IN MEMORIAM: Dr. Michael Fawcett Card (1937 – 2013)

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"Dr. Michael Fawcett Card, 76, of Williamsburg, passed away peacefully after a lengthy illness on November 8, 2013. Born in Seattle, Washington, Card earned a Bachelor of Science degree in aerospace engineering from the Massachusetts Institute of Technology. He also received a masters and PhD from Virginia Tech. He retired in 1995 after 37 years of service at NASA Langley Research Center in Hampton, where he served as Chief Scientist. Prior to this appointment, he served as the Chief of the Structural Mechanics Division. From 1988 to 1989 he worked at Marshall Space Flight Center in Huntsville, Alabama on the space shuttle as assistant to the Director to Marshall Structures and Dynamics Laboratory. During his career he was the author of more than 30 papers on structural mechanics. Card loved music, reading, and the movies."

Selected Publications:

Anderson, M. S. and Card, M. F., "Buckling of Ring-Stiffened Cylinders Under a Pure Bending Moment and a Nonuniform Temperature Distribution," NASA TN D-1513, 1962.

Card, M.F., "Preliminary results of compression tests on cylinders with eccentric longitudinal stiffeners", NASA TM X-1004, 1964

Block, D.L., Card, M.F. and Mikulas, M.M., "Buckling of Eccentricelly Stiffened Orthotropic Cylinders", NASA TN D-2960, August,1965.

Card, M.F. and Jones, R.M., "Experimental and Theoretical Results for Bucklinq of Eccentrically Stiffened Cylinders", NASA TND-3639, October, 1966.

Michael F. Card (NASA Langley Research Center, Hampton, Virginia, USA), "Bending tests of large-diameter stiffened cylinders susceptible to general instability", NASA TN D-2200, 1964

Michael F. Card (NASA Langley Research Center, Hampton, Virginia, USA), "Experiments to Determine Elastic Moduli for Filament-Wound Cylinders", NASA Technical Note TN D-3110, November 1964
DTIC Accession Number: ADA310372, Handle / proxy Url : http://handle.dtic.mil/100.2/ADA310372
ABSTRACT: Elastic moduli for filament wound cylinders having a wall configuration composed of several alternating helically and circumferentially wrapped layers are determined experimentally. The moduli were determined from measurements made on several glass epoxy cylinders and tubes loaded in pressure, torsion, or compression. Computations of elastic constants were made for the test specimens as well as for hypothethical boron epoxy cylinders to demonstrate the importance of the matrix in determining extensional stiffness. A comparison of calculations and experiment indicates that moduli measured in regions where the cylinder matrix behaves linearly are in reasonable agreement with computed values.

J. Peterson and M.F. Card, "Investigation of the buckling strength of corrugated webs in shear", NASA TN D-424, 1966

Michael F. Card (NASA Langley Research Center, Hampton, Virginia, USA), "Experiments to Determine the Strength of Filament-Wound Cylinders Loaded in Axial Compression", NASA Technical Note D-3522, August 1966,

DTIC Accession Number: ADA307211, Handle / proxy Url : http://handle.dtic.mil/100.2/ADA307211
ABSTRACT: Results of compression tests conducted on 51 multilayered glass-epoxy cylinders are presented. Tests were conducted at both room temperature and elevated temperatures on cylinders having various helical wrap angles, matrix materials, and diameters. Experimental results indicate that, in some of the cylinders, failures were induced by buckling whereas, in others, failures were induced by thermal degradation and/or nonlinearity in the stiffness of the matrix material in the cylinder wall. The data obtained from the unheated cylinders are compared with buckling predictions based on linear anisotropic shell theory and with material strength predictions based on anisotropic yield criteria. The comparison indicated that agreement obtained between buckling tests and theoretical predictions was comparable to that obtained in previous experience with metal cylinders and that strength predictions were overly conservative. The results suggest that the compressive strength of a filament-wound cylinder can be limited by its material strength and that more refined material strength analyses are needed for multilayered fibrous composites loaded in axial compression.

M.F. Card, The sensitivity of buckling of axially compressed fibre-reinforced cylindrical shells to small geometric imperfections, NASA TMX-61914 (1969)

Chang, L. K. & Card, M. F. (1970). Thermal buckling of stiffened cylindrical shells. Proceeding of the AIAA/ASME 11th structures, Structural Dynamics, and Material Conference, pp. 260-272.

L. K. Chang and Michael F. Card (NASA Langley Research Center, Hampton, Virginia, USA), "Thermal Buckling Analysis for Stiffened Orthotropic Cylindrical Shells" (Structural analysis of thermal buckling of orthotropic, multilayered, stiffened cylindrical shell using finite differences and determinant plotting or modal iteration), NASA Technical Note TN D-6332, April 1971
Accession Number: ADA309606, Handle / proxy Url : http://handle.dtic.mil/100.2/ADA309606
ABSTRACT: A theory for thermal buckling of an orthotropic, multilayered, stiffened cylindrical shell is presented. The theory includes the effects of eccentricity of layers and stiffening, and deformations prior to buckling. It is sufficiently general to account for discrete rings and averaged properties of longitudinal stiffening, as well as arbitrary temperature distributions through the thickness of the shell and depth of the stiffeners. Two computer programs are described corresponding to solutions for buckling obtained by using finite differences and determinant plotting or modal iteration. Computed results for thermal buckling of unstiffened and ring-stiffened shells are presented and are in reasonable agreement with published results. The interaction of thermal loading and axial compression in two large-diameter stiffened shells representative of a launch vehicle interstage and a preliminary supersonic transport fuselage design is investigated. Results indicate that buckling can occur in both structures at a realistic temperature under thermal loading alone.

Wall, Jr., L. D., and Card, M. F., Torsional Shear Strength of Filament-Wound Glass-Epoxy Tubes, NASA TN D-6140, August 1971.
Almroth's comments: The tests on torsion tubes were intended as fracture tests. However, it is observed in many cases that fracture was preceded by strain reversal. Evaluation of the results seems difficult because the stress-strain curves show considerable nonlinearity at low stress.
Authors' ABSTRACT: Results are presented from torsion tests conducted on 36 multilayered, filament-wound, glass-epoxy tubes. Configurations with helical windings and with alternating helical and circumferential windings were investigated for various winding angles. Under small loadings, shear moduli deduced from linear shear stress-strain curves were found to be in reasonable agreement with analytical predictions. Under larger loadings, various degrees of nonlinearity in shear stress-strain curves were encountered, depending on the helical winding angle. Experimental torsional strengths were defined by a 0.2-percent offset yield stress or by

maximum stress when large nonlinearities did not exist. These strengths were compared with torsional buckling predictions for orthotropic cylinders, and with material strength predictions based on orthotropic yield criteria and elastic stress analysis. Computed elastic buckling stresses were considerably higher than the experimental strengths for most of the test specimens except for those with only 30 deg and 45 deg windings. Experimental torsional strengths were found to correlate with conventional yield predictions if predicted yielding in certain layers were ignored or if unrealistically large transverse tensile and shear strengths of unidirectional laminae were employed in the analysis.

Mikulas, Martin M., Bush, Harold G., and Card, Michael F., "Structural Stiffness, Strength and Dynamics Characteristics of Large Tetrahedral Space Truss Structures," NASA TMX-74001, March, 1977.

Michael F. Card and James H. Starnes, Jr. (NASA Langley Research Center, Hampton, Virginia, USA), "Current research in composite structures at NASA's Langley Research Center", Sadhana, Vol. 11, Nos. 3-4, 1987, pp. 277-298, doi: 10.1007/BF02811358
ABSTRACT: Research on the mechanics of composite structures at nasa's Langley Research Center is discussed. The advantages and limitations of special purpose and general purpose analysis tools used in research are reviewed. Future directions in computational structural mechanics are described to address analysis short-comings. Research results on the buckling and postbuckling of unstiffened and stiffened composite structures are presented. Recent investigations of the mechanics of failure in compression and shear are reviewed. Preliminary studies of the dynamic response of composite structures due to impacts encountered during crash-landings are presented. Needs for future research are discussed.

Theodore F. Johnson and Michael F. Card (NASA Langley Research Center, Hampton, Virginia, USA), "Effects of stiffening and mechanical load on thermal buckling of stiffened cylindrical shells", 36th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics & Materials Conference. Vol. 2, pp. 1380-1388. 1995
ABSTRACT: A study of thermal buckling of stiffened cylindrical shells with the proportions of a preliminary supersonic transport fuselage design (1970) is presented. The buckling analysis is performed using an axisymmetric shell-of-revolution code, BOSOR4. The effects of combined mechanical (axial loading) and thermal loading (heated skins) are investigated. Results indicate that the location of longitudinal eccentric stiffening has a very large effect on the thermal buckling strength of longitudinally stiffened shells, and on longitudinally stiffened shells with rings.