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Impact of Boundary Conditions on the Behavior of Thin-Walled Laminated Column with L-Profile under Uniform Shortening

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Abstract : Simply supported angle columns subjected to uniform shortening are tested. The experimental studies are conducted on a testing machine using additional Aramis and the acoustic emission system. The laminate samples are subjected to axial uniform shortening. The tested columns are loaded with the force values from zero to the maximal load destroying the L-shaped column, which allowed one to observe the column post-buckling behavior until its collapse. Laboratory tests are performed at a constant velocity of the cross-bar equal to 1 mm/min. In order to eliminate stress concentrations between sample and support, flexible pads are used. Analyzed samples are made with carbon-epoxy laminate using the autoclave method. The configurations of laminate layers are: $[60,0_2,-60_2,60_3,-60_2,0_3,-60_2,0,60_2]T$, where direction 0 is along the length of the profile. Material parameters of laminate are: Young's modulus along the fiber direction - 170GPa, Young's modulus along the fiber transverse direction - 7.6GPa, shear modulus in-plane - 3.52GPa, Poisson's ratio in-plane - 0.36. The dimensions of all columns are: length-300 mm, thickness-0.81mm, width of the flanges-40mm. Next, two numerical models of the column with and without flexible pads are developed using the finite element method in Abaqus software. The L-profile laminate column is modeled using the S8R shell elements. The layup-ply technique is used to define the sequence of the laminate layers. However, the model of grips is made of the R3D4 discrete rigid elements. The flexible pad is consists of the C3D20R type solid elements. In order to estimate the moment of the first laminate layer damage, the following initiation criteria were applied: maximum stress criterion, Tsai-Hill, Tsai-Wu, Azzi-Tsai-Hill, and Hashin criteria. The best compliance of results was observed for the Hashin criterion. It was found that the use of the pad in the numerical model significantly influences the damage mechanism. The model without pads characterized a much more stiffness, as evidenced by a greater bifurcation load and damage initiation load in all analyzed criteria, lower shortening, and less deflection of the column in its center than the model with flexible pads.
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