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Mike Nemeth (2006)

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Selected Publications:


ABSTRACT: A summary of the existing NASA design criteria monographs for the design of buckling-resistant thin-shell structures is presented. Subsequent improvements in the analysis for nonlinear shell response are reviewed, and current issues in shell stability analysis are discussed. Examples of nonlinear shell responses that are not included in the existing shell design monographs are presented, and an approach for including reliability-based analysis procedures in the shell design process is discussed. Suggestions for conducting future shell experiments are presented, and proposed improvements to the NASA shell design criteria monographs are discussed.


ABSTRACT: A procedure for deriving nondimensional parameters and equations for bifurcation buckling of
anisotropic shallow shells subjected to combined loads is presented. First, the Donnell-Mushtari-Vlasov
equations governing buckling of symmetrically laminated doubly curved thin elastic shallow shells are
presented. Then, the rationale used to perform the nondimensionalization of the buckling equations is presented,
and fundamental parameters are identified that represent measures of the shell orthotropy and anisotropy. In
addition, nondimensional curvature parameters are identified that are analogues of the well-known Batdorf Z
parameter for isotropic shells, and analogues of Donnell’s and Batdorf’s shell buckling equations are presented.
Selected results are presented for shear buckling of balanced symmetric laminated shells that illustrate the
usefulness of the nondimensional parameters.

Nemeth, M. P., "Buckling Behavior of Long Anisotropic Plates Subjected to Combined Loads," NASA TP-

M. Nemeth, Buckling and postbuckling behaviour of laminated composite plates with a cut-out, in: G. Turvey,

Michael P. Nemeth (Langley Research Center, Hampton, Virginia), “Buckling Behavior of Long Symmetrically
Laminated Plates Subjected to Shear and Linearly Varying Axial Edge Loads”, NASA Technical Paper 3659,
July 1997

ABSTRACT: A parametric study of the buckling behavior of infinitely long symmetrically laminated
anisotropic plates that are subjected to linearly varying edge loads, uniform shear loads, or combinations of
these loads is presented. The study focuses on the effects of the shape of linearly varying edge load distribution,
plate orthotropy, and plate flexural anisotropy on plate buckling behavior. In addition, the study examines the
interaction of linearly varying edge loads and uniform shear loads with plate flexural anisotropy and orthotropy.
Results obtained by using a special purpose non-dimensional analysis that is well suited for parametric studies
of clamped and simply supported plates are presented for [±θ]s thin graphite-epoxy laminates that are
representative of spacecraft structural components. Also, numerous generic buckling-design charts are
presented for a wide range of nondimensional parameters that are applicable to a broad class of laminate
constructions. These charts show explicitly the effects of flexural orthotropy and flexural anisotropy on plate
buckling behavior for linearly varying edge loads, uniform shear loads, or combinations of these loads. The
most important finding of the present study is that specially orthotropic and flexurally anisotropic plates that are
subjected to an axial edge load distribution that is tension dominated can support shear loads that are larger in
magnitude than the shear buckling load.

Nemeth, Michael P.; Britt, Vicki O.; Collins, Timothy J.; and Starnes, James H., Jr.: Nonlinear Analysis of the

Michael P. Nemeth, Vicki O. Britt, Timothy J. Collins, and James H. Starnes, Jr. (Langley Research Center
Technical Paper 3616, December, 1996. (Also see Journal of Spacecraft and Rockets, Vol. 36, No.6,
November-December, 1999, pp. 788-803)

ABSTRACT: Results of buckling and nonlinear analyses of the Space Shuttle external tank superlightweight
liquid-oxygen (LO2) tank are presented. Modeling details and results are presented for two prelaunch loading
conditions and for two full-scale structural tests that were conducted on the original external tank. The results
illustrate three distinctly different types of nonlinear response for thin-walled shells subjected to combined
mechanical and thermal loads. The nonlinear response phenomena consist of bifurcation-type buckling, short-
wavelength nonlinear bending, and nonlinear collapse associated with a limit point. For each case, the results show that accurate predictions of nonlinear behavior generally require a large-scale, high-fidelity finite-element model. Results are also presented that show that a fluid-filled launch-vehicle shell can be highly sensitive to initial geometric imperfections. In addition, results presented for two full-scale structural tests of the original standard-weight external tank suggest that the finite-element modeling approach used in the present study is sufficient for representing the nonlinear behavior of the superlight-weight LO2 tank.

Nemeth, M.P. 1997. Buckling behavior of long symmetrically laminated plates subjected to shear and linearly varying axial edge loads, TP 3659: NASA.

Knight, Norman F., Jr and Nemeth, Michael P (editors), “Stability Analysis of Plates and Shells”, NASA no. 19980019011. In: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference. ABSTRACT: This special publication contains the papers presented at the special sessions honoring Dr. Manuel Stein during the 38th AIAA /ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference held in Kissimmee, Florida, Apdl 7-10, 1997. This volume, and the SDM special sessions, are dedicated to the memory of Dr. Manuel Stein, a major pioneer in structural mechanics, plate and shell buckling, and composite structures. Many of the papers presented are the work of Manny's colleagues and co-workers and are a result, directly or indirectly, of his influence. Dr. Stein earned his Ph.D. in Engineering Mechanics from Virginia Polytechnic Institute and State University in 1958. He worked in the Structural Mechanics Branch at the NASA Langley Research Center from 1943 until 1989. Following his retirement, Dr. Stein continued his involvement with NASA as a Distinguished Research Associate.


ABSTRACT: Results of linear bifurcation and nonlinear analyses of the Space Shuttle superlightweight (SLWT) external liquid-oxygen (LO2) tank for an important early booster ascent loading condition are presented. These results for thin-walled linear elastic shells that are subjected to combined mechanical and thermal loads illustrate an important type of response mode that may be encountered in the design of other liquid-fuel launch vehicles. Linear bifurcation analyses are presented that predict several nearly equal eigenvalues that correspond to local buckling modes in the forward ogive section of the LO2 tank. In contrast, the nonlinear response phenomenon is shown to consist of short-wavelength bending deformations in the forward ogive and barrel sections of the LO2 tank that grow in amplitude in a stable manner with increasing load. Imperfection sensitivity analyses are presented that show that the presence of several nearly equal eigenvalues does not lead to a premature general instability mode for the forward ogive section. For the linear bifurcation and nonlinear analyses, the results show that accurate predictions of the response of the shell generally require a large-scale, high-fidelity finite-element model. Results are also presented that show that the SLWT LO2 tank can support loads in excess of approximately 2.6 times the values of the operational loads considered.


ABSTRACT: Results from a study of the effects of cutouts and laminate construction on the prebuckling and initial postbuckling stiffnesses, and the effective widths of compression-loaded laminated-composite and aluminum square plates are presented. An effective-width concept is derived for plates with and without cutouts, and experimental and nonlinear finite-element analysis results are presented. Behavioral trends are compared for seven plate families and for cutout-diameter-to-plate-width ratios up to 0.66. A general compact design curve that can be used to present and compare the effective widths for a wide range of laminate constructions is also presented. A discussion of how the results can be used and extended to include certain types of damage, cracks, and other structural discontinuities or details is given. Several behavioral trends are described that initially appear to be nonintuitive. The results demonstrate a complex interaction between cutout size and plate orthotropy that affects the axial stiffness and effective width of a plate subjected to compression loads.


ABSTRACT: An analytical, parametric study of the attenuation of bending boundary layers or edge effects in balanced and unbalanced, symmetrically and unsymmetrically laminated thin cylindrical shells is presented for nine contemporary material systems. The analysis is based on the linear Sanders-Koiter shell equations and specializations to the Love-Kirchhoff shell equations and Donnell’s equations are included. Two nondimensional parameters are identified that characterize and quantify the effects of laminate orthotropy and laminate anisotropy on the bending boundary-layer decay length in a very general and encompassing manner. A
substantial number of structural design technology results are presented for a wide range of laminated-composite cylinders. For all laminate constructions considered, the results show that the differences between results that were obtained with the Sanders-Koiter shell equations, the Love-Kirchhoff shell equations, and Donnell’s equations are negligible. The results also show that the effect of anisotropy in the form of coupling between pure bending and twisting has a negligible effect on the size of the bending boundary-layer decay length of the balanced, symmetrically laminated cylinders considered. Moreover, the results show that coupling between the various types of shell anisotropies has a negligible effect on the calculation of the bending boundary-layer decay length in most cases. The results also show that, in some cases, neglecting the shell anisotropy results in underestimating the bending boundary-layer decay length and, in other cases, results in an overestimation. An example problem is included in an appendix that demonstrates how to perform the calculations that were used to generate the results of the present study.


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“Buckling Behavior of Compression-Loaded Quasi-Isotropic Curved Panels With a Circular Cutout,”
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ABSTRACT: Results from a numerical and experimental study of the response of compression-loaded quasi-isotropic curved panels with a centrally located circular cutout are presented. The numerical results were obtained by using a geometrically nonlinear finite element analysis code. The effects of cutout size, panel curvature and initial geometric imperfections on the overall response of compression-loaded panels are described. In addition, results are presented from a numerical parametric study that indicate the effects of elastic circumferential edge restraints on the prebuckling and buckling response of a selected panel and these numerical results are compared to experimentally measured results. These restraints are used to identify the effects of circumferential edge restraints that are introduced by the test fixture that was used in the present study. It is shown that circumferential edge restraints can introduce substantial nonlinear prebuckling deformations into shallow compression-loaded curved panels that can result in a significant increase in buckling load.


ABSTRACT: Validity of the assumptions relating the applicability of continuum shell theories to the global mechanical behavior of carbon nanotubes is examined. The present study focuses on providing a basis that can be used to qualitatively assess the appropriateness of continuum-shell models for nanotubes. To address the
effect of nanotube structure on their deformation, all nanotube geometries are divided into four major classes that require distinct models. Criteria for the applicability of continuum models are presented. The key parameters that control the buckling strains and deformation modes of these classes of nanotubes are determined. In an analogy with continuum mechanics, mechanical laws of geometric similitude are presented. A parametric map is constructed for a variety of nanotube geometries as a guide for the applicability of different models. The continuum assumptions made in representing a nanotube as a homogeneous thin shell are analyzed to identify possible limitations of applying shell theories and using their bifurcation-buckling equations at the nano-scale.


ABSTRACT: The results of an analytical study of the elastic buckling and non-linear behavior of the liquid-oxygen tank for the new Space Shuttle superlightweight external fuel tank are presented. Selected results that illustrate three distinctly different types of non-linear response phenomena for thin-walled shells which are subjected to combined mechanical and thermal loads are presented. These response phenomena consist of a bifurcation-type buckling response, a short-wavelength non-linear bending response, and a non-linear collapse or “snap-through” response associated with a limit point. The effects of initial geometric imperfections on the response characteristics are emphasized. The results illustrate that the buckling and non-linear response of a geometrically imperfect shell structure subjected to complex loading conditions may not be adequately characterized by an elastic linear bifurcation buckling analysis, and that the traditional industry practice of applying a buckling-load knock-down factor can result in an ultra-conservative design. Results are also presented that show that a fluid-filled shell can be highly sensitive to initial geometric imperfections, and that the use a buckling-load knock-down factor is needed for this case.


ABSTRACT: An approach for synthesizing buckling results and behavior for long, balanced and unbalanced symmetric laminates that are subjected to uniform heating or cooling and that are fully restrained against thermal expansion or contraction is presented. This approach uses a nondimensional analysis for infinitely long, flexurally anisotropic plates that are subjected to combined mechanical loads and is based on useful nondimensional parameters. In addition, stiffness-weighted laminate thermal-expansion parameters are derived that are used to determine critical temperature changes in terms of physically intuitive mechanical buckling coefficients, and the effects of membrane orthotropy and membrane anisotropy are included. Many results are presented for some common laminates that are intended to facilitate a structural designer’s transition to the use of the generic buckling design curves that are presented in the paper. Several generic buckling design curves are presented that provide physical insight into the buckling response in addition to providing useful design data. Examples are presented that demonstrate the use of the generic design curves. The analysis approach and generic results indicate the effects and characteristics of laminate thermal expansion, membrane orthotropy and anisotropy, and flexural orthotropy and anisotropy in a very general and unifying manner.

ABSTRACT: An analysis-based approach for developing shell buckling design criteria for laminated-composite cylindrical shells that accurately account for the effects of initial geometric imperfections is presented. With this approach, measured initial geometric imperfection data from six graphite-epoxy shells are used to determine a manufacturing-process-specific imperfection signature for these shells. This imperfection signature is then used as input into nonlinear finite-element analyses. The imperfection signature represents a "first-approximation" mean imperfection shape that is suitable for developing preliminary-design data. Comparisons of test data and analytical results obtained by using several different imperfection shapes are presented for selected shells. These shapes include the actual measured imperfection shape of the test specimens, the "first-approximation" mean imperfection shape, with and without plus or minus one standard deviation, and the linear-bifurcation-mode imperfection shape. In addition, buckling interaction curves for composite shells subjected to combined axial compression and torsion loading are presented that were obtained by using the various imperfection shapes in the analyses. A discussion of the nonlinear finite-element analyses is also presented. Overall, the results indicate that the analysis-based approach presented for developing reliable preliminary-design criteria has the potential to provide improved, less conservative buckling-load estimates, and to reduce the weight and cost of developing buckling-resistant shell structures.


ABSTRACT: A parametric study of the effects of test-fixture-induced initial prestress and elastic edge restraints on the prebuckling and buckling responses of a compression-loaded, quasi-isotropic curved panel is presented. The numerical results were obtained by using a geometrically nonlinear finite element analysis code with high-fidelity models. The results presented show that a wide range of prebuckling and buckling behavior can be obtained by varying parameters that represent circumferential loaded-edge restraint and rotational unloaded-edge restraint provided by a test fixture and that represent the mismatch in specimen and test-fixture radii of curvature. For a certain range of parameters, the panels exhibit substantial nonlinear prebuckling deformations that yield buckling loads nearly twice the corresponding buckling load predicted by a traditional linear bifurcation buckling analysis for shallow curved panels. In contrast, the results show another range of parameters exist for which the nonlinear prebuckling deformations either do not exist or are relatively benign, and the panels exhibit buckling loads that are nearly equal to the corresponding linear bifurcation buckling load. Overall, the results should also be of particular interest to scientists, engineers, and designers involved in simulating flight-hardware boundary conditions in structural verification and certification tests, involved in validating structural analysis tools, and interested in tailoring buckling performance.


ABSTRACT: An approach for synthesizing buckling results and behavior for thin balanced and unbalanced symmetric laminates that are subjected to uniform heating or cooling and elastically restrained against thermal expansion or contraction is presented. This approach uses a nondimensional analysis for infinitely long, flexurally anisotropic plates that are subjected to combined mechanical loads and is based on useful nondimensional parameters. In addition, stiffness-weighted laminate thermal-expansion parameters and compliance coefficients are derived that are used to determine critical temperatures in terms of physically intuitive mechanical-buckling coefficients. The effects of membrane orthotropy and membrane anisotropy are included in the general formulation. Many results are presented for some common laminates that are intended to

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facilitate a structural designer’s transition to the use of the generic buckling design curves. Several curves that illustrate the fundamental parameters used in the analysis are presented, for nine contemporary material systems, that provide physical insight into the buckling response in addition to providing useful design data. Examples are presented that demonstrate the use of the generic design curves. The analysis approach and generic results indicate the effects and characteristics of elastically restrained laminate thermal expansion or contraction, membrane orthotropy and anisotropy, and flexural orthotropy and anisotropy in a very general and unifying manner.