

# FAILURE MODES OF SANDWICH STRUCTURES WITH FRP FACES – THEORY VS EXPERIMENTS

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The main advantages of sandwiches having composite faces are now well-known and well established. The current difficulty to overcome is to provide designers with proper methodologies and tools that could enable them to design improved sandwich structures based on advanced knowledge of sandwich behaviour at global and local scales. It relies on our capability to test, identify, control and model structural performances. The impressive variety of core and face materials gives new opportunities to design components which have more complex shapes and higher integrated functional capabilities but on the other hand it requires refined testing and modelling approaches that should be encouraged by relevant design guidelines.

Now, the finite element method gives an opportunity to model and compute almost everything but it is very difficult to call it as a practical guideline for designers. In addition to describe sandwich structure deformation in an accurate way it is necessary to introduce a special multi degrees of freedom finite elements since the correct modelling of the structural behaviour is of relevant interest. A broader discussion of those problems is presented in Ref [1]. In this paper we intend to propose an alternative approach based on the symbolic computations – the use of the Mathematica package. In the proposed approach shear deformation effects are taken into account for different variants of laminate-wise and layer-wise 2-D shell theories. The order of the theory is completely free but it should be chosen at the beginning of computations. The formulation is based on the functional of total potential energy in the Lagrange form. An arbitrary form of 2-D sandwich structure can be analysed via the required form of the Lamé parameters. Then with the aid of the Rayleigh-Ritz formulation buckling load factors can be derived for an arbitrary sandwich structure. The theoretical

formulation of this problem is discussed in Ref [2]. Some examples are presented in order to demonstrate the performance of such theories in the buckling analysis of sandwich plates, panels and shells.

In order to illustrate the validity of theoretical results the experimental verification of them have been conducted. It deals with the buckling analysis of axially compressed sandwich cylindrical panels. The experimental rig and forms of cylindrical panels are presented in Fig.1, whereas their failure modes are demonstrated in Fig.2.



Fig.1. The experimental rig

It has been observed that discrepancies between analytical results and experimental ones decrease as the order of 2-D shell theory increases. The better agreement has been obtained for layer-wise than laminate-wise variants of 2-D shear deformation theories. Theoretical results are very sensitive to the accurate description of sandwich core mechanical properties. It is and becomes

particularly manifest in the case of honeycomb cores.

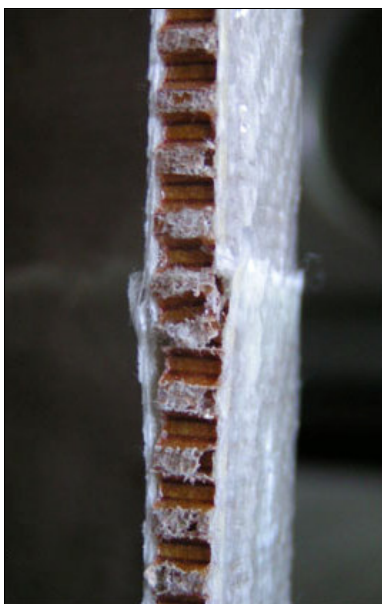


Fig.2. Failure mode of sandwich panel

#### References:

- [1] Muc A. "*Mechanics of Fibrous Composites*", Ksiegarnia Akademicka, Kraków, 2003 (in Polish).
- [2] Muc A. and Zuchara P. "Buckling and Failure Analysis of FRP Faced Sandwich Plates", *Composite Structures*, 48, pp. 145-50, 2000.