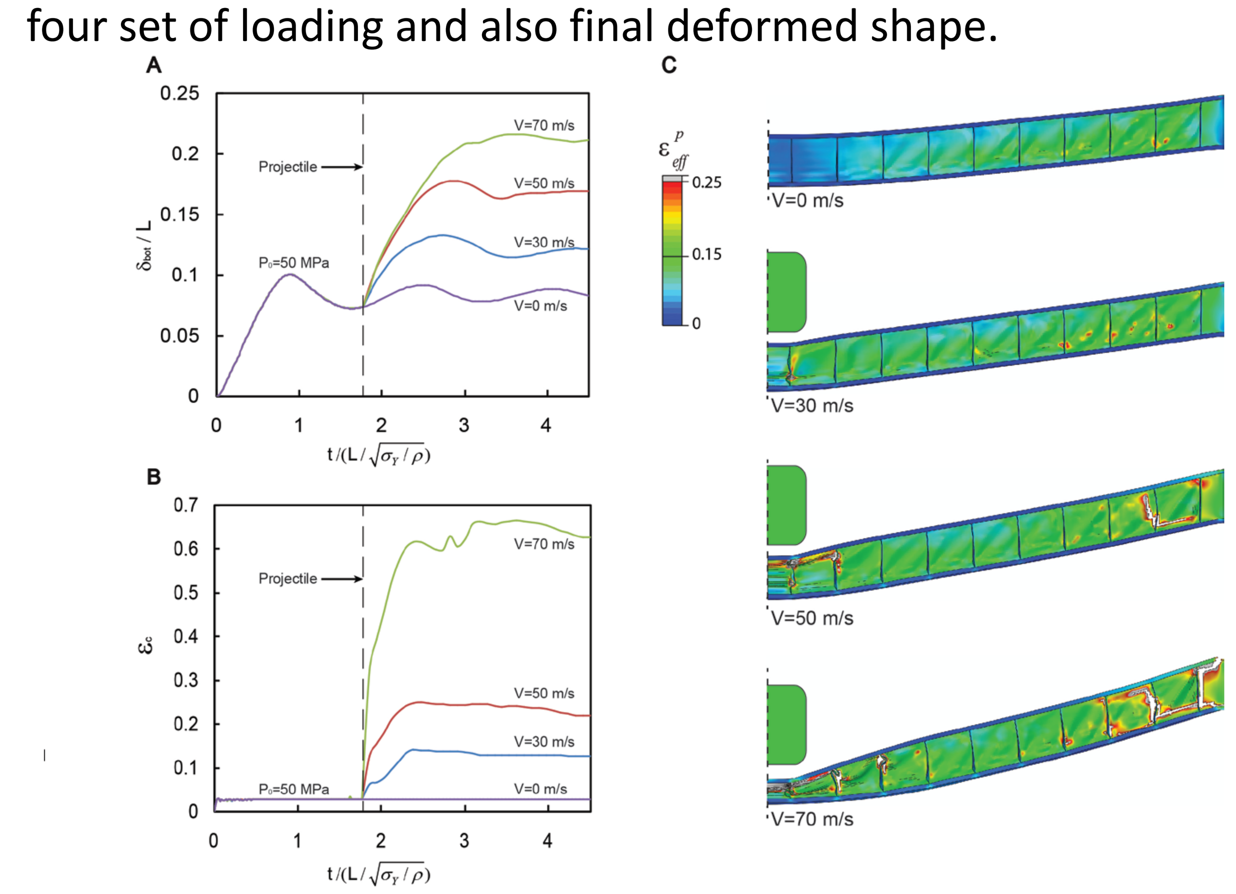

Fig 10. A) Normalized deflection of bottom face and (B)crushing strain at the center of the square honeycomb with $\bar{\rho}_c$=0.04 made of AH36 under combined loading and (C) Schematic view of final deformed profile of square honeycomb sandwich plate for each of four loading sets.

Failure map of honeycomb sandwich plate is constructed for different core relative density and velocity of projectile while the peak over-pressure of shock remains constant.

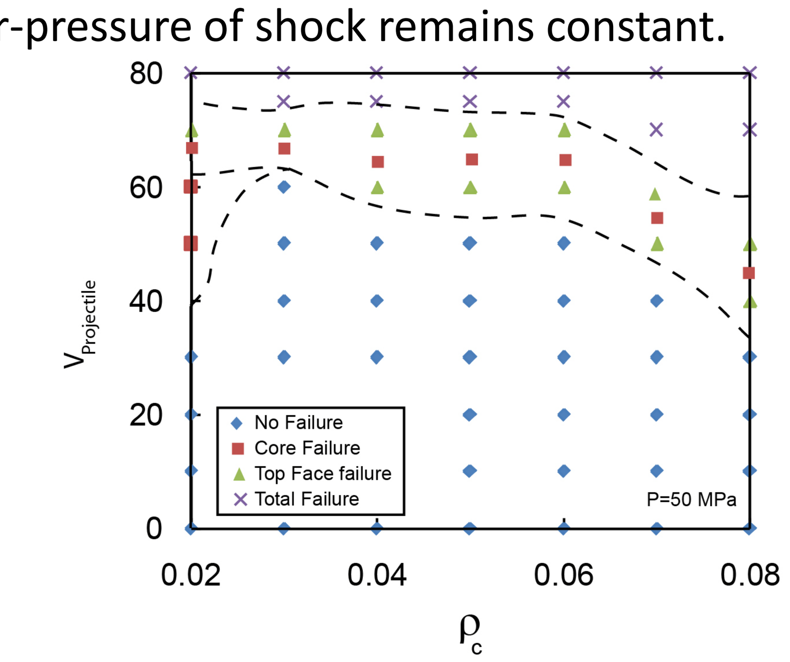

Fig 11. Failure map of square honeycomb core sandwich plate under combined shock/projectile impact made of AH36 with $\bar{\rho}_c$ =0.04. In all simulations P = 50 MPa remains constant.

Conclusion

This work has emphasized fractures that develop in a sandwich plate subjected to a multiple shocks and combined shock/projectile impact loading and examined their extent as a function of blasts intensity. Actually It studied the residual strength and blast resistance of plate after it has been damaged by a single shock.

Acknowledgment

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