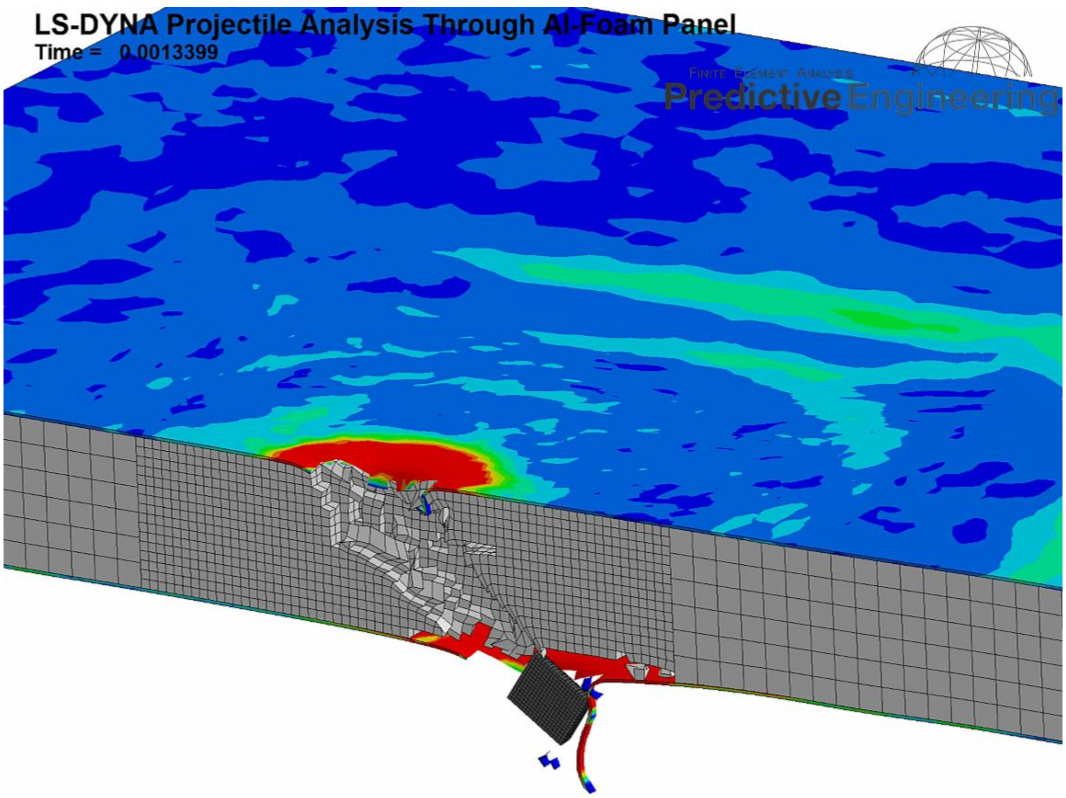
Title: LS-DYNA FEA Simulation of Projectile Penetration through Aluminum-Foam Sandwich Panel

Keywords: LS-DYNA, projectile, blast, penetration, composite sandwich structure, aluminum foam composite, nonlinear analysis, transient, dynamic, element erosion, damage prediction, contact analysis, MOTS shelter roof, trade study report, secondary mortar, rocket propelled grenade fragmentation, Trymer 400l foam, 6061-T6 aluminum, Femap, LSTC, 20mm FSP round, MIL-DTL-46593, Finite Element Analysis, Femap, Foam Material Modeling,

Main Graphic:



LS-DYNA Simulation of Projectile Penetration of Al-Foam

LS-DYNA simulation of Projectile Penetration through Sandwich Panel of Aluminum and Foam

Objective:

A projectile penetration study was conducted to assess the protective capabilities of a standard aluminum skinned foam sandwich panel. The LS-DYNA FEA simulation showed that the panel would provide more than sufficient protection against falling mortar segments. Results from this study allowed the client to avoid physical prototype testing of the final mobile electronics shelter.

Introduction: These types of panels are commonly used to create lightweight mobile shelters as shown in Figure 1. For this analysis work, a section of the panel was idealized into a plate and brick FEA model. The foam material (Trymer 400L) was modeled using brick elements and the aluminum tubes and skin were modeled using brick elements. An example of the model is given in Figure 2.

The panel was subjected to a secondary ballistic impact penetration of a grenade fragment falling at terminal velocity. The fragment is described in MIL-DTL-46593. LS-DYNA results showed that the sandwich panel's foam core absorbs significant amounts of ballistic energy. To model the foam properties, element erosion was enabled along with different tensile and compressive failure limits. This allowed the foam to compress without failure yet capture the brittle failure mode that is prevalent in polyisocyanurate foams.

The final results allowed the client to meet their design requirements without the need of experimental testing. Although this was unusual (i.e., no experimental testing) the robustness of the analysis results coupled with prior experience provided sufficient margin to proceed with manufacturing.

Figure 1: Mobile military electronics shelter built with Al-Foam sandwich panels

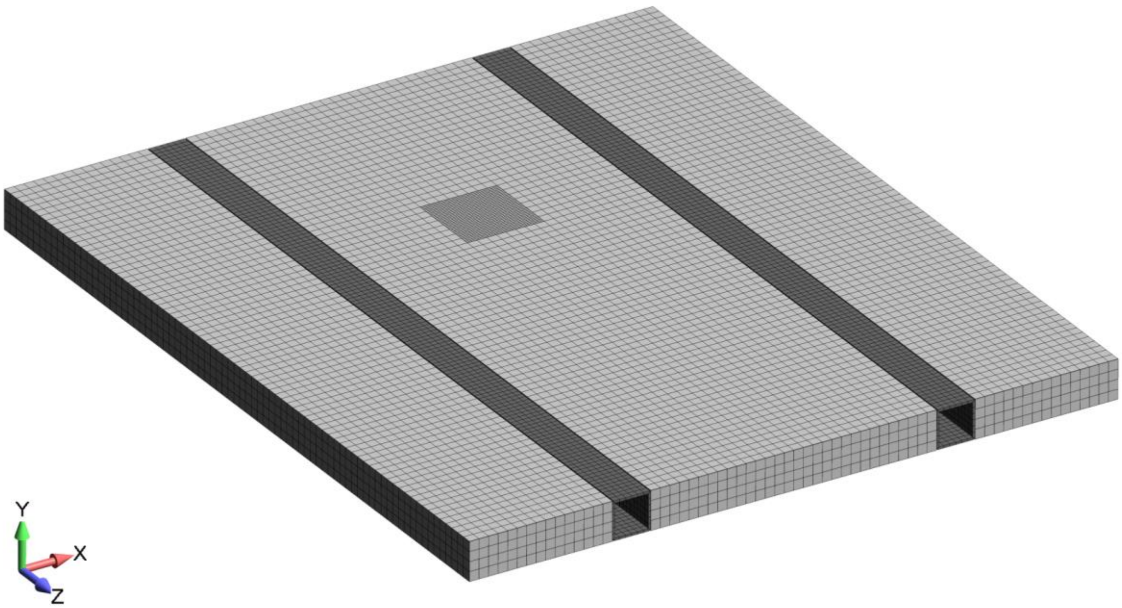


Figure 2: Finite element model of section of roof structure for LS-DYNA impact model.

The skins are meshed using plate elements with the foam core with brick elements. The projectile is modeling as a rigid material. The foam material model used element erosion to mimic the penetration process of the projectile.

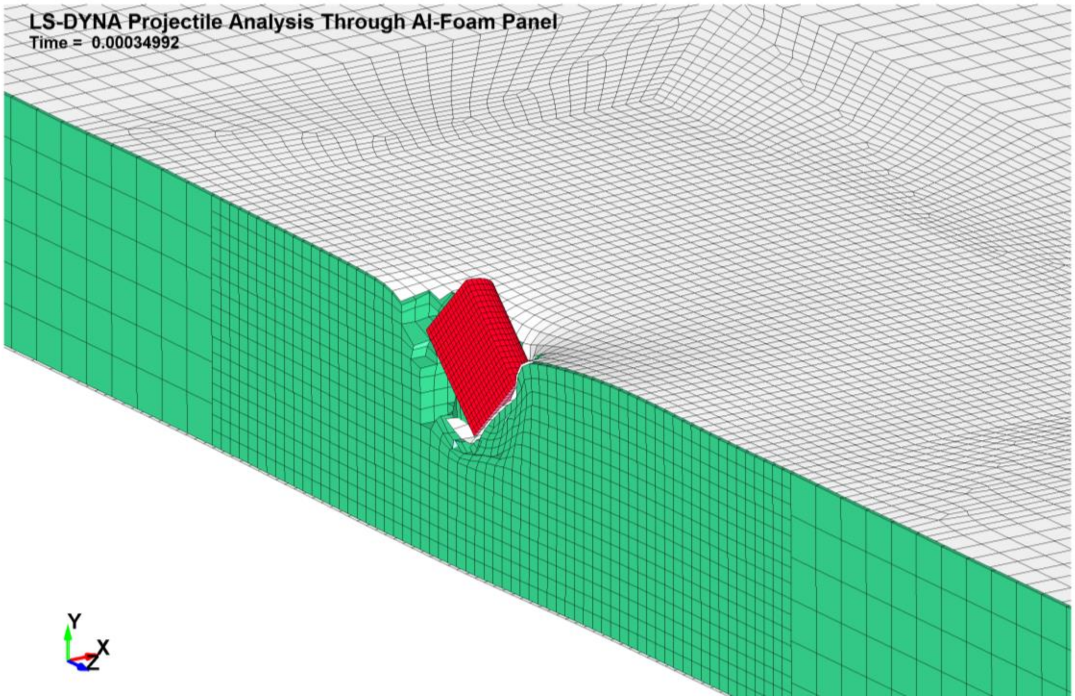


Figure 3: The metal grenade fragment penetrates through the 6061 aluminum skins and dumps energy into the polyisocyanurate (trimer) foam.

The foam was idealized using *MAT_083 or *MAT_FU_CHANG_FOAM with a supplemental material erosion law using *MAT_ADD_EROSION to set different compressive and tensile material failure limits.

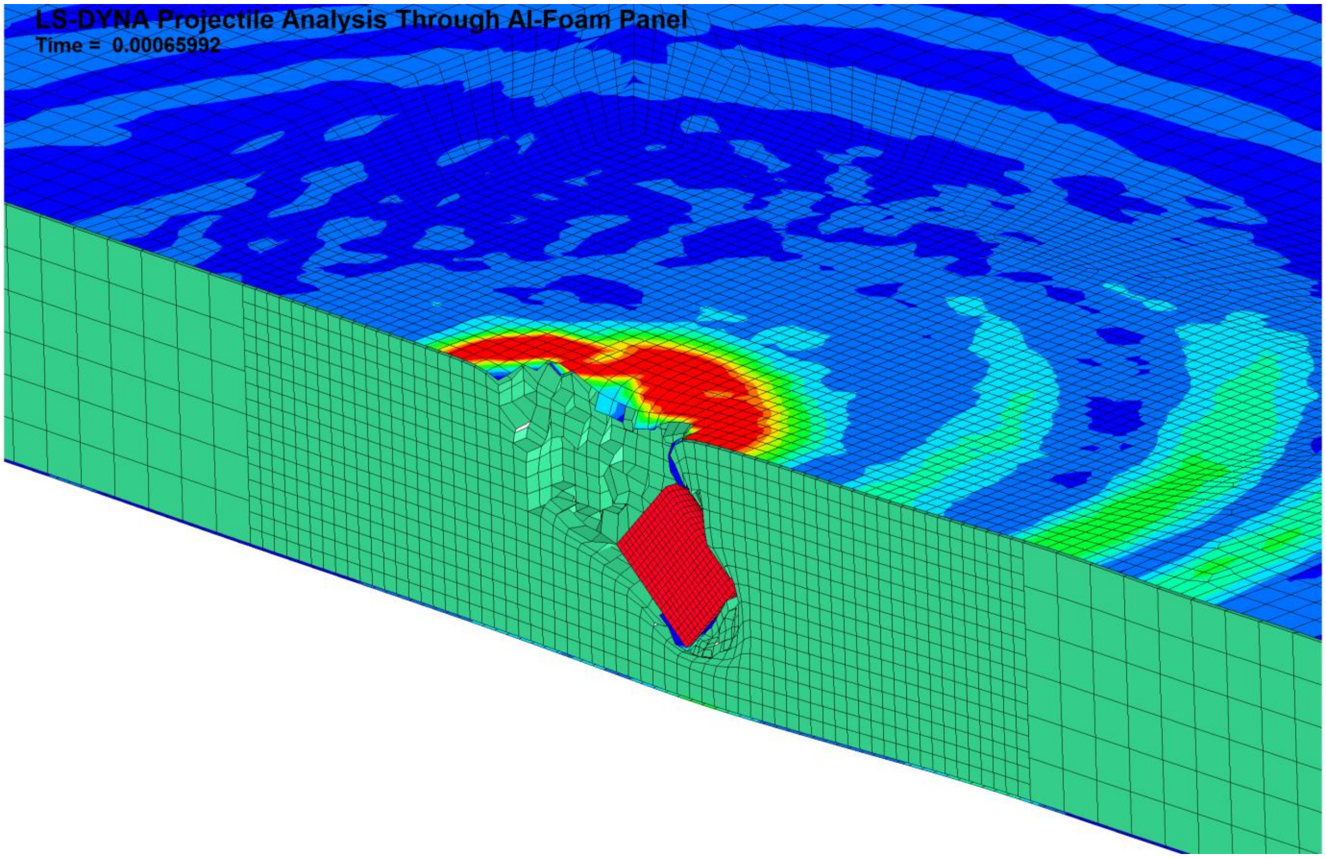


Figure 4: Stress waves propagating over the aluminum skin. The FSP round (MIL-DTL-46593) is shown eroding the surrounding foam elements of the sandwich panel.

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