Design And Analysis Of Corrugated Steel Sandwich Structures Using Ansys Workbench

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Abstract

A structural sandwich consists of two thin face sheets made from stiff and strong relatively dense material such as metal or fiber composite bonded to a thick light weight material called core. This construction has often used in lightweight applications such as aircrafts, marine applications and wind turbine blades.

In this paper the structural analysis of corrugated sand which panel with stainless steel face sheets and mild steel as core is done using Ansys work bench and compressive strength is compared with experimental value.

The model of the curved corrugated core is done in pro/E and the effect of wave length on strengthto weight ratio is analyzed.

1. Introduction & Literature Review

Noor, Burton and Bert state that the concept of sandwich construction dates back to Fairbairn in England in 1849. Also in England, sandwich construction was first used in the Mosquito night bomber of World War II which employed plywood sandwich construction. Feichtinger states also that during world war II, the concept of sandwich construction in the United States originated with the faces made of reinforced plastic and low density core. In 1951, Bijlaard studied sandwich optimization for the case of a given ratio between core depth and face thickness as well as for a given thickness[1]

Various analyses on sandwich structure are Kevin J. Doherty investigate sandwich panels of metallic face sheets and a pyramidal truss core subjected to panel bending and in plane compression testing to explore the effects of relative core density and process parameters.[2]. Aydıncak, İlke made a design and analysis of honeycomb structures to develop an equivalent orthotropic material model that is substitute for the actual honeycomb core.[3] . Jukka Säynäjäkangas make a review in design and manufacturing of stainless steel sandwich panels and conclude an efficient sandwich is obtained when the weight of the core is close to the combined weight of the both faces[4]. Tomas Nordstrand made an analysis on corrugated board in three-pointbending and evaluation of the bending stiffness and the transverse shear stiffness[5]. Pentti Kujala discussed that steel sandwich panels that are welded by laser can save 30-50% weight compared to conventional steel structures[6]. Jani Romanoff presents a theory of bending of laser welded web core sandwich panels by considering factors that effect the total bending response of laser welded web core sandwich plates[7]. Pentti Kujala made analysis on metallic sandwich panels which are laser welded have excellent properties with light weight having more applications[8]. Narayan Pokharel determined local buckling behavior of fully profiled sandwich panels which are based on polyurstyrene foam and thinner and high strength steels[9]. Pentti kujala determined ultimate strength of all steel sandwich panels and numerical FEM analysis and development of design formulations for these panels.[10]

2. Corrugated sandwich structures

A structural sandwich typically consists of two thin face sheets made from stiff and strong relatively dense material such as metal bonded to a thick lightweight material called core. This concept mimics an I beam, but in two dimensions, where the face sheets support bending loads and the core transfers shear force between the faces in a sandwich panel under load. Face sheets used

in structure are mainly in three forms flat, lightly profiled and profiled. The face sheets of sandwich panels provide structural stiffness and protect the core against damage and weathering. During loading the face sheets take compressive and tensile loads and core transforms shear loads between the faces and provide high bending stiffness. Sandwich structures are used in applications requiring high stiffness to weight ratios because for a given weight, the sandwich structures has a much higher moment of inertia compared to solid or I-beam structures.

Sandwich panels with top and bottom plates as well as the core made up of steel are called steel sandwich panels. The core structures are of different types according to core structures the steel sandwich structures are divided some of them are I-core, O- core with rectangular beams, Vf/V- core with hat or corrugated sheets as a core, web core, round O-core and X-core with two hats as a core as shown in Fig.1.

In this paper a steel sandwich structure with curved corrugated core made of mild steel and stainless steel face sheets are considered.

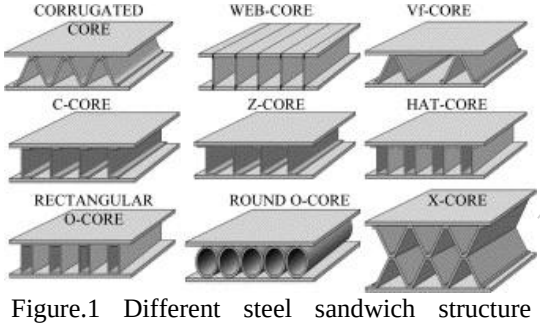

Figure.1 Different steel sandwich structure with various cores

3. ANSYS Workbench

ANSYS Work bench can be thought of as a software platform or framework where you perform your analysis (Finite Element Analysis) activities. In other words, workbench allows you to organize all your related analysis files and databases under same frame work. Among other things, this means that you can use the same material property set for all your analyses.

Some of the applications that fit into the workbench framework are:

1. Design modeler
2. Mechanical (simulation)
3. Design Xplorer
4. AUTODYN
5. CFX Mesh
6. FE Modeler

The ANSYS Workbench platform allows users to create new, faster processes and to efficiently interact with other tools like CAD systems. In this platform working on Multiphysics simulation is easy. Those performing a structural simulation use a graphical interface (called the ANSYS Workbench Mechanical application) that employs a tree-like navigation structure to define all parts of their simulation: geometry, connections, mesh, loads, boundary conditions and results.

By using ANSYS workbench the user can save time in many of the tasks performed during simulation. The bidirectional links with all major CAD systems offer a very efficient way to update CAD geometries along with the design parameters.

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4. Design and Analysis of Sandwich Structures.

Sandwich panels are modeled in PRO/E. The top and bottom plates are modeled by using extrude command and the core part is modeled by using sweep command. The three parts are assembled by using assembling command. Then the assembled part is saved in IGS format and imported to ANSYS workbench. In ANSYS Workbench the IGS format is Imported and geometry will show three contact pairs. Materials properties are given to the individual part i.e, top and bottom plates are selected and stainless steel properties are given to them. Now core is selected and mild steel properties are given. now mesh the geometry as free mapped mesh and structural analysis is done by fixing the plate at bottom and pressure is applied at top face of the plate as shown in fig. now by solving the structure the deflection and von misses stress are noted. By changing the wave length of corrugated core and same is modeled and analyzed at a constant pressure the variation in deflection and von misses are compared.

Compression test

Steel sandwich structure with stainless steel faces and mild steel core are joined by welding and compression test is conducted on Universal testing machine (UTM) and ultimate stress and deflection are studied. The in-plane compression testing of sandwich structure was performed on universal testing machine (UTM)having capacity 400KN. The samples were placed between hardened end plates in order to protect the surface of the machine's platens. Load is applied uniformly and deflection and compression strength are noted.

Figure 8: In plane compression test

Table 1 shows the experimental results compared with ANSYS workbench resuts

	Load KN	Deflection mm
Ansys workbench	13.58	0.23
UTM	15	0.25

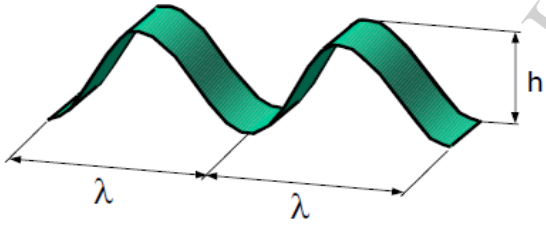

Figure2: geometry of corrugated core

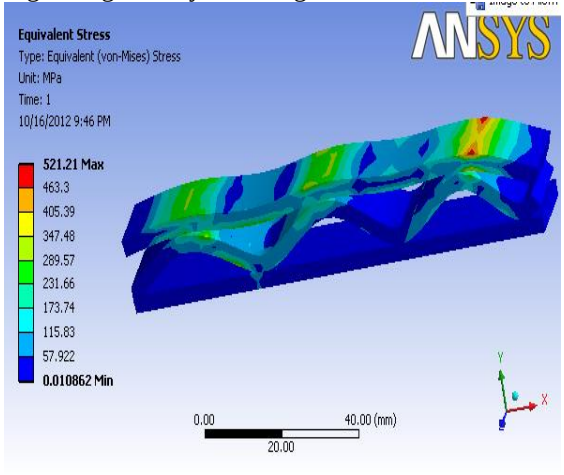

Figure 3: Von misses stress for a 3 wave core sandwich structure

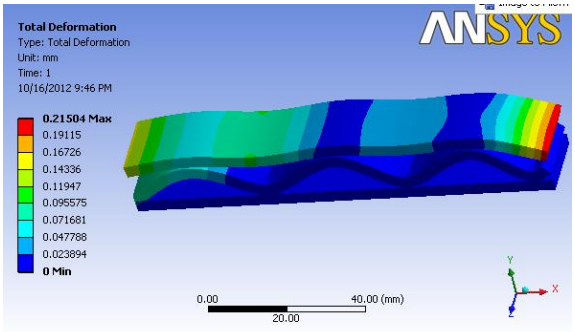

Figure 4: Total deformation for a 3 wave core sandwich structure

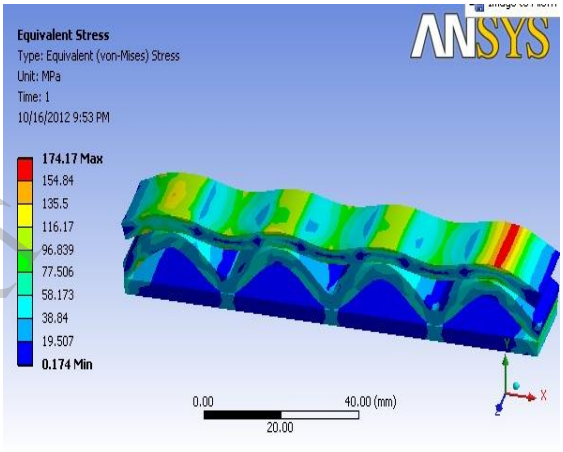

Figure 5: von misses stress for a 4 wave core sandwich structure

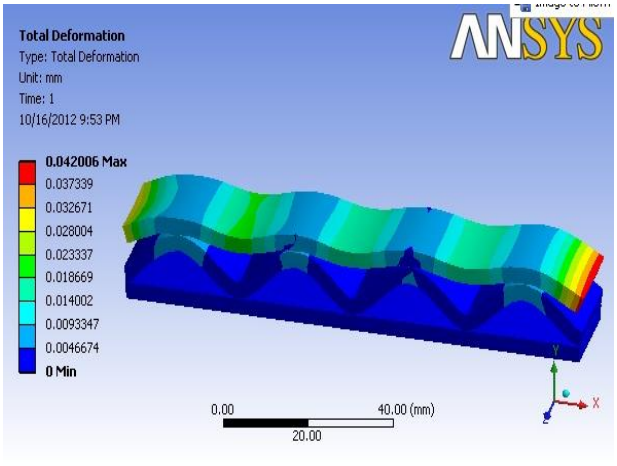

Figure 6: Total deformation for a 4 wave core sandwich structure

5. RESULTS AND DISCUSSION

Sandwich panel	Load applied (KN)	Von misses stresses (MPA)	Total deformation (mm)	Total weight (N)
3 curve	13.5	521.2	0.215	161.7
4 curve	13.5	174.17	0.042	168.7

By comparing the increase in weight percentage and increase in strength percentage the results gives that for 4% increase of weight gives 66% increase of strength.

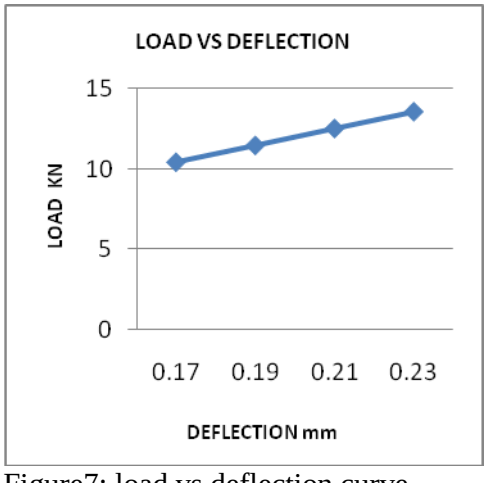

Figure7: load vs deflection curve

6.CONCLUSION

The sandwich panel model in PRO/e is efficiently imported into Ansys workbench structural analysis is done and max stress is observed at top face. For given length and height of the structure increasing the number of curved waves (3 waves to 4 waves) the strength increases effectively. For increase of 4% weight, the strength is increase to 66%

7. References

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