DYNAMIC BUCKLING OF FML THIN-WALLED PANELS

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1. INTRODUCTION

The introduction of Fiber Metal Laminates (FMLs), especially GLARE™, into aircraft primary structure applications has brought significant improvements over current available materials for aircraft structures. The hybrid nature of FMLs (partly metallic and partly composite - see Fig. 1a) has the advantage of lower density when compared with monolithic aluminium fuselage skins, but more importantly it has better fatigue features due to the fibre layers which 'arrest' fatigue crack growth [1]. However, the hybridization of materials in multi-layered structures makes lower thickness of particular layer and leads to a decrease in the buckling load capacity [5]. Thus the buckling problem becomes more demanding in case of thin-walled profiles made of FML type material when they may undergo local, distortional, overall or mixed modes of buckling and the accurate prediction on the FML member strength becomes more complex task.

One can find some works devoted to buckling of thin-walled members made of FML like materials. These rather few works published mostly in Delft and our Department concern static response of FML plates, shallow cylindrical panels and plate profiles [5][6]. However as structural elements of aircraft structures they may be subjected to dynamic loads which can also lead to buckling response [3]. The dynamic stability of thin-walled members encompasses many classes of problems and physical phenomena, for example parametric resonance, parametric excitation and impulse buckling. The latter concern dynamic discrete loading of finite duration caused also by natural forces like wind or in terms of solid-fluid interaction. The dynamic impulse buckling occurs when the loading process is of an intermediate amplitude and the pulse finite duration is close to the period of fundamental natural flexural vibrations [3]. Under in-plane dynamic loads a rapid deflections growth of panel walls, which are initially not flat but imperfect can be observed. There is no buckling load and there is no bifurcation point over the loading path, as in the static case. Therefore the dynamic critical load is to be defined on the basis of an assumed dynamic buckling criterion [2].

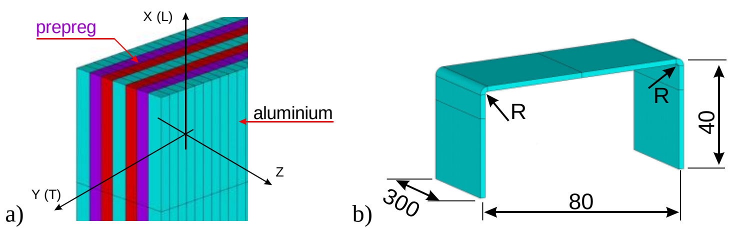

Fig. 1. a) FML lay-up; b) dimension of channel profile

2. CHANNEL PROFILE DYNAMIC BUCKLING

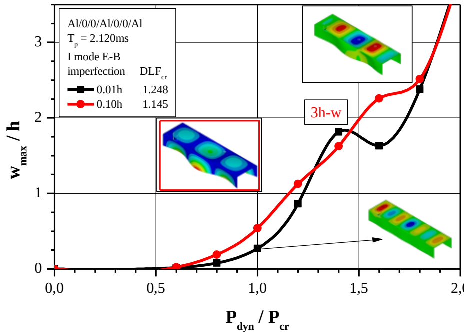

Fig. 2. Maximal deflection of channel wall as a function of pulse amplitude

Under analysis is a thin-walled channel profile made of FML material subjected to axial uniform pulse compression. The dimensions of considered structural element are given in Fig. 1b. It is assumed that both loaded edges of channel section are simply supported. Material properties of FML constituents - isotropic of aluminium and orthotropic of glass fiber composite, are assumed as in [5] and not repeated here. The dynamic buckling analysis is performed with application of FEM and ANSYS software. Employed numerical model made of shell finite element was evaluated during previous static buckling research when agreement with laboratory tests and analytical approach proved its quality [5]. The whole analysis was performed in three steps [4]. The last one - transient analysis has led to plots as in Fig. 2 which allows to determine a critical dynamic load value with application of chosen dynamic buckling criterion. Details of this procedure one can find in [3]. During the Symposium on Stability of Structures some representative results of this investigation will be presented where the influence of FML stacking, pulse shape and pulse duration are considered.

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