International Journal of Engineering Trends and Applications (IJETA) – Volume 2 Issue 2, Mar-Apr 2015

RESEARCH ARTICLE OPEN ACCESS

Buckling Behavior of Skew Sandwich Plate Using Numerical Simulation

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ABSTRACT

The stability analyses of simply supported layered isosceles skew sandwich plate subjected to axial in-plane compression are presented. The lay-up configuration is confined to symmetric laminates. The analysis is done using Ansys-14 FEM software. The computed results are in the form of graphs of the buckling force with varying skew angle and h/t ratio are shown along with the comparison of various variation in geometric parameters.

Keywords:- Perl, ABAQUS, Buckling

I. INTRODUCTION

Sandwich structures have been used in numerous aspects of aircraft construction as well as in many other applications. Typical sandwich structures are made up of two thin, stiff strong faces separated by a very lightweight material known as the core. By choosing appropriate core materials based on intended applications, not only are sandwich panels able to achieve high stiffness, and strength s comparable to those of single solid panels, but also great savings in weight. Depending on the strength characteristics of the core and its ability to carry in-plane loading, one can distinguish between soft and rigid cores. The core in between is adhesively bonded by two face sheets, at the top and bottom of the core. Thick core is generally of soft material with low in-plane and transverse shear modulus and is responsible for transverse normal and shear load transfer. In case of similar mechanical properties of materials that the faces and the core are made of, one can say a sandwich plate with a rigid core. It is assumed that the core participates in carrying in-plane loads.

The face sheets are usually thin and carry the in-plane and bending loads. Metals as well as composite laminates can be used as face sheets. Because of high thickness of soft core, the deformation and buckling behavior of sandwich constructions is different than laminated composites. The problem in the analysis of layered structures arises due to variation of in-plane displacement across the thickness. Transverse shear strains are discontinuous at the interface between layers due to significant difference in transverse shear properties and thickness of the layers. This phenomenon is ignored in the laminated composite plates because in general the thickness of each layer is the same and the difference of transverse shear rigidities of two adjacent layers is negligible.

In Noor[1] et al. give a broad review of computational models of sandwich composite structures. They comment on the specific procedures performed to predict the properties of sandwich core in terms of their geometric and material characteristics. A survey of different cases of buckling of multilayered composite plates has been presented by Leissa[2]. The solution that accounts for crosswise compressibility of the core is shown in Perel and Palaz-otto[3], where the authors propose a finite element-based computational algorithm, which improves the accuracy of plate load computations. Narita and Leissa[4] considered the stability analysis of a rectangular multilayered plate with a symmetrical structure. Loughlan and Ata[5] modified the theories for isotropic thin-walled structures in order to analyse rigidity of multilayered materials and introducing the idea of effective thickness. In[6] the authors also try to find a way to determine the material parameters of a rectangular multilayered plate that exert a significant influence on the plate loss of stability. It is difficult to determine precisely many of these parameters during manufacturing, therefore a proposal of modelling a specially and generally orthotropic plate, in which material constants are assumed as random variables, is put forward.

A multilayered parallelogram plate, whose sides are simply supported or fixed, subjected to unidirectional or bidirectional compression, is discussed by Krishna and Palaninathan[7]. Also Babu and Kant[8] analyse a parallelogram plate and propose two models of the finite element, according to the theory of non-dilatational strain of the first and higher order (third). In the presented analysis that refers to an isotropic, anisotropic and sandwich plate, they conclude that the differences between both the models are slight for laminates and they increase with an increase in the side inclination angle in the case of sandwich panels. The same authors[8], employing the method discussed here, present the results of the thermal stability analysis of a three-layered parallelogram plate. The stability of the parallelogram multilayered plate subjected to unidirectional compression is analysed by Hu and Tzeng[13]. The authors, who use the ABAQUS program, analyse the effect of the inclination angle of parallelogram sides, the sequence of its layer arrangement and the boundary conditions on the critical load value. A plate with a centrally located circular hole is the object of their analysis. Although the buckling of trapezoidal composite sandwich plate has not been reported.

Considering the three-layered laminate trapezoidal sandwich plate subjected to in-plane compression with different boundary conditions. The sandwich plate considered is symmetric structure as shown in fig. A with isotropic material property.

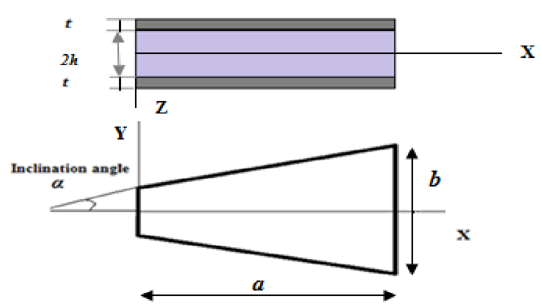
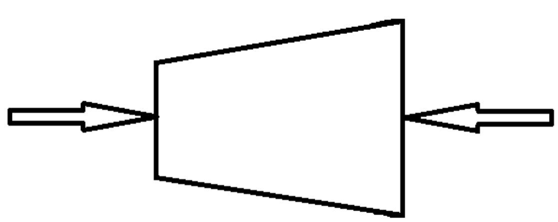


fig. A



Loading conditions

Material properties

Face Plate material properties:-

E = 94GPa, ν = 0.3, ρ=2700 kg/m^3

Core material properties:-

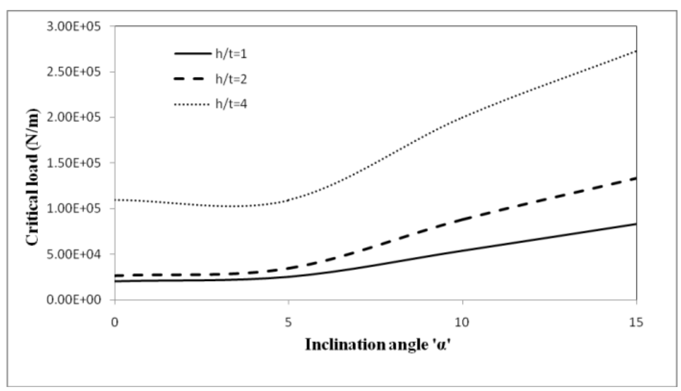
E = 140GPa, ν = 0.3, ρ=1200 kg/m^3

II. FEM RESULTS

Angle 'α'	a/b	h/t	Critical Load (N/m)
0	0.6	4	0.10976E+06
5	0.6	4	0.10919E+06
10	0.6	4	0.20010E+06
15	0.6	4	0.27256E+06

Angle 'α'	a/b	h/t	Critical Load (N/m)
0	0.6	2	0.26584E+05
5	0.6	2	0.34486E+05
10	0.6	2	0.88222E+05
15	0.6	2	0.13318E+06

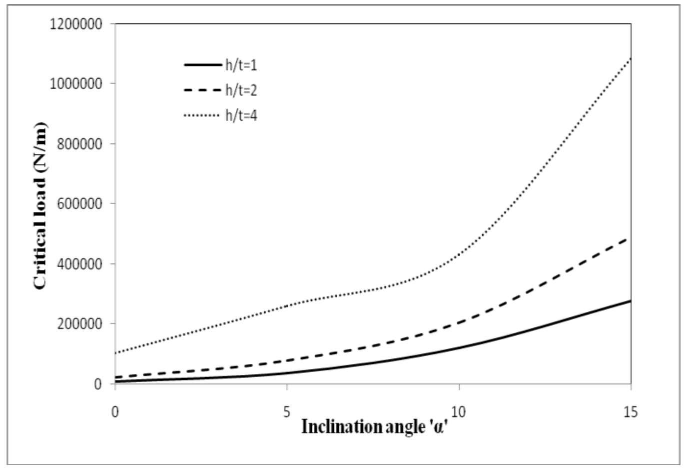
Angle 'α'	a/b	h/t	Critical Load (N/m)
0	0.6	1	0.20099E+05
5	0.6	1	0.25222E+05
10	0.6	1	0.53647E+05
15	0.6	1	0.82881E+05



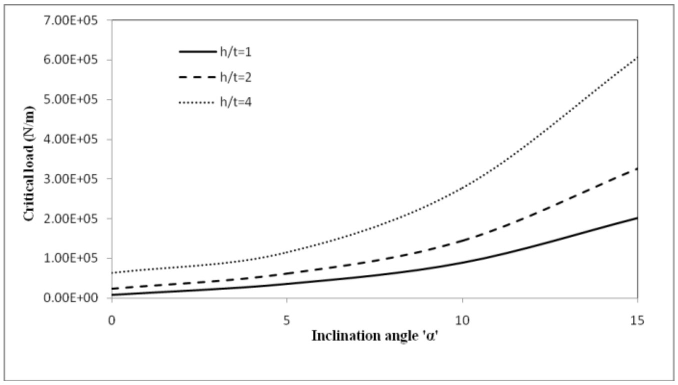
Angle 'α'	a/b	h/t	Critical Load (N/m)
0	1	4	0.63996E+05
5	1	4	0.11491E+06
10	1	4	0.27797E+06
15	1	4	0.60619E+06

Angle 'α'	a/b	h/t	Critical Load (N/m)
0	1	2	0.24367E+05

5	1	2	0.61020E+05
10	1	2	0.14383E+06
15	1	2	0.32665E+06



Angle ‘α’	a/b	h/t	Critical Load (N/m)
0	1	1	0.82125E+04
5	1	1	0.35547E+05
10	1	1	0.88530E+05
15	1	1	0.20161E+06



Angle ‘α’	a/b	h/t	Critical Load(N/m)
0	1.5	4	0.10393E+06
5	1.5	4	0.25980E+06
10	1.5	4	0.43014E+06
15	1.5	4	0.10848E+07

Angle ‘α’	a/b	h/t	Critical Load(N/m)
0	1.5	2	23037
5	1.5	2	79327
10	1.5	2	0.20491E+06
15	1.5	2	0.48881E+06

Angle ‘α’	a/b	h/t	Critical Load(N/m)
0	1.5	1	7344.1
5	1.5	1	36733
10	1.5	1	0.12011E+06
15	1.5	1	0.27723E+06

III. CONCLUSIONS

The FEM solution calculations obtained for a large number of models with compressive loading for simply supported boundary condition. The new buckling behaviour of the skew sandwich composite plate has been presented. For skew laminates with the same layup with simply supported boundary conditions the buckling force increases with increase of the skew angle α. The buckling load is sensitive for value of the lamination angle according to the plate length. The ranges of changes in material and geometrical parameters of sandwich trapezoidal composite plates correspond to the structural materials used for composite plates in practice. The values found for buckling forces and the diagrams presented can be employed in design calculations of such structures by practicing engineers. The solution of the problem is the background for post-buckling analysis.

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