BUCKLING AND POSTBUCKLING BEHAVIOUR OF THIN-WALLED COMPOSITE CHANNEL SECTION BEAM

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Summary: The article presents results of experimental investigations of thin-walled beams made with carbon fiber composite. Experimental studies were conducted to confirm results obtained from numerical calculations, which was performed using finite element method and proposed analytical-numerical method. The studies consisted of axially compressed thin-walled channel section columns.

1 EXPERIMENTAL INVESTIGATION

The experimental tests were conducted on axially compressed thin-walled composite columns with channel cross-section. The main aim of the study was to confirm the results obtained by using the drop-down from many years of analytical-numerical method and adopted numerical models. The critical load, postbuckling behaviour, carrying capacity and failure form was investigated.

The specimen for the tests were made of unidirectional composite HexPly prepreg system codenamed M12/35%/UD134/AS7/300. The used laminate was epoxy resin matrix with carbon fibers AS7J12K reinforcement. The nominal volume fraction of reinforcement was about 60%. The manufacturing process included the preparation of vacuum bag, which is connected to a vacuum pump providing a pressure of about -0.1 MPa, and then subjected to a process of curing in autoclave. For the carbon/epoxy composite, a limit of pressure in an autoclave at 0.4 MPa and a temperature of 135 °C heat in about 2 hours. Thin-walled channel columns were prepared with dimensions of 80×40×1.048 mm and a length of 300mm consisting of eight carbon/epoxy plies with different symmetrical arrangements. For the materials produced have been experimentally determined tensile properties in accordance with the relevant standards for this type of the indicated materials. Also assessed the quality of structures produced using non-destructive methods of NDT and microstructural...
examination using optical microscopy. Thus prepared and tested columns were used as samples for experimental research.

All tests were performed using the Zwick Z100 static test machine type SN3A (accuracy class 1). It is a table top system machine. The laminated channel specimens was held by the fixture apparatus that was placed on the upper and lower crosshead of a testing machine which was designed to offer simple support conditions on the edges and axial compression. Using small increments the applied axial load was increased in the experiment for the imperfect structures. The resulting axial force, longitudinal shortening and lateral displacement were recorded. The development of the displacement was recorded via optical sensor NCDT 1605/2. Additionally in chosen points the strain were registered using strain gauges measurement technique. There were used the VISHAY single gauges. The loads, displacements and strains were recorded during tests using Hottinger MGC plus Date Acquisition Systems.

The experimental critical loads using the different method were determined. In calculations, the method base on Koiter’s theory [1] and Tereszkowski’s method [2] or tracking the post buckling path were used. A good agreement of the results obtained by mentioned above method has been achieved, but the well known Southwell’s method didn’t work correctly in considered cases.

2 NUMERICAL METHODS

The finite element method and analytical-numerical method were employed to buckling analysis and post buckling behaviour of thin-walled composite columns.

Two different software packages (ANSYS® and ABAQUS®) were used for numerical calculation. For discretization the four nodes multilayers shell elements with six degree of freedom at each node was used. The modeled boundary condition were as close as possible to condition in experimental tests.

The buckling load and postbuckling behaviour was analyse using also analytical-numerical method [3]. In analytical-numerical method the thin-walled prismatic columns composed of rectangular plate segments interconnected along longitudinal edges were considered. The postbuckling behavior of elastic thin-walled composite columns been analysed within the second order of the Koiter’s asymptotic stability theory of conservative systems [1].

REFERENCES

