ELASTIC-PLASTIC STABILITY OF FML COLUMNS OF OPEN CROSS-SECTIONS

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1. INTRODUCTION

Fiber Metal Laminates (FMLs) are hybrid materials, built from thin layers of metal alloy and fiber reinforced epoxy resin. These materials are manufactured by bonding composite plies to metal ones. FMLs, with respect to metal layers, can be divided into FMLs based on aluminum alloys (ARALL reinforced with aramid fibers, GLARE - glass fibers, CARALL - carbon fibers) and others. Nowadays material such as GLARE (glass fiber/aluminum) due to their very good fatigue and strength characteristics combined with the low density find increasing use in aircraft industry [1].

When the plate structures made of GLARE subject to in-plane uniform compression in the elasto-plastic range of stresses, the buckling occurs in such a way that aluminum layers become plastic but the glass layers remain elastic. Therefore the behavior of such structures differs significantly from the behavior of pure aluminum ones.

2. SUBJECT OF CONSIDERATION

A prismatic thin-walled structure built of FML plates connected along longitudinal edges has been considered (Fig. 1). The structure is simply supported at its ends. In order to account for all modes of global, local and coupled buckling, a plate model of thin-walled structure has been applied. It is also assumed that both component materials the structure is made of obey Hooke's law.

3. METHOD OF SOLUTION

The problem of inelastic buckling is examined using the analytical-numerical method elaborated for the analysis of the elastic stability of multi-layered thin-walled columns [2]. The layers can be isotropic or orthotropic. Determination of buckling stresses and buckling modes of thin-walled plate structures in the elastic plastic range requires the material characteristic to be known for a material under consideration. In case of aluminum it can be described in an analytical way by Ramberg-Osgood formula or Needleman-Tvergaard relation [2]. The relationships between stress and strain for a component elasto-plastic layer are derived on the basis of the J_2-deformation theory of plasticity and/or J_2-flow theory (incremental theory). On the other side the same relations are written for an orthotropic elastic layer. Comparing the appropriate coefficients in both relations the instantaneous "conventional" parameters of orthotropy can be found out.

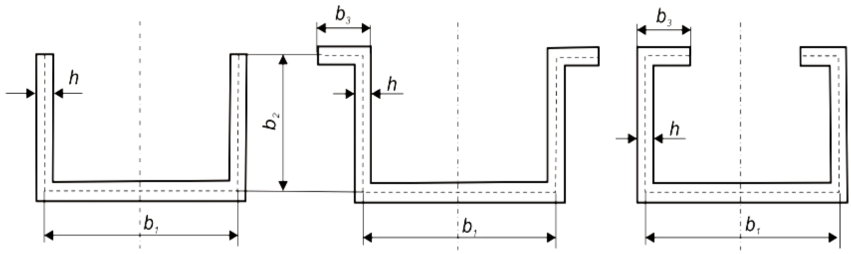

Fig. 1. Cross-sections of analysed columns

The columns are built of rectangular flat plates. The material is GLARE 3 [1] with an even number of glass reinforced layers, the outer layers are always aluminum. The overall laminate is symmetric. The dimensions of structures are chosen in such a way that the stability loss occurs in the elastic-plastic range for aluminum layers.

4. SOME RESULTS OF CALCULATIONS

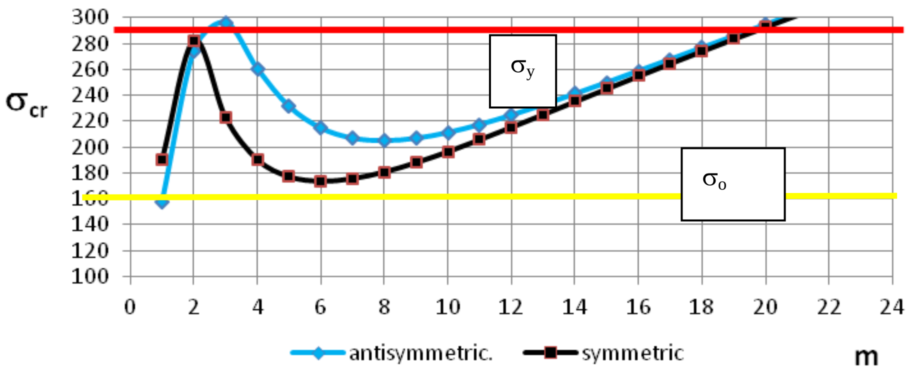

Fig. 2. Buckling stress versus number of half-waves *m* for symmetry and antisymmetry conditions imposed along cross-section symmetry axis (σ_y-aluminum yield limit, σ_o -proportional limit)

In Fig. 2 the calculation results for a column of a channel cross-section are shown. The calculations are based on J_2 deformation theory and Ramberg-Osgood relation.

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