A REVIEW: ON SANDWICH STRUCTURE AND THEIR DIFFERENT PROCESS PARAMETERS

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***Abstract*: Sandwich structure have shown the most promising candidate for structural application now a days. It is a challenging task to advance the excellent strength and structural performance of sandwich structures, while continuing to reduce the weight and cost parameters. Thousands of researchers have studied and developed the core structural innovation with periodical achievements. This paper contains the review on honeycomb sandwich structure and their application.**

***Keywords*: Sandwich panel, internal structure, performance, deformation behaviour**

1. Introduction

Over the past few decades, sandwich structures have become increasingly popular in civil, aerospace and automobile industries. Applications of the sandwich structures in civil engineering constructions are found in the bridge decks, wall and roof claddings for buildings, stairs, landings, balusters etc. A sandwich structure is a material composed of two rigid sheets that are joined together by a core or low-density structure. Separation of the coating with the light core plays an important role in increasing the time of the second zone (and thus the stiffness of the bend) of the cross section of the material with only a slight increase. In aerospace industries, the honeycomb cored sandwich structures are used for space shuttle constructions for both military and commercial aircrafts and this sandwich construction is also found to be used for both the primary load carrying and aerodynamic control surfaces such as the flaps and spoilers, for achieving maximum weight savings and providing more efficient features. Because of higher structural efficiency and functional integration advantages, the sandwich composites fuselages appear to be a good choice for the future aircrafts. The sandwich structures also find their applications in the manufacturing of railcars, buses, sail boats, racing boats and cars etc. For making these sandwich structures, a three-layer type construction is generally used in which two strong and stiff face sheets are separated by a thick core (Fig. 1.1). The face sheets of these sandwich structures are primarily made of fibre reinforced composites and the core from a low-density material [1-5]. The moment of inertia of the sandwich structure increases considerably due to the separation of the face sheets by the thick core.

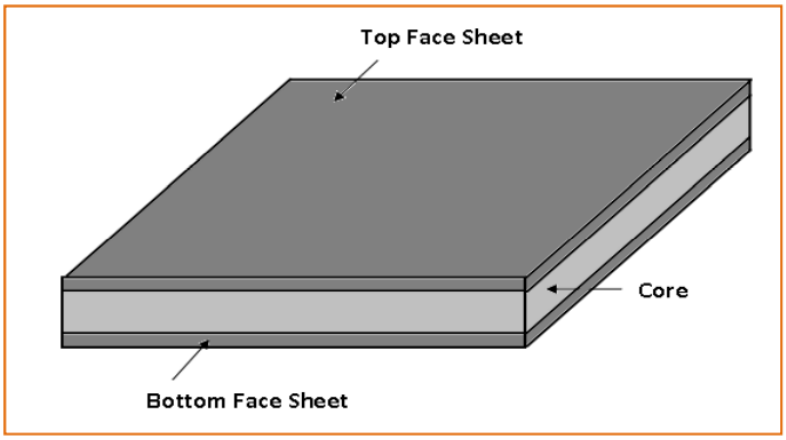

Figure 1. Schematic representation of a sandwich structure

The strength as well as the stiffness of the sandwich structure increases without substantial increase in the overall structural weight thereby making the structure more efficient against bending and buckling [6-8]. Also, in case of the sandwich structure, the transverse stress is resisted by the core while the flexural and in-plane loading is carried by the faces in a manner similar to an I-beam [9-10]. A great deal of work on the analysis of sandwich structures is available in the literature [11-19].

2. Classification of Sandwich Structures

Many materials can be used for filling and sandwich cores. Common coating materials include metals (e.g., steel or aluminum) and composites (e.g., fibrous polymers). Foundation or construction materials include reinforced foam, metal (polymer or steel), rosewood and balm. The connection of the core to the front is usually made by glue or welding. Figure 1.1 shows some of the configuration of the sandwich structure.

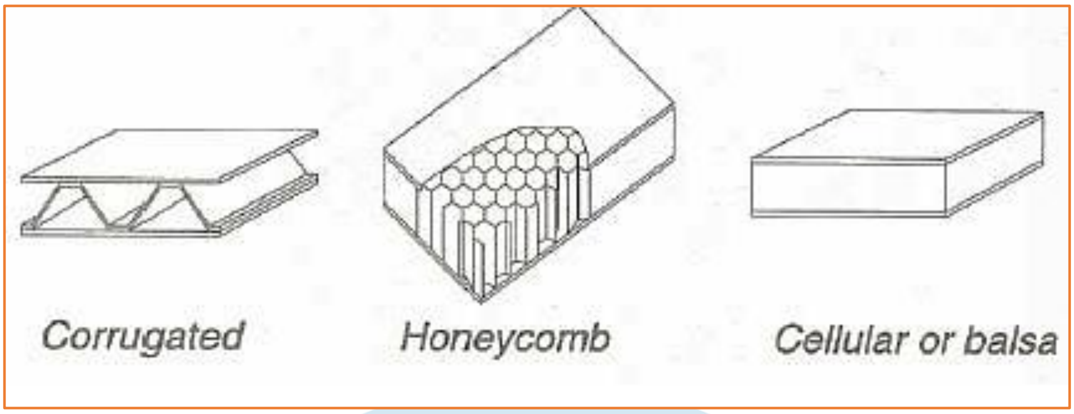

Figure 2. Typical sandwich configurations

3. Applications of Sandwich Panels

The practical application of steel sandwich panels in shipbuilding began in the mid-1990s with the development and implementation of sandwich panels in the United States, then led by the US Navy and focused on maritime applications. The main reasons for the application are weight saving and increased resistance to fire, explosion and penetration. In recent years, many applications of stainless-steel sandwich panels have been used in civil and mechanical engineering as well as other industries. These include bus floors, elevator walls, and work platform floors in industrial and shipbuilding applications. Meyer Werft's first program started in 1995 with the production of the first sandwich panel on a test bench. The program focuses on wing partitions and stairs, but also for other walls, such as balcony partitions. The program then extended the stairs and landed in public.

Meyer Werft panels are installed in the two cabins of the Superstar Virgo cruise ship. This is possible after a severe fatigue test of the joint between the sandwich panel and the surrounding normal structure. Sandwich panels have proven to be the best solution for walls and platforms, providing space saving and high precision, leading to reduced straight cuts. In addition, a significant reduction of the floor level material, the lightness and reduction of the insulation, as well as a high degree of pre-fitting were observed, avoiding "hot work" during installation, block installation and Final installation. Cutting tools and holes are made and installed in the panel with the connecting profile. (Figures 3).

Figure 3. In the special container for gravel truck the stainless-steel sandwich panels as side walls are welded to wear resistant plates in the bottom of the structure.

4. Sandwich Panel for Impact Energy Absorption

Sandwich panels are made from a lightweight, compatible material (called a core) sandwiched between two sides (or leather) made of a material harder and stronger than light, hard leather to form a durable structure. In this way, a stronger structure with less weight is synthesized from two different materials. For this reason, sandwich panels are often used in applications where weight gain becomes the greatest [1]. Some examples of its implementation are the helicopter beam, floor and chassis. Etc. Sandwich panels are increasingly used in the transport industry (aerospace and marine) due to their high structural capacity and absorbency combined with low weight.

5. Application of Sandwich structures as floor

Stainless steel can be used in various ways on the floor. The Doltrac floor is a stainless-steel floor with a sandwich structure. It has a steel surface of 1.9 m. M and an area of 1.2 or 1.5 m. L is located in a rectangular shape with a height of 50 m. M (type O) or by software for continuous or reverse V interference (Figure 1.10) The composite is assembled by glue or by laser or welding. These soil composites offer high rigidity at low weight.

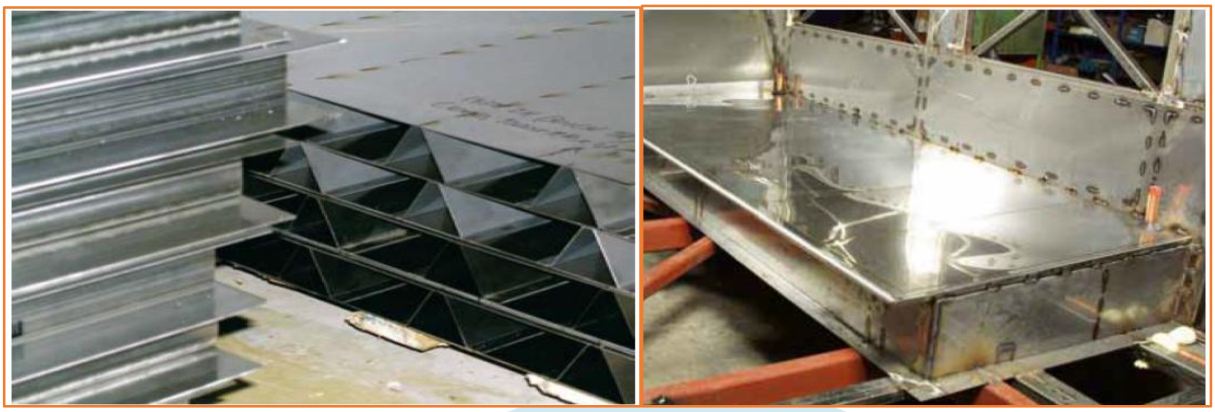

Figure 4. Stock of Doltrac floor assemblies with sandwich structure which profiles are of continuous 'V'

6. Existing Research Work

Sandwich panels are widely and increasingly used in the fields of construction, aerospace technology and shipbuilding, where weight is an important design criterion. With many faces and cores, sandwich panels are widely used in many fields such as sound and heat insulation and fire safety.

1) **ASTM standard** illustrates the methodology for testing the properties of rigid cellular plastics under compressive loading.
2) **Fotsing et al. (2016)** had studied the effect of artificially induced face sheet or core discontinuities on static and dynamic mechanical behaviour of sandwich panels with aramid honeycomb core and carbon/epoxy face sheets. They reported that the presence of core discontinuities or viscoelastic film in between plies of face sheet did not affect the properties such as tensile and bending strength, but affected the in–plane compressive properties. Also, the increase in viscoelastic layers or core discontinuities, improved the energy absorption capacity of sandwich panels under low velocity impact conditions.
3) **Atas & Potoglu (2016)** had investigated the influence of face sheet thickness on the low velocity impact behaviour of sandwich panels. It was reported that with increase in thickness of face sheet, the impact energy required for perforation also increases. The damage size was same for different foam core sandwich panel with same core shear propertis. The damages observed are face sheet fiber breakage, delaminations, and core shear failure.
4) **He et al. (2016)** had conducted experimental studies and numbers on the low impact response of hybrid sandwich panels. Samples were made to affect energy levels between 10 and 50 g, the effects of applied energy and core thickness on impact resistance, energy absorption mode and failure mode are discussed. The facial destruction was mimicked by following the Haskin failure criteria and the Yeh stopping criteria. Observed damage includes fiber breakage, matrix breakdown, and core deformation. Experimental results and numbers agreed.
5) **James et al. (2015)** had developed a numerical model for compression after impact behaviour using a cohesive surface for interlaminar damage prediction. The face sheets damage instigation and core crushing behaviour was modelled using Hashin composite failure criteria and simple plasticity response. The numerical predictions of residual strength show fair agreement with the experimental results. The failure was delamination buckling and propagation of delamination was through the width of the sandwich panel.
6) **Olsson & Block (2015)** had derived an expression of criteria for low velocity impact induced face sheet damage and core shear cracking for foam core sandwich panels, based on available experimental data and literatures. It was reported that face sheet damage could be avoided by increasing the flexural rigidity of the face sheet and similarly core shear cracking by increasing the thickness or density of the core.
7) **Yang et al. (2015)** had studied the low velocity impact and compression after impact behaviour of foam filled sandwich panels with different face sheets made of carbon/glass/vinyl ester resin. The result showed that face sheet fiber layer arrangement has an effect on the mode of damage. Also, panels with hybrid face sheet possess high contact force, energy absorption capacity and compression after impact strength. From SEM images, it was revealed that damages in hybrid face sheet includes matrix micro-cracking, fiber breakage and debonding of fiber from matrix.
8) **Mozafari et al. (2015)** Here, to study the effect of filling the aluminum core of Honeycomb with foam and its density on the final compression properties by experimental and numerical methods. It has been observed that there is a correlation between the average crushing resistance of foam-filled cores and the overall crushing resistance of honeycomb and foam. Core honeycomb panels significantly improve energy, crush energy absorption capacity and absorb energy by weight.
9) **Qu et al. [2015]** had demonstrated an effective method for the analysis of free and temporary vibrations of sandwich structures with composites with the same shape, including sliding beams and solid particles. They propose higher-level theories to perform linear and non-linear analysis of components and sandwich plates and based on these analytical models developed for static as well as free vibration analysis of Sandwich plate. Recently, researchers have also presented similar theories for the static and dynamic analysis of sandwich panels and shells. They applied higher control theorems to study the transient response of composite structures in bone and sandwich layers.
10) **Akatay et al. (2015)** had studied the effect of repeated low velocity impacts on post compressive strength of sandwich panels made up of glass/epoxy face sheets and aluminium honeycomb core. The study showed that low impact of 5 J induced matrix cracking and high energy of 110 J of single impact leads to perforation of samples. Repeatedly impacted samples show significant reduction in post compressive strength when compared to the single impacted samples.

11) **Ramakrishnan et al. (2014)** The effects of nano-reinforcements on the behaviour of sandwich panels at high speed have been studied. The results show that the hardness of the sandwich panel is slightly reduced. For low energy levels, splitting and indentation of fibers is done in panels without nanoparticles, while at high energy levels, only fiber failure occurs in panels with nanoparticles. It can be concluded that the presence of nanotite significantly improved the resistance of the sandwich panel to damage.
12) **Zhang et al. (2014**) A sandwich panel made of a polyurethane foam composite with a pyramidal plate core and a carbon / epoxy face sheet is formed. Low speed impact tests were performed to obtain a history of contact force, and foam core panels were shown to have shorter contact times and higher impact loads compared to non-contact core panels.
13) **Wahl et al. (2014)** The drilling properties of honey aluminum sandwich panels have been investigated experimentally and numerically using three-point bending and rolling tests with food carts. The test is carried out in three directions: the strictest direction, the most suitable direction and the most stressful direction. The failure due to the bending load was observed to be shear damage to the rod and the deepening of the rod was not observed. In tests on a mixer with food packaging surrounded by a sandwich panel, a crack occurred under the load wheel plate. The numerical results correspond well to the experimental values.
14) **Abdi et al. (2014**) had Learned the behavior of compression and bending with flat cores and sandwich panels with reinforced foam. They produce panels using a vacuuming process using glass / polyurethane sheets and polyurethane foam cores. It has been found that foam reinforced with polymer needles significantly increases the compaction and flexibility characteristics. The improvement of the bending properties is due to the strong interconnection of the interface provided by the similar face / core connection pins, the higher the compressive strength is due to the desired properties of the needle thickness compared to will only foam.
15) **Kong et al. (2014)** wrer applied edge compression and bending for sandwich panels with different cores and face sheets. He also performed a compact test of the perforated sandwich panel and analyzed the failure mode by limiting element analysis. Uneven load distribution and fiber content leads to damage to the sandwich panel with aluminum honeycomb at 40% of the face plate deformation during compaction, while 100% deformation of the sandwich plate damages the plate with foam. The compressive strength of the sandwich panel is 72% higher than that of the aluminum core sandwich panel. Analysis of sandwich panel failure shows that cutting leads to final failure. The highly compressed module of the aluminum core creates a higher stress for the breaking of the almond sandwich panel, which in turn leads to a higher specific bending strength of the sandwich panel with the foam.

7. Conclusion

Sandwich structures are the need of current development, because of their light weightiness and high energy absorption capacity. These sandwich structures are used for panels, crashworthiness during accident, vibration damping and also used for sound absorption. The performance or strength of the sandwich structure depends on the materials used for manufacturing, sheet thickness, orientation, structure design and many others. Honeycomb is the most promising sandwich structure now a days which full fill the requirement of current scenario. Further research is required for the enhancement of energy absorption, strength and crashworthiness of the honeycomb structures.

References

[1] ASTM D-1621-04a, "Standard test method for compressive properties of rigid cellular plastics", American Society for Testing and Materials, Philadelphia (2004).
[2] Fotsing, ER, Leclerc, C, Sola, M, Ross, A & Ruiz, E 2016, 'Mechanical properties of composite sandwich structures with core or face sheet discontinuities', Composites Part B: Engineering, vol. 88, pp. 229-239.
[3] Atas, C & Potoglu, U 2016, 'The effect of face-sheet thickness on lowvelocity impact response of sandwich composites with foam cores', Journal of Sandwich Structures & Materials, vol. 18, no. 2, pp. 215-228.
[4] He, W, Liu, J, Tao, B, Xie, D, Liu, J & Zhang, M 2016, 'Experimental and numerical research on the low velocity impact behavior of hybrid corrugated core sandwich structures', Composite Structures, vol. 158, pp. 30-43.
[5] James, CT, Watson, A & Cunningham, PR 2015, 'Numerical modelling of the compression-after-impact performance of a composite sandwich panel', Journal of Sandwich Structures & Materials, vol. 17, no. 4, pp. 376-398.
[6] Olsson, R & Block, TB 2015, 'Criteria for skin rupture and core shear cracking induced by impact on sandwich panels', Composite Structures, vol. 125, pp. 81-87.
[7] Yang, B, Wang, Z, Zhou, L, Zhang, J, Tong, L & Liang, W 2015, 'Study on the low-velocity impact response and CAI behavior of foamfilled sandwich panels with hybrid facesheet', Composite Structures, vol. 132, pp. 1129-1140.
[8] Mozafari, H, Molatefi, H, Crupi, V, Epasto, G & Guglielmino, E 2015, 'In plane compressive response and crushing of foam filled aluminum honeycombs', Journal of Composite Materials, vol. 49, no. 26, pp. 3215-3228.
[9] Qu Y., Wu S., Li H. and Meng G., 2015, "Three-dimensional free and transient vibration analysis of composite laminated and sandwich rectangular parallelepipeds: Beams, plates and solids", Composites: Part B, Vol. 73, pp.
[10] Akatay, A, Bora, M.O, Çoban, O, Fidan, S & Tuna, V 2015, 'The influence of low velocity repeated impacts on residual compressive properties of honeycomb sandwich structures', Composite Structures, vol. 125, pp. 425-433.
[11] Ramakrishnan, KR, Guerard, S, Viot, P & Shankar, K 2014, 'Effect of block copolymer nano-reinforcements on the low velocity impact response of sandwich structures', Composite Structures, vol. 110, pp. 174-182.
[12] Zhang, G, Wang, B, Ma, L, Wu, L, Pan, S & Yang, J 2014, 'Energy absorption and low velocity impact response of polyurethane foam filled pyramidal lattice core sandwich panels', Composite Structures, vol. 108, pp. 304-310.

[13] Wahl, L, Maas, S, Waldmann, D, Zurbes, A & Freres, P 2014, 'Fatigue in the core of aluminum honeycomb panels: Lifetime prediction compared with fatigue tests', International Journal of Damage Mechanics, vol. 23, no. 5, pp. 661-683.
[14] Abbadi, A, Koutsawa, Y, Carmasol, A, Belouettar, S & Azari, Z 2009, 'Experimental and numerical characterization of honeycomb sandwich composite panels', Simulation Modelling Practice and Theory, vol. 17, no. 10, pp. 1533-1547.
[15] Kong, CW, Nam, GW, Jang, YS & Yi, YM 2014, 'Experimental strength of composite sandwich panels with cores made of aluminum honeycomb and foam', Advanced Composite Materials, vol. 23, no. 1, pp. 43-52.