Journal of Solid and Fluid Mechanics (JSFM), 14(4): 1-4, 2024

Shahrood University of Technology

Journal of Solid and Fluid Mechanics (JSFM)

DOI: 10.22044/jsfm.2024.14207.3836

Manufacturing Engineering of Iran

Numerical modeling of sandwich panel with different layers and core gradient under explosive impact

Mohammad Solooki

PhD Student, Mechanical Engineering, Bu Ali Sina University, Hamedan, Iran
*Corresponding author: mohammadsolooki459@gmail.com

Received: 02/17/2024 Revised: 07/20/2024 Accepted: 08/19/2024

Abstract
In this research, the modes of retardation and deformation of sandwich panels against Explosive impacts have been numerically investigated and compared with experimental results. Explosive impacts have been done on a sandwich panel with uniform foam core and FGM, and tops with aluminum 5182, stainless steel 304 and CFRP (Carbon Fiber-Reinforced Plastic). The deformation modes of the top face sheet, the foam core and the bottom face sheet have been analyzed with a certain method. In this research, it has been shown that the deformation modes are dependent on the intensity of the impact, the material of the face sheets and the gradient of the sandwich core. Based on the results of the research, the transverse deformation of the bottom face sheet increases linearly with the intensity of the impact. At a certain impact intensity (The mass of the Explosive is 30 gr) and the same metal material of the bottom face sheet, the resistance to Explosive of the sandwich panel sample with CFRP top face sheet is 19% higher than the sandwich sample with metal top face sheet.

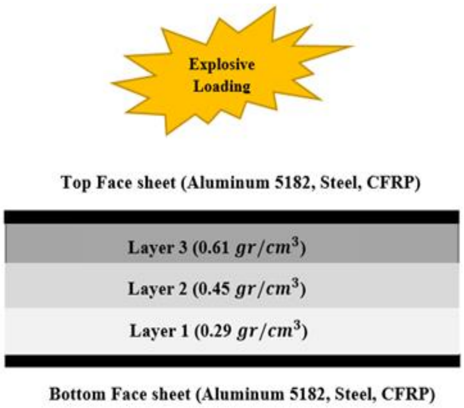
Keywords: Sandwich panel – FGM foam core – Explosive loading – Dynamic response

1. Introduction
Sandwich structures generally consist of two rigid tops and a soft core. One of the important components of sandwich panels is the core, which is a material with energy absorption and light weight, such as foam [1, 2], honeycomb [3, 4]. The strength and high energy absorption capacity and other high mechanical properties have led to the widespread use of sandwich structures in engineering applications such as aerospace [6], automobiles [7] and protection applications [8]. Considering that in previous researches, the effects of the type of procedures and the different effects of the gradient of the sandwich core on the dynamic response and deformation modes have been less investigated. In this research, the investigation of various parameters such as different configurations of sandwich panel samples, such as uniform core with different top materials and sandwich core with functionally graded materials with different core gradients, as well as the impact intensity of the explosion on the resistance to the explosion of sandwich panels has been investigated. According to the results of the research, the transverse deformation of the lower surface increases linearly with the intensity of the impact. At a certain impact intensity (explosive mass 30 grams) and the same metal material of the lower surface, the resistance to explosion of the sandwich panel sample with CFRP upper surface is 19% higher than the sandwich sample with metal upper surface. The resistance to explosion of the sandwich panel sample with the upper material of aluminum and the lower material of steel is 6% higher than the sample of the sandwich panel with the upper material of steel and the lower material of aluminum.

2. Problem definition
During the last three decades, a lot of researches have been done in the field of failure modes and deformation of sandwich panels against explosive impacts. The results of most of these researches were to improve the resistance to explosion of sandwich panels against explosive impacts. Also, during these years, a lot of research has been done

on the effects of the thickness and type of core, the thickness of the layers, the type of blast impact on the blast resistance of the sandwich panel. However, structures in which a combination of layers of aluminum 5182, stainless steel 304 and CFRP and as the top and core of uniform foam and FGM as the core of the sandwich panel proposed in this research have not been investigated. It is predicted that the use of this combination will increase the resistance against the explosion of sandwich panels. Therefore, the combined use of layers of aluminum 5182, stainless steel 304 and CFRP as the top and core of uniform foam and FGM, as well as the investigation of the effect of the gradient of the core on the resistance to the explosion of sandwich panels can be considered as the innovation of this research. The structure of the sandwich panels investigated in this research is shown in Figure 1.

a



b

Figure 1. Sandwich panel structure a) Uniform core b) FGM core

3- Numerical modeling process

The 2019 version of ABAQUS software was used to simulate the blast impact on the sandwich panel. The correct selection of the material model and also the correct application of the physical conditions of the problem, such as the boundary conditions and the use of contact surfaces and elements suitable for the type of problem, make it possible to carry out accurate simulation with the help of this software. Steel, aluminum 5182 and CFRP laminate were used in the simulation. The classification of sandwich panel samples is according to Table 1.

Table 1. Classification of sandwich panel samples.

Samples	Face sheets Material		Core Density			Core Density Average	Layers Density Gradient	Structure Mass
	Top	Bottom	Layer 1	Layer 2	Layer 3			
AL-UD45-AL	AL	AL	-	0.45	-	0.45	0	1692
AL-UD45-ST	AL	Steel	-	0.45	-	0.45	0	2167
AL-UD45-CF	AL	CFRP	-	0.45	-	0.45	0	1576
ST-UD45-AL	Steel	AL	-	0.45	-	0.45	0	2167
ST-UD45-ST	Steel	Steel	-	0.45	-	0.45	0	2642
ST-UD45-CF	Steel	CFRP	-	0.45	-	0.45	0	2052
CF-UD45-AL	CFRP	AL	-	0.45	-	0.45	0	1576
CF-UD45-ST	CFRP	Steel	-	0.45	-	0.45	0	2052
CF-UD45-CF	CFRP	CFRP	-	0.45	-	0.45	0	1461
GD-P	AL	AL	0.29	0.45	0.61	0.45	0.016	1692
GD-N	AL	AL	0.61	0.45	0.29	0.45	-0.016	1692

4- Results and discussion

In this section, the results and modes of deformation and deformation of sandwich panel components from simulation have been compared and analyzed with experimental results.

4-1- Failure and deformation modes of sandwich panel

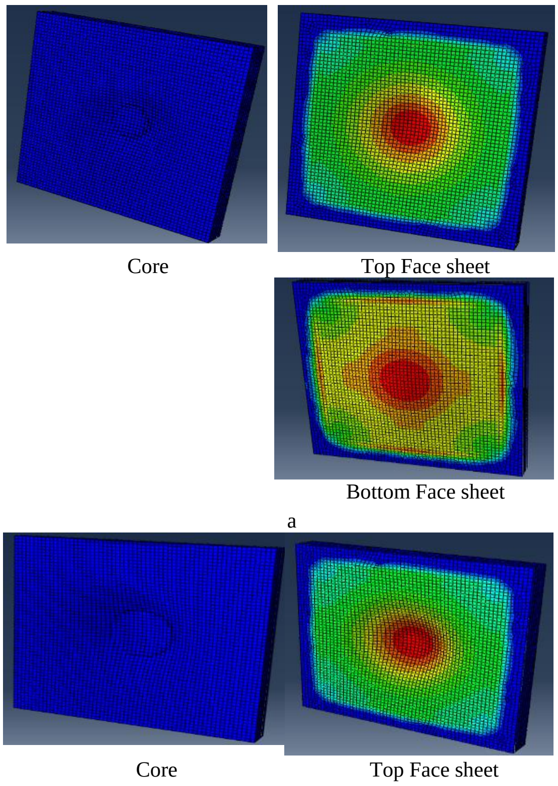
The modes of failure and deformation of sandwich panels with metal tops can be divided into three modes:

Mode 1) Large deformations with a slight local compression of the nucleus

Mode 2) large deformations with more compression of the core

Mode 3) Large deformations with tearing of the top and foam core

Figure 2 shows these three types of fashion for sandwich panels with metal tops.



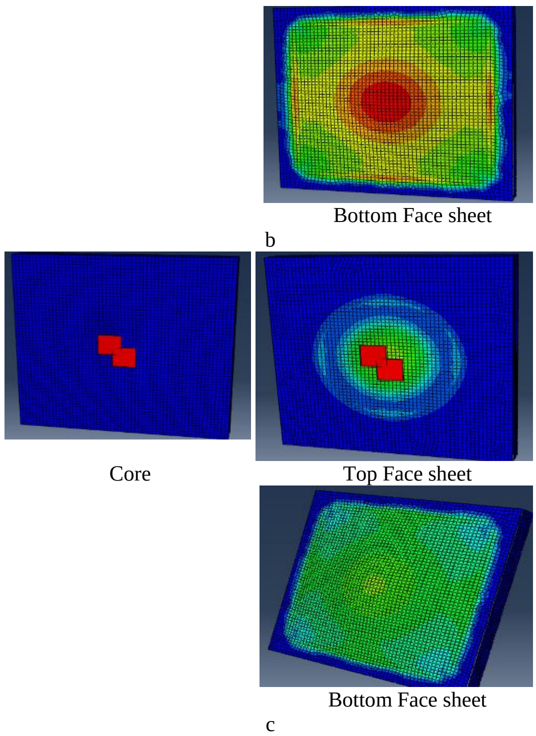


Figure 2 - Modes of failure and deformation of sandwich panels a) First mode (sandwich sample ST-UD45-Al-40g) b) Second mode (sandwich sample Al-UD45-Al-50g) c) Third mode (sandwich sample GD- L-50g)

5- Conclusion

In this research, the dynamic responses of sandwich panels with different types of tops and uniform foam core and FGM for different blast impulses were numerically investigated and compared with experimental results. The deformation/failure modes of the entire sandwich structure, the upper layer, the foam core and the lower layer were fully investigated. The effects of the material of the tops, the configuration of the tops and the density gradient of the sandwich core on the burst resistance of the sandwich structure were measured based on the deformation/break and permanent deflection modes. The most important results obtained are as follows:

1- For sandwich panels with metal tops, three deformation/failure modes were identified. Large plastic deformation without significant local core compression (mode 1) was observed in sandwich panel samples under a low blast impact (explosive mass 30 grams). The core was compressed significantly more than half of the initial thickness (mod2) under a moderate impact (explosive mass 45 grams). The local rupture of the upper surface and foam cores (mod 3) occurred under a high impact (explosive mass 62 grams).

2- Taking into account the same aluminum bottom material, the explosion resistance of the sandwich panel sample with CFRP upper material was 19% higher than the sandwich panel sample with metal upper material.

3- In the same equivalent mass, the explosion resistance of the Al-UD45-ST sandwich panel sample was 6% higher than the ST-UD45-Al sandwich panel sample.

6- References

[1] Xi H, Tang L, Luo S, Liu Y, Jiang Z, Liu Z. (2017) A numerical study of temperature effect on the penetration of aluminum foam sandwich panels under impact. *Compos Part B Eng*; 130:217–29.

[2] Zhu L, Guo K, Li Y, Yu T, Zhou Q. (2018) Experimental study on the dynamic behaviour of aluminium foam sandwich plates under single and repeated impacts at low temperature. *Int J Impact Eng*; 114:123–32.

[3] Sun G, Chen D, Huo X, Zheng G, Li Q. (2018) Experimental and numerical studies on indentation and perforation characteristics of honeycomb sandwich panels. *Compos Struct*; 184:110–24.

[4] Sun G, Huo X, Chen D, Li Q. (2017) Experimental and numerical study on honeycomb sandwich panels under bending and in-panel compression. *Mater Des*; 133:154–68.

[5] McShane GJ, Radford DD, Deshpande VS, Fleck NA. (2006) The response of clamped sandwich plates with lattice cores subjected to shock loading. *Eur J Mech*; 25:215–29.

[6] Hanssen AG, Girard Y, Olovsson L, Berstad T, Langseth M. (2006) A numerical model for bird strike of aluminium foam-based sandwich panels. *Int J Impact Eng*; 32:1127–44.

[7] Xiao Z, Fang J, Sun G, Li Q. (2015) Crashworthiness design for functionally graded foamfilled bumper beam. *Adv Eng Softw*; 85:81–95.

[8] Xia Y, Wu C, Liu Z, Yuan Y. (2016) Protective effect of graded density aluminium foam on RC slab under blast loading – An experimental study. *Construct Build Mater*; 111:209–22.