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BUCKLING ANALYSIS OF GRID STIFFENED COMPOSITE CYLINDERS

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ABSTRACT

Due to their high stiffness to mass ratio, stiffened cylindrical composite shells are major components of Aerospace and Aircraft industries. These structures are employed in fuselage and fuel tank applications, and are usually subjected to combinations of compressive, shear or transverse loads. Usually the failure mode associated with these structures is buckling. This failure mode is further subdivided into 'local skin and/or stiffener buckling', and 'universal buckling'.

In this paper buckling investigation of a grid stiffened composite cylinder is presented using analytical model, Finite elements model and experimentation. The cylinder under discussion has orthotropic stiffeners integrally made with an orthotropic shell. All the buckling analysis is based on a uniaxial compressive load condition.

An analytical mo del is first developed that reduces the grid/shell cylinder panel to an equivalent orthotropic laminate (Fig. 1). This model makes use of the force and the moment interactions and derives the A, B and D matrix of the equivalent laminate model. Consequently buckling loads are calculated making use of the energy method. Using the analytical model developed, parametric analysis is preformed to determine optimum configuration of stiffeners and shell.

A Finite elements model is also built using ANSYS for the same cylinder. Buckling analyses are performed on different models built with different configurations of stiffener and shell parameters. The effect of shell thickness variation on buckling load and buckling mode is studied in detail (Fig 2). Based on this the optimum skin thickness is determined for a given stiffener configuration. In this section correlation is made between failure mode and optimum skin thickness. In addition to skin thickness the effect of stiffeners angle variation is also analyzed using ANSYS. The result is plotted and conclusions are drawn on optimum stiffener orientation.

Buckling experiment was also performed on a stiffened composite cylinder specimen (Fig 3). The test setup and the results obtained are discussed briefly.

Finally this paper tries to compare the different results obtained using the three analysis methods. An attempt is made to account for certain differences observed between the three analysis methods. Conclusions are drawn on the reliability of the analytical model developed and remarks made on limitation of model.

FIGURES AND TABLES

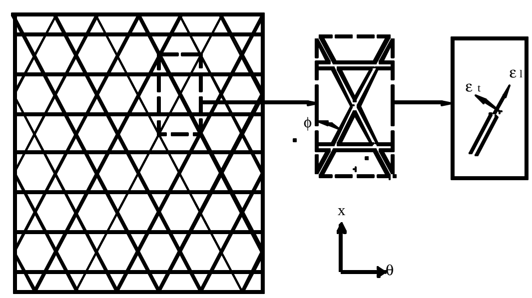

Fig. 1 Unit cell.

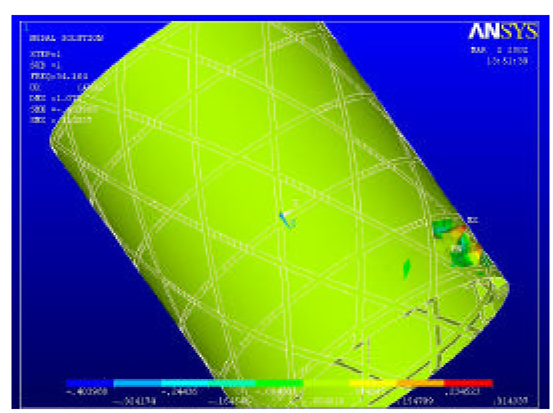

Fig. 2 FEM analysis (local skin buckling)

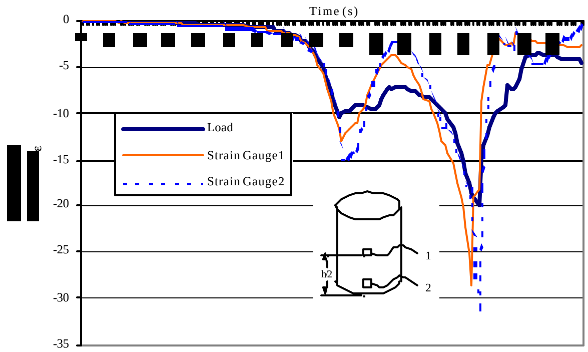

Fig. 3 Experimental results.

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REFERENCES

1. Helms JE, Li G, Smith BH. Analysis of Grid Stiffened Cylinders. ASME/ETCE 2001.
2. Brush DO, Almroth BO. Buckling of Bars, Plates, and Shells. McGraw-Hill Book Company, New York, NY 1975.
3. Bruhn EF. Analysis and Design of Flight Vehicle Structures. Jacobs Publishing, Inc., Carmel, IN June 1973
4. Navin J, Norman FK, Damodar R. Formulation of An Improved Smeared Stiffener Theory of Buckling Analysis of Grid-Stiffened Composite Panels. NASA technical Memorandum 110162, June 1995.
5. Ramm E. Buckling of Shells. Springer-Verlag, Berlin 1982.
6. Gerdon G, Gurdal Z. Optimal Desing of Geodesically Stiffened Composite Cylindrical Shells. AIAA Journal, November 1985; 23(11):1753-1761.
7. Troisky MS. Stiffened Plates, Bending, Stability and Vibrations. Elsevier, 1976.
8. Phillips JL, Gurdal Z. Structural Analysis and Optimum Design of Geodesically Stiffened Composite Panels. Report NASA CCMS-90-50, (VPI-E-90-08), Grant NAG-1-643, July 1990.
9. Whitney JM. Structural Analysis of Laminated Anisotropic Plates. Technomic, 1987.
10. Agarwal BD, Broutman LJ. Analysis and Performance of Fiber Composites. John Wiley and Sons, 1990.
11. Dow NF, Libove C, Hubka RE. Formulas for Elastic Constants of Plates with Integral Waffle-like Stiffening. NACA RM L53L1 3a, August 1953.