Blended-Wing-Body Structural Technology Study

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FINAL REPORT

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INTRODUCTION

In most studies of stability of plates, the axial stress has been taken as uniform compression throughout flat rectangular plates.[1-3] Buckling of isotropic plates under a compressive stress that varies linearly from one loaded edge to the other has been studied by Libove *et al.*[4] Cases of practical interest exist, however, in which the axial stress is not uniform but varies from tension at both loaded edges to compression in the middle. An example is the stability of the crown of the hat stiffened panel, a candidate configuration of the upper and lower skin of the Blended Wing Body (BWB) Aircraft. The BWB Aircraft is an advanced long-range ultra-high-capacity airliner with the principal feature being the pressurized wide double-deck body which is blended into the wing.[5]

In the present research, analytical methods are used to investigate the local stability of the crown in order to minimize its weight while optimizing its buckling strength. The crown is modeled as a rectangular laminated composite plate subjected to a second degree parabolic variation of axial stresses in the longitudinal direction. A varying tension-compression-tension axial stresses are induced in the crown of the stiffeners due to bending. The change in axial stresses is equilibrated by nonuniform shear stresses along the plate edges and transverse normal stresses.

SUMMARY OF ACCOMPLISHMENTS

The elastic buckling load of simply supported rectangular composite plates subjected to a second degree parabolic variation of axial stresses in the longitudinal direction is calculated using analytical methods. The variation of axial stresses is equilibrated by nonuniform shear stresses along the plate edges and transverse normal stresses. Numerical results are reported for three different cases: (1) orthotropic plates, (2) symmetrically laminated plates with multiple generally orthotropic layers exhibiting coupling between normal moments and twist, and twisting moment and normal curvatures, and (3) unsymmetrically laminated plates. Rayleigh-Ritz and Galerkin's methods are used to calculate the buckling loads. An approximate solution using "reduced bending stiffness" is adopted for unsymmetrically laminated plates. The influence of the aspect ratio is examined, and the results are compared with plates subjected to uniform axial stresses.

Detailed analysis and results are outlined in the attached two publications:

1. Badir, A., H. Hu, and A. Diallo "Elastic Buckling Of Orthotropic Plates Under Varying Axial Stresses," *Proceedings of the American Society For Composites (ASC)*, Dearborn, Michigan, October 1997, pp. 23-30.

2. Badir, A. and Hu, H. "Elastic Buckling of Laminated Plates Under Varying Axial Stresses," *Proceedings of the 39th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, Long Beach , California, April 20-23, 1998, pp. 635-640.

PRESENTATIONS

1. Badir, A. "Elastic Buckling Of Orthotropic Plates Under Varying Axial Stresses," *Presented at the American Society For Composites (ASC)*, Dearborn, Michigan, October 1997.

2. Badir, A. "Elastic Buckling of Laminated Plates Under Varying Axial Stresses," Presented at *the 39th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, Long Beach , California, April 20-23, 1998.

STUDENT PRESENTATION

1. Diallo, A. "Buckling of Composite Plates Under Combined Non-Uniform Stresses," Presented at the NASA URC Technical Conference, Huntsville, Alabama, February, 22-25, 1998.

STUDENT PARTICIPATION

Student Name : A. Diallo, Graduate Student, Department of Mathematics, Clark Atlanta University.

REFERENCES

1. Timoshenko, S. P. and J. M. Gere, 1961. "Theory of Elastic Stability," 2nd ed. McGraw-Hill Book Company.
2. Allen, H. G., and P. S. Bulson, 1980. "Background to Buckling," McGraw-Hill Book Company.
3. Whitney, J. M. 1987. "Structural Analysis of Laminated Anisotropic Plates," Technomic Publishing Company.
4. Libove, C., S. Ferdman, and J. Reusch. 1949. "NACA Tech. Note No. 1891."
5. Popular Science Magazine, April, 1995.