8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

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

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Key Words: *crushing Nomex honeycomb core, instability, experimental characterization, numerical modelling*

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 abondons. 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 mesured 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

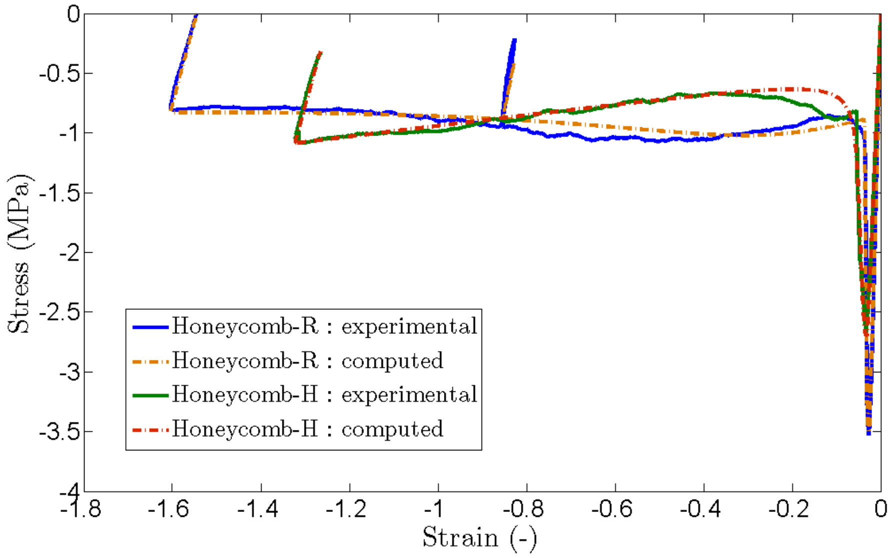

Figure 1: Comparison model/experience in out-of-plan compression

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

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