DOI: 10.5075/epfl-ICSS12-2018-218-219

THERMAL NON-LINEAR RESPONSE OF SANDWICH PANELS WITH TEMPERATURE DEPENDENT PROPERTIES – AN EXTENDED HIGH-ORDER APPROACH

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The non-linear geometrical response of a sandwich panel when subjected to thermal induced deformations field with and without external loads within the framework of high-order theories such as the High-Order Sandwich Panel Theory (HSAPT) and the extended high-order theory (EHSAPT). The proposed analysis takes into account the differences in the coefficients of the thermal expansion of the face sheets and the core and considers the effects of the properties degradation with rising temperatures on the response. The mathematical formulation is based on the EHSAPT model. It includes the thermal field effects through the kinematic relations on one hand and the degradations of the properties of the core through the definition of the stress resultant – displacements relations, see similar formulation in Frostig and Thomsen [1-2]. Please notice that the constitutive relations within the core consist of moduli of elasticity and shear that are coordinate dependent. A numerical study on a specific sandwich panel is conducted and its results consist of displacements, interfacial stress and stress resultants along the panel and through its depth. A comparison with other theories such as Classical, First-Order Shear Deformation Theory (FOSDT), Ordinary Sandwich Panel Theory (OSPT) and the High-Order Sandwich Panel Theory (HSAPT). In addition, equilibria curves of temperature or load versus extreme quantities of these structural quantities along the panel are presented. The thermo-mechanical response is demonstrated for a combination of specific defined external and rising temperatures with and without degrading mechanical properties. In general, this kind of combination cause an early failure due to loss of stability.

Two cases of load transfer are investigated. In the first one the compressive in-plane load is transferred through the core only, yielding a non-uniform in-plane displacement of the entire section of the panel at its edges, and in the second case the in-plane loads are applied at the face sheets and the core simultaneous leading to a uniform end-shortening.

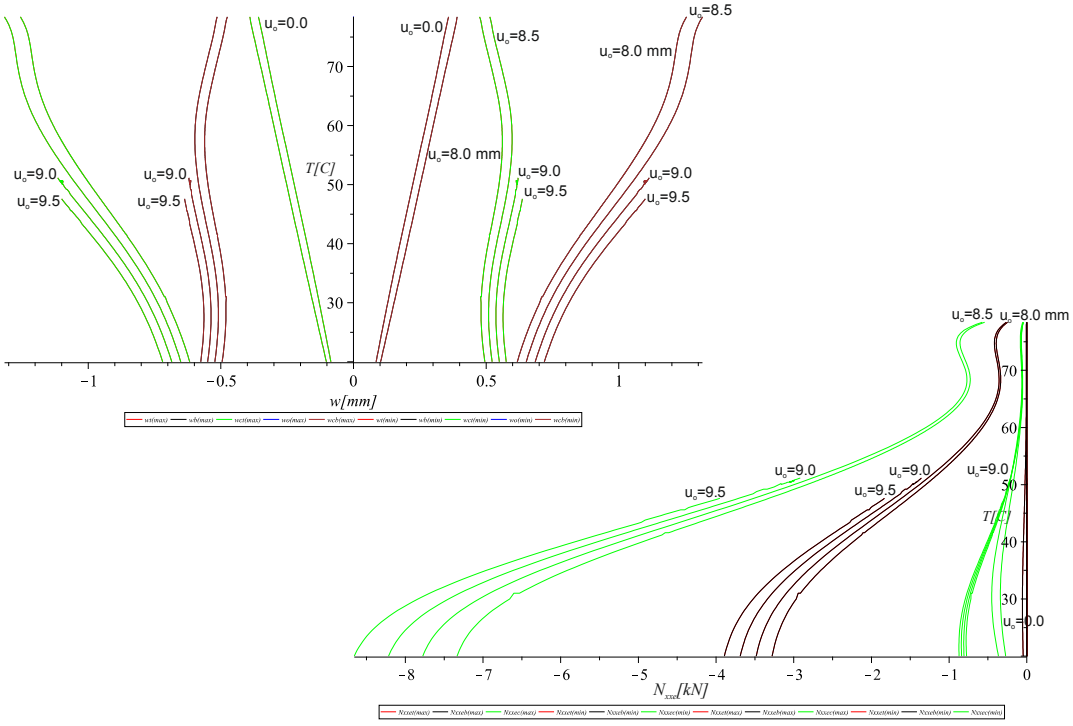

Fig. 1: Temperature versus extreme displacements for various in-plane load levels for load applied at core only, (uo=0 – temp. loading only, uo=9.5mm - 65% of failure load).

In both cases, an early failure occurs, prior to the collapse of the panel, due to temperature rise only, see Figs. 1 and 2.

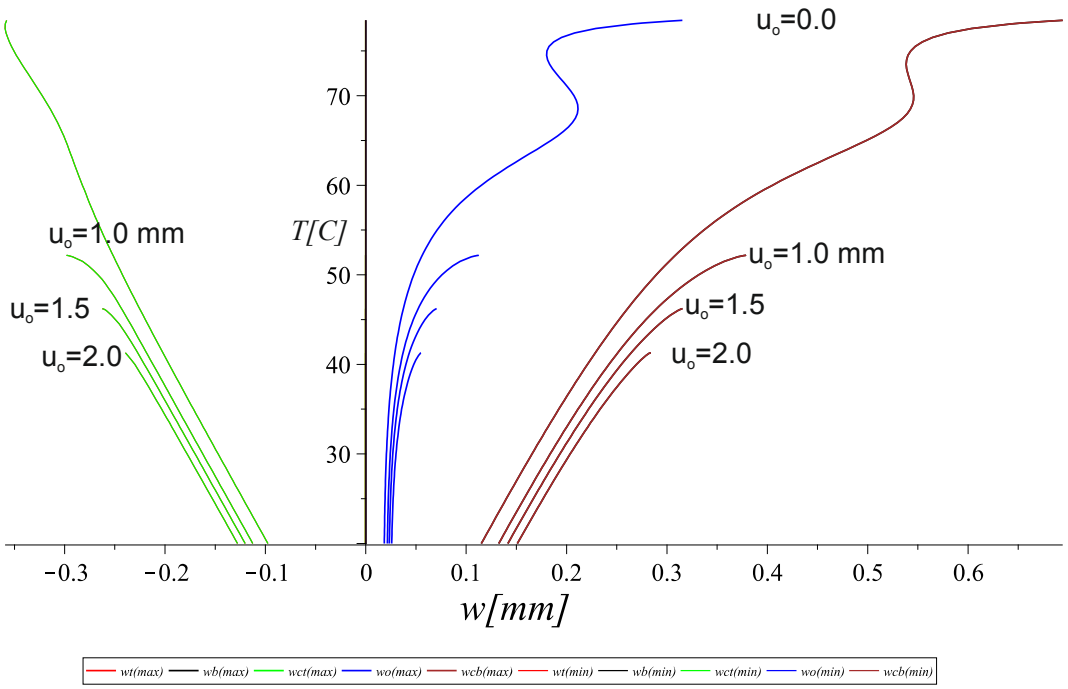

Fig. 2: Temperature versus extreme displacements for various in-plane load levels, end shortening load transfer, (uo=0 – temp. loading only, uo=2.0mm - 50% of failure load).

Please notice that the initial loss of stability (wrinkling), in both cases, occurs at temperature between 40-50ºC when external loads are applied simultaneous. Hence, the combination of load-temperature and degrading mechanical properties due to temperature must be considered simultaneously and not separately.

REFERENCES

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