

Experimental characterization and numerical modelling of the non-linear mechanical behaviour of Nomex honeycomb cores

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ABSTRACT

In this paper, a constitutive model dedicated to the non-linear mechanical behaviour up to failure of Nomex honeycomb cores is proposed. In nautical applications such as multihull sailing race boats, sandwich structures made of carbon/epoxy skins and Nomex honeycomb core are widely used. In terms of service, these boats have to face numerous severe mechanical loadings: wave impacts, slammings and violent swellings of veil, loadings which can lead to local failures of sandwich panels and eventually to abandons. As a consequence, the use of suitable constitutive laws appears necessary to ensure a safe design of these structures.

In a first part of the present work, the experimental characterization of the mechanical behaviour of two kinds of Nomex honeycomb cores is performed. The out-of-plan compressive response of the cores is measured by performing standard compression tests (ASTM C365-94). The out-of-plan shearing behaviour is investigated by the use of a non classical test involving quad-block specimen that avoids the drawbacks met in standard tests (ASTM C273-94) [1]. An important study of the interface, size and side effects, resting on numerical simulations, allows to propose an optimal design for the quad-block specimen.

The data collected from compressive tests underline the failure of the honeycomb core, failure due to buckling and apparition of a complex folding mechanism [2]. At the macroscopic level, this mode of degradation results in a stress versus strain curve outlining three major steps: elastic response, buckling instability associated to an important loss of stiffness and to a grow of irreversible strain and, at last, compaction hardening. Stress versus strain response curves also appear to be non-linear for shearing tests. They traduce a progressive loss of stiffness of the material before failure.

In a second part, a hypoelastic mechanical law, based on the thermodynamics of irreversible processes [3] and developed in the local objective corotational frame associated with the Green-Naghdi derivative [4], is proposed. The honeycomb core is modelled as a continuous medium. Its in-plan behaviour, considered as elastic fragile, is obtained thanks to classical homogenization methods [5]. Its non-linear out-of-plan behaviour, of major interest in sandwich applications, is modelled in a synthetic fashion by coupling damage and plasticity theories. The introduction of complex dissipation potentials enables to

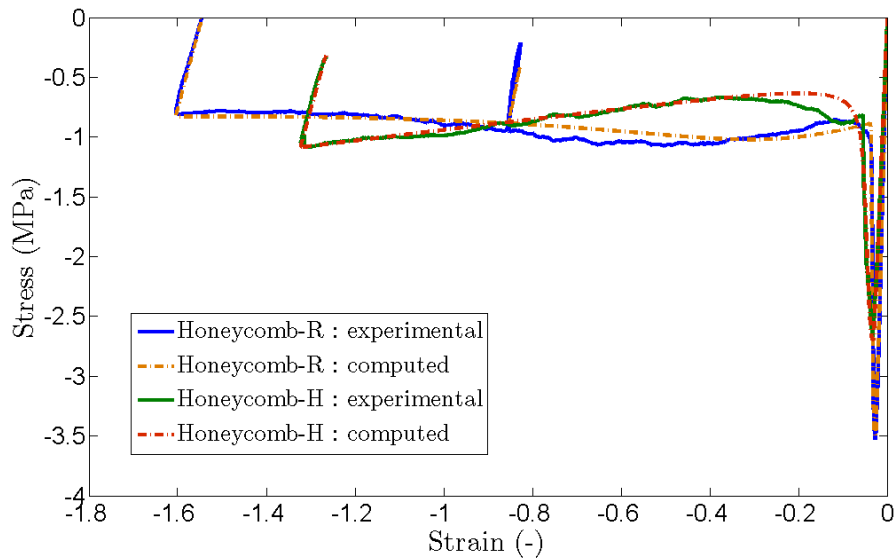


Figure 1: Comparison model/experience in out-of-plan compression

reproduce the whole response of the specimen as illustrated in figure 1 for the two kinds of honeycomb investigated.

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