Insert sizing of sandwich panels by means of a failure mode map

abst. 15548
Auditorium
Wednesday
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10h20

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Sandwich structures are widely used in many industrial applications like acclimated transportation, aeronautics, aerospace, naval, civil engineering, fluid storage, electronics, etc. These structures offer an exceptional benefit when they are used in aeronautics, the incorporation of this technology into the aircraft structures has proved to be a great solution for mass reduction problems due to their important bending stiffness and low weight, which allows to design lightweight parts. Nevertheless, sandwich panels are only used for secondary structures of airplanes, like gear doors or control surfaces. The reason is because their design is complex (against impacts or loads introductions for instance) and difficult to ensure the quality requirements. In this context, sandwich panels joints trough inserts is a problem that is still investigated today and is the main subject of this research. The insert sizing is usually made using the methods proposed in the ”Insert design handbook” of the ESA and the ”Military handbook 23A”. These analytical methods based in the in the research carried by Ericksen in 1953 could lead to important errors of the pull-out allowable load prediction for some cases. This research is about the study of an insert installed into a sandwich panel for aeronautical applications with Nomex honeycomb core and CFRP skins. The objective is to develop a model of the insert behavior (including the different failure mechanisms) when it is pulled out. This includes a detailed study of the Nomex honeycomb core shear damage behavior, and a modelling strategy that allows to incorporate the nonlinear shear behavior at a very low computational cost. Also, a study of the breaking of the potting is made to better understand this failure mode of inserts. Then, a F.E. model of the insert is developed and validated by comparison against experimental results showing good agreement Finally, this F.E. model it is used extensively to perform virtual tests and to trace an insert failure mode maps that allows to estimate the insert pull-out strength as function of the properties of the inserts, like size and their material properties.

Free-vibration analysis of sandwich panels with viscoelastic cores using a Ritz-based variable kinematics approach and a fractional derivatives model

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This paper presents the extension to viscoelastic cores of a recently proposed variable kinematics (VK) modeling approach, the Sublaminate Generalized Unified Formulation (SGUF). The plate model is defined as a Layer-Wise (LW) assembly of "sublaminates", each composed of an arbitrary number of adjacent plies. An arbitrary approximation across the thickness can be attributed to each displacement component in each sublaminate: ESL or LW descriptions can be used in conjunction with any order of polynomial expansion. This VK approach is particularly effective for sandwich structures, whose strong material mismatch calls for a LW description for the skins and the core, each requiring adequate kinematic assumptions for representing the different mechanical response (e.g., transverse shear in the core, membrane in the skins). Viscoelastic core properties are taken into account through a fractional derivatives (FD) representation of the frequency-dependent material parameters. In order to simulate viscoelastic materials defined within a generalised Maxwell model, the corresponding FD model is first identified by means of a Particle Swarm Optimization process. The in-plane solution for the

variable kinematics plate model is defined through a Ritz-based approach. The resulting computational procedure is applied to free-vibration problems of several viscoelastic sandwich panels, and several algorithms for the solution of the non-linear complex eigenvalue problem are devised.

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Bending response of laminated sandwich beams with foam core - experimental tests and numerical analyses

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We study the behaviour of laminated sandwich beams (FRP skin-foam core-FRP skin) subjected to bending. Our aim is to find, basing on experimental observations, practical descriptions enabling effective and accurate estimation of the elastic response, damage and failure of the beam. Therefore a number of three (3p) and four (4p) point bending tests were launched for this purpose. Continuum mechanics is used in order to predict the beam response and the equations are solved by means of the finite element method (FEM). All the analysed beams have laminated skins composed of fire retardant vinylester resin and four layers (4x0.663 mm) of bi-directional balanced sewn E-glass woven fabrics. The beams foam core is made of Polyethylene Terephthalate (PET). Two core densities are considered: 100kg/m3 and 200kg/m3. The beams are 1200 mm long, 90 mm wide, and 75 mm high in all cases. The distance between supports in the 3p and 4p tests is set to 1000 mm. The force is applied via steel cylindrical cross-head at the mid-span in the 3p test and at the one-third spans in the 4p test. The experiments are carried out by the Zwick/Roell Z400 testing machine with a constant speed of the cross-head displacement 2 mm/min. It is observed during the experiments that the response of all the analyzed beams is linear at first. After that, in the 3p test, the cross-head force-displacement relation becomes nonlinear and local plastic deformation of the foam under the cross-head emerges, a moment before an inclined crack propagates suddenly through the core thickness from the location where the cross head is acting and the core fails because of shear. Slightly different behavior is observed in the 4p test. At first the beam response is linear, but then the force-displacement relation becomes nonlinear, but at a lower load level than in the 3p test, without any signs of plastic damage or cracking in the core. Finally, plastic deformation of the core is observed under the cross-heads and the beam suffers a rapid core shear failure. No damage of the laminated skins was observed during the 3p and 4p tests. Numerical simulations are performed, owing to the aforesaid experimental observation, that aim to describe the beam response. The problem is treated as a static one. Material and geometric nonlinearities are included in the equations to be solved by means of FEM using ABAQUS code. A fully elastic orthotropic material law under plane stress is used to represent stiffness of the skins. The foam is described with aid of the crushable foam plasticity material model with volumetric hardening. In order to establish the required law constants additional experiments were made: uniaxial tensile, uniaxial compression and isotropic compression tests. In consequence we obtained a very good agreement of the numerical and experimental results for the 3p tests in the field of force-displacement relations and comparison of strains. The foam shear strength was achieved in the core approximately at the moment of the observed beam failure during the experiment, therefore the numerical failure load and the damage mechanism also match the experiment. However, the estimations for the 4p tests differ from the measured response. Although the initial linear response of the beams in the simulations corresponds with the experiments, it remains linear until the start of local plastic deformation under the cross-head preluding the rapid beam failure, whereas the response became nonlinear much earlier in the experiment. This difference is caused by the inability of the crushable foam law to recreate the failure evolution in the foam because of shear. The numerical simulations revealed that the foam shear strength is achieved approximately when the early nonlinear behavior of the beam in 4p test started. Further research will address this problem.
