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NUMERICAL STUDY AND DESIGN OF EXTRUDED INTEGRALLY STIFFENED PANELS (ISP) FOR AERONAUTIC APPLICATIONS SUBJECTED TO BLAST LOADING

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Fuselage panels in aircraft applications are reinforced structural parts subjected to strong buckling effects under normal flight loads. These loads are typically in-plane compression and in-plane shear solicitations, leading to complex buckling behaviors [1]. The ability of a structure to survive non-typical loads, i.e. blast loading from a terrorist attack or an incidental explosion, has also became a major concern. The detonation of an explosive material in the air generates an expanding shock front of finite amplitude moving supersonically [2]. The space and conditions between the point of detonation and the encountered obstacles affect the propagation and magnitude of the pressure wave, resulting in a complex transient structural load [3, 4, 5]. Advanced numerical techniques, such as the Finite Element Method (FEM), can be used in understanding the influence of the blast load and the resulting dynamic structural response in detail. However the reliability and stability of finite element results must be validated with experimental data.

Analysis of the dynamic response of plates subjected to different kinds of impulsive loads has been an area of active research over the last decade [6, 7]. More recently, Spranghers *et al.* [2] presented a experimental and numerical study of aluminum plates under blast loading with some numerical considerations that are adopted in the present work. Also, Kumar *et al.* [8] presented a study on the response of aluminum plates under blast loading and the effect of the plates curvature on the structural response. Nurick *et al.* [9] presented an experimental study on the deformation and tearing of blast-loaded stiffened square steel plates. In addicion, Nurick and Shave [10] and Teeling-Smith [11] performed experiments on plates attached to a ballistic pendulum under impulsive loads and presented an experimental study on the deformation and tearing of thin circular plates subjected to blast loading, respectively. Neuberger *et al.* [12, 13] measure the deflection of the central point of a circular plate subjected to free air blast loading and detonations of buried charges, obtaining a good agreement between numerical simulations predictions and test results. Finaly, Ramajeyathilagam *et al.* [14] and Chan-Yung Jen *et al.* [15] both presented studies of the dynamic behaviour of rectangular plates and stiffened panels, respectively, subjected to underwater shock loading.

In this study, the Finite Element Method was used to analyze the structural response of integrally stiffened panels (ISP) subject to a blast loading from a Composition C4[1] explosive material. For this purpose, two approaches were made in the development of the numerical models, the first approach corresponding to the validation of the numerical model. In this approach, 4 types of models were developed, being divided in 2 groups: (i) type of elements used in the model (shell or solid); and (ii) the complexity of the models. The simplified model considered only the thin aluminum plate (target), while the complete model considered the set used in the experimental setup (steel frame, aluminum clamp and plate). This part of the work relies in what was already developed and studied by Spranghers *et al.* [2], serving only as a basis for the rest of the numerical study. The numerical validation of the models was made through the comparison between the center point displacement of the aluminum plate and x-axis and y-axis cut view in three time instances (0.24, 0.48 and 0.72 ms). The second approach corresponds to a sensitivity analysis of different stiffener profiles and configurations. For this study, 4 stiffener profiles were initially used: I shaped, L shaped, T shaped and trapezoidal shaped stiffeners.

The developed numerical models showed accurate results when compared to the experimental data provided by Spranghers *et al.* [2]. The complete model with solid elements provided the more accurate results. On the other hand, it's CPU time, when compared to the shell element model, is much higher. Both analysis, presented good results which led to the conclusion that the model is valid. However, the numerical model accounting for the stiffeners didn't benefit from any experimental data to compare, so the conclusion are still theoretical. From the different stiffener profiles studied, the T shaped stiffener showed the best results, with an optimized geometry of $L = 90$ mm and $b = 60$ mm.

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[1]C4 is cyclotrimethylene-trinitramine (C3H6N6O6), commonly called RDX. The additive material is made up of polyisobutylene, the binder, and di(2-ethylhexyl) sebacate, the plasticizer. It also containsa small amount of motor oil and some 2,3-dimethyl-2,3dinitrobutane (DMDNB).

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