A Simple Efficient Finite Element for the Sandwich Plates Analysis

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Abstract. *In this work, a numerical simulation has been considered of a sandwich composite panel subjected to a mechanical uniaxial load in order to study the buckling behaviors. In this study, we used the finite element Abaqus software and a simple efficient finite element model available in the literature* [1] *in order to:*
1- Describe the fundamental buckling modes of a sandwich composite panel.
2- Understand the buckling behavior on this type of structure.
3- Validate the reply of the developed element on buckling behavior for the sandwich composite structure with the finite element ABAQUS software.

1. INTRODUCTION

Nowadays, the sandwich composite materials have found more and more wide applications in all industrial sectors, such as aerospace, transport, civil engineering and leisure. This considerable use is probably due to the remarkable benefits of this type of materials namely; an excellent rigidity weight, good corrosion resistance, fatigue resistance and many more advantages particularly since their properties are adjustable for different situations. On the other hand, the analysis of multilayer composite structures is still questionable and soliciting accurate theories about complicated to describe their behavior and different mechanical problems. The modeling thick multilayer structures requires refined theories taking into account good expression of the effect due to the transverse shear deformation through their thicknesses and in particular the interlaminar. Therefore, several theories take into account the transverse shear effect on the analysis of multilayer composite structures that are the extension of the equivalent single layer approach [2]. The theories of higher order shear deformation (HSDT) have been proposed in the literature [3,4], in accurately assessing the deformation and stress of transverse shear multilayer plates without to need factors correction. Moreover, the theory of Reddy (TSDT) is the higher order theory most frequent for multilayer plates analysis when it is able to assess the stresses and transverse shear deformations with a small number unknown and do not depend on the layer number [5,6]. However, the third order theory of Reddy [TSDT] encounters a problem when finites elements are applied by requiring the second derivative C_1 [7], it is identical in the finite elements development of thin plate based on the classical theory [8]. Therefore, many of finite element models (2D) based on the higher order theory have been proposed in the literature and in various geometries and nodes and thus different number of degrees of freedom [9] for the analysis the stability behavior of sandwich composite plates. A review has published by Zhang and Yang (2009) [9] contains a recent development finite element for the analysis of multilayer composite plates.
The objective of this paper is to propose an efficient numerical model for the buckling problem of the sandwich composite panel in order to enrich the library of finite element simulation of the composite sandwich structure field.

2. THEORY

The static equation of the sandwich plate theory can be derived from the virtual work principle [5] by expressing the strain variation energy as follow:

$$\int_{-h/2}^{h/2}\int_{A}\left(\sigma_1\delta\varepsilon_1+\sigma_2\delta\varepsilon_2+\sigma_6\delta\varepsilon_6+\sigma_5\delta\varepsilon_5+\sigma_4\delta\varepsilon_4\right)dA\,dz+\int_{A}q\delta W dA=0 \tag{1}$$

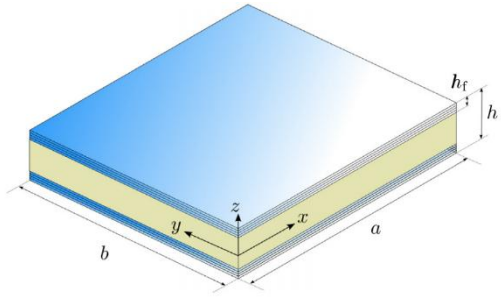

Figure 1. Geometry and coordinate system of sandwich composite plate.

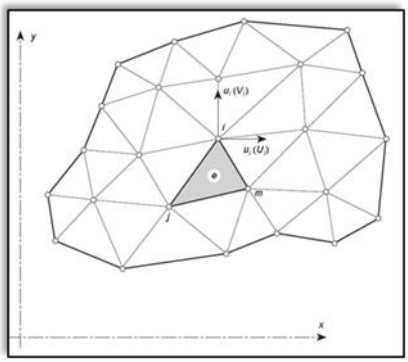

Figure 2. Finite element meshing *description of a solid*

In the linear buckling analysis, critical buckling load and modes are obtained by solving the eigenvalue of the stiffness matrix and geometric in a linear system. The linear analysis of a finite element-buckling problem could be expressed as follow [10]:

$$[K]+\lambda[Kg]=0 \quad (2)$$

3. FINITE ELEMENT FORMULATION

The present finite element is a C_0 four nodes isoparametric having seven DOF for each node [1] based on the higher order theory of the multilayer composite plate Fig 2.

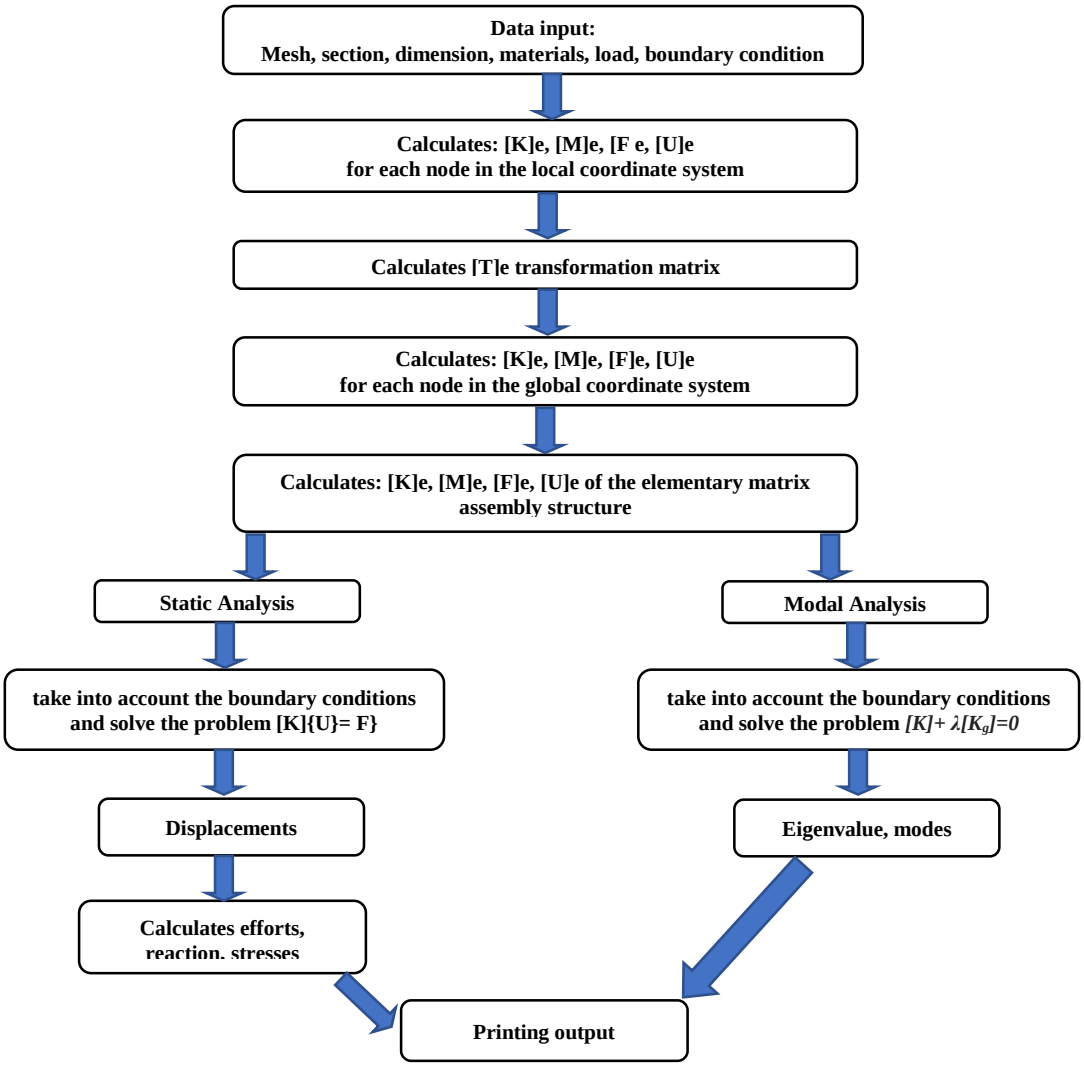

Figure 3. Program of the developed numerical finite element model.

4. RESULTS & DISCUSSION

A description has been considered for the first six buckling modes from the both numerical developed present element Fig 5. and the Abaqus software finite element S4R Fig 6. for a simply supported sandwich square plate subjected an uniaxial load with the ratio a/h=10. Very good agreement six results of the critical load buckling and also the same six shape modes have been obtained from the present element comparing with the software solution Abaqus.

Table 1. Mechanical proprieties normalized for sandwich plate.

Mechanical proprieties		E1	E2	G12	G13	G23	v12
Sandwich plate	core	0.04E	0.04E	0.016	0.06	0.06	0.25
	sheet	25E	E	0.5	0.2	0.5	0.25

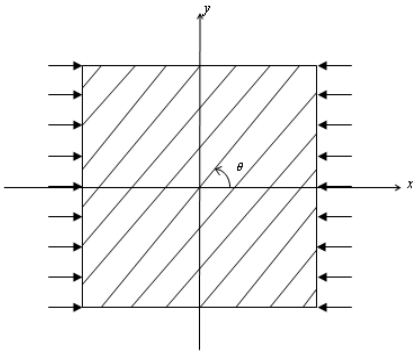

Figure 4. *Description of the plates subjected to uniaxial load*

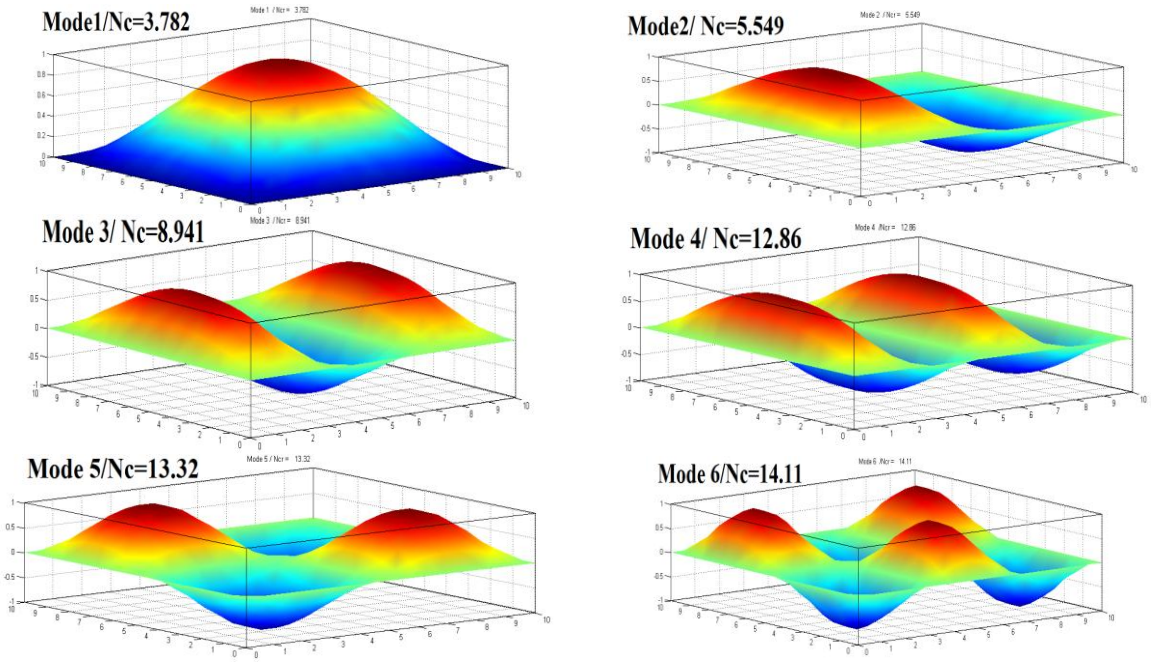

Figure 5. Six first buckling modes for an uniaxial buckling load of a simply supported sandwich square plate from the developed element

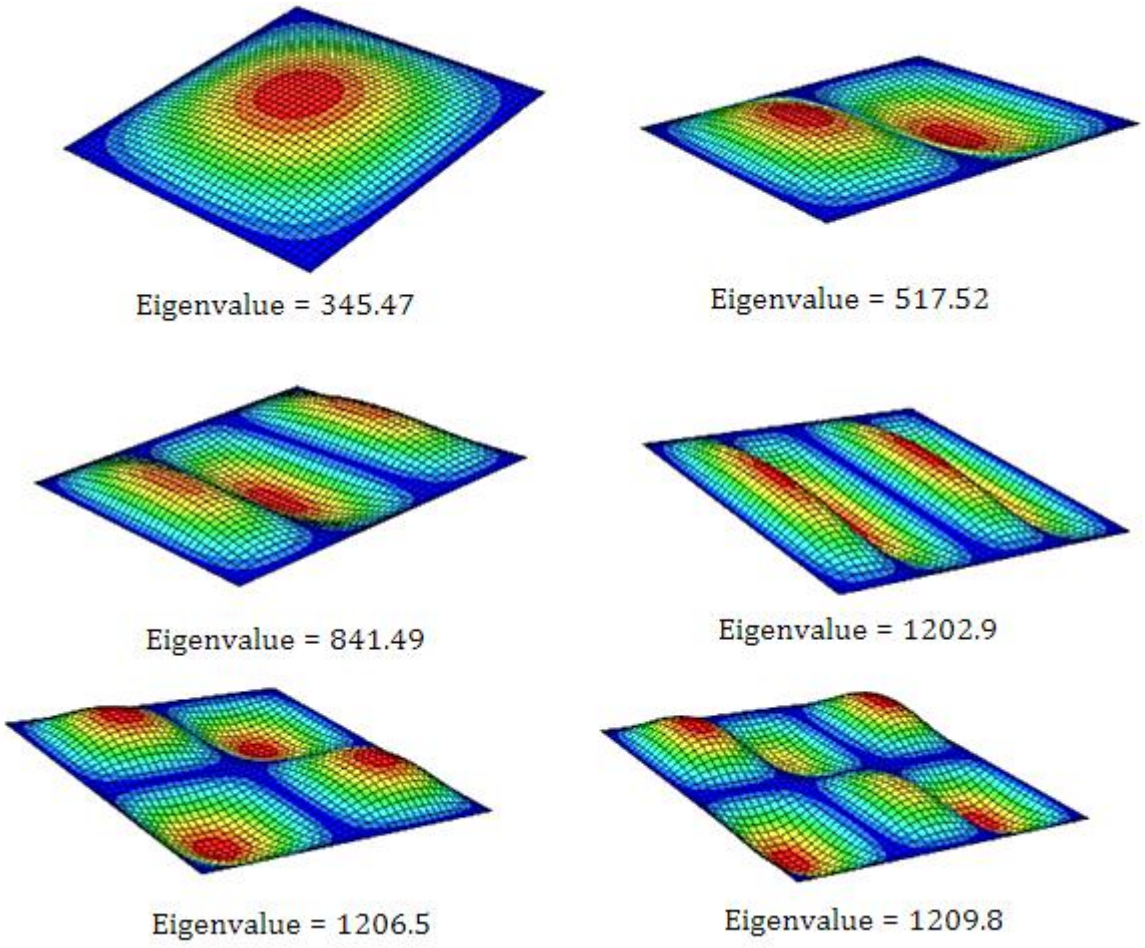

Figure 6. Six first buckling modes for an uniaxial buckling load of a simply supported sandwich square plate from the Abaqus element S4R

5. CONCLUSION

In this paper, a numerical study of a sandwich composite materials structure has been presented for the mechanical buckling behavior by a numerical finite element model available in the literature and via the finite element Abaqus software, that in order to: describing the fundamental buckling modes of a sandwich composite plate. More understanding about the sandwich structure on the buckling behavior. Confirming the results of the developed element on buckling behavior for the sandwich composite structure with the available finite element ABAQUS software.

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