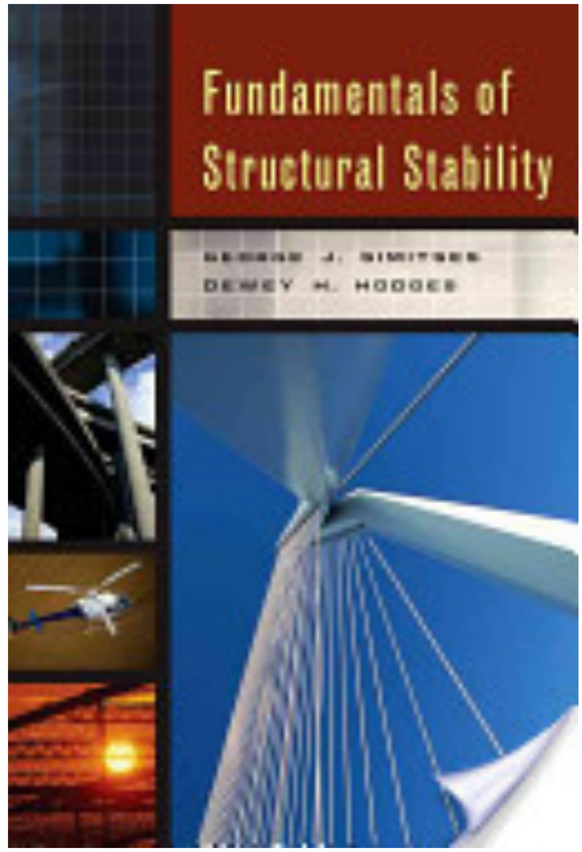
Professor George John Simitses (1932-2016)



Fundamentals of structural stability by George J. Simitses, Dewey H. Hodges, Butterworth-Heinemann, 2006, 389 pages

Obituary (Published in the Atlanta Journal-Constitution, April 29, 2016):

Professor George John Simitses died April 24, 2016 at age 83. Born 31 July 1932 in Athens, Greece, Dr. Simitses came to America in 1951 to study engineering, graduating from the Georgia Institute of Technology in 1956 with a Bachelor of Aeronautical Engineering and Master of Science in Aerospace Engineering and from Stanford University in 1965 with a Ph.D. in Aeronautics and Astronautics. His academic career includes teaching and research at Georgia Tech (Professor) and at the University of Cincinnati (Professor, Department Head of Aerospace Engineering and Engineering Mechanics, and Interim Dean of Engineering). Professor Simitses is the recipient of many awards and honors, including having been elected Corresponding Member of the prestigious Academy of Athens (the Greek equivalent of the US National Academy of Science). His distinguished career and academic achievements were enhanced by the love and passion he had for family, students, Greek community and importance of education. Dr. Simitses was a constant mentor to students throughout his career, advising 23 Ph.D. students to completion and often inviting those here from Greece to his home to celebrate his favorite holiday, Orthodox Pascha (Easter). Dr. Simitses was a founding member of the Ahepa Mother Lodge Chapter #1 Educational Foundation, which has awarded nearly $800K in scholarships to date. As a father and grandfather, Dr. Simitses loved sports, especially Georgia Tech athletics. A consecutive football ticket holder since the 1950's, his love for this school runs through the family, with both sons graduating from Tech and his grandchildren already life-long fans. Professor Simitses will be greatly missed by wife Nena Economy Simitses; three children, John Simitses, William Simitses (Victoria) and Alexandra

Simitses Zaden (Mark); and eight grandchildren, Michael, Christina, George, Matthew and Luke Simitses, and Athena, Marian and Joseph Zaden.

Dedication by George Kardomateas and Victor Birman in the Journal of Materials and Structures, Vol. 4, No. 7-8, pp. 1185-1186, 2009, DOI: 10.2140/jomms.2009.4.1185:

George J. Simitses was born on 31 July 1932 in Athens, Greece. After receiving his high school diploma, he came to the United States to study engineering. He first attended the University of Tampa (1951–52) and then the Georgia Institute of Technology (1952–56), where he earned the degrees of Bachelor of Aeronautical Engineering and Master of Science in Aerospace Engineering. After a few years, he attended Stanford University (1963–65), where he earned a Ph.D. in Aeronautics and Astronautics. His academic career includes teaching and research at Georgia Tech (Instructor, Assistant Professor, Associate Professor and Professor) in the Schools of Aerospace Engineering and Engineering Science and Mechanics and at the University of Cincinnati (Professor and Department Head of Aerospace Engineering and Engineering Mechanics and Interim Dean of Engineering). He retired in March 2000 from the University of Cincinnati and he is presently Professor Emeritus at both schools.

As a researcher, Professor Simitses has made pioneering and lasting contributions in the field of Solid and Structural Mechanics. He has written three graduate level text-books and several book chapters. He has authored or coauthored over 160 refereed journal articles in archival engineering journals. He has advised 23 Ph.D. students to completion as well as dozens of M.Sc. students, and he has hosted ten post-doctoral fellows, visiting scholars and faculty from throughout the world during the past three decades. His research publications include works in structural stability, dynamic stability, structural optimization, delamination buckling and growth, analysis of thick composite shells and structural similitude. In his research, he has dealt with beams, bars, plates and shells of various constructions, metallic structures with and without stiffeners, laminated composites, sandwich systems and simple mechanical models.

Professor Simitses has served and is still serving the scientific and engineering profession through journal editing, organization and participation in professional meetings, membership in professional societal committees and chairing sessions at national and international conferences. He has been invited to deliver Keynote Addresses and Plenary Lectures at several professional meetings. He has also participated in many panels and workshops. He has been a frequent seminar lecturer to many universities and industrial companies and he has participated in numerous continuing education courses.

Professor Simitses is the recipient of many awards and honors. He is a Fellow of the AIAA, the ASME, and the American Academy of Mechanics, and an Honorary Member of the Hellenic Society of Theoretical and Applied Mechanics and Member of the International Union of Theoretical and Applied Mechanics. He has also been elected Corresponding Member of the Academy of Athens (the Greek equivalent of the US National Academy of Science). Professor Simitses has been married to Nena Athena Economy for 49 years. They have three children, John, William and Alexandra, and six grandchildren, Michael, Christina, George and Matthew Simitses, Athena and Marian Zaden, with one more on the way.

We, the guest editors of this volume, have been happy to enjoy collaboration and friendship with Professor Simitses. Professor Simitses is renowned for his ability to quickly understand and assess a scientific problem. His vision and readiness to share and discuss ideas are admirable. Both of us immensely benefited from joint research and long conversations, in which we would solicit Professor Simitses's opinion and advice. Besides our collaboration, it is a real pleasure and honor to associate with Professor Simitses. His wisdom, erudition, optimism and sincere personal interest have always been an inspiration to us. We are happy to dedicate this volume to Professor Simitses as a modest token of our appreciation, respect and recognition of his lifetime contributions.

Selected Publications:

Website: http://www.ase.uc.edu/faculty/info/simitses.htm

Selected Publications:

George J. Simitses, "Buckling and postbuckling of imperfect cylindrical shells: a review", Applied Mechanics Reviews, Vol. 39, No. 10, October 1986
ABSTRACT: Thin-walled cylinders of various constructions are widely used in simple or complex structural configurations. The round cylinder is commonly found in tubing and piping, and in offshore platforms. Depending on their use, these cylinders are subjected (in service) to individual and combined application of external loads. In resisting these loads the system is subject to buckling, a failure mode which is closely associated with the establishment of its load-carrying capacity. Therefore, the system buckling a

-Book
George J. Simitses, Dynamic stability of suddenly loaded structures, 1990, Springer-Verlag, New York

--------Book
Fundamentals of structural stability by George J. Simitses, Dewey H. Hodges, Butterworth-Heinemann, 2006, 389 pages
ABSTRACT: The ability of a structural assembly to carry loads and forces determines how stable it will be over time. Viewing structural assemblages as comprising columns, beams, arches, rings, and plates, this book will introduce the student to both a classical and advanced understanding of the mechanical behavior of such structural systems under load and how modeling the resulting strains can predict the overall future performance the stability of that structure. While covering traditional beam theory, the book is more focused on elastic theory in keeping with modern approaches. This text will be an expanded and updated version a similar, previously published book, but with pedagogical improvements and updated analytical methods.
This engineering textbook will provide a focused treatment on the study of how structures behave and perform when under stress loading, including plastic deformation and buckling. All advanced engineering students studying engineering mechanics, structural analysis and design, fatigue and failure, and other related subjects need to have this knowledge, and this book will provide it in a thorough and coherent fashion. Written by two of the world's leading engineering professors in this subject area, the pedagogy has been classroom-tested over many years and should find a receptive readership among both students and instructors. An understandable introduction to the theory of structural stability, useful for a wide variety of engineering disciplines, including mechanical, civil and aerospace engineering Covers both static and dynamic loads, for both conservative and nonconservative systems. Emphasizes elastic behavior under loads, including vertical buckling, torsional buckling and nonlinear affects of structural system buckling and stability Case examples to illustrate real-world applications of Stability Theory.

Simitses, G. J., and Girn, J., Buckling of Rotationally Restrained Orthotropic Plates Under Uniaxial Compression, J. Composite Mat., Vol. 11, pp. 345-364, July 1977.
Almroth's comments: A two-term Galerkin solution is used for analysis of critical axial compression of orthotropic plates. Results are given for different degrees of rotational constraint along the edges.

G. J. Simitses, "Dynamic Snap-through Backling of Shallow Spherical Caps, " AIAA/ASME 7th Structures and Materials Conference, Cocoa Beach, Florida (1966)

Sheinman I and Simitses GJ, "Buckling analysis of geometrically imperfect stiffened cylinders under axial compression", Journal of American Institutes of Aeronautics and Astronautics 1977;15(3):374–379.

Simitses GJ. Dynamic stability of suddenly loaded Structures, Springer-Verlag, 1990.

Huyan X and Simitses GJ. Dynamic buckling of imperfect cylindrical shells under axial compression and bending moment. AIAA Journal, Vol. 35, No. 8, pp 1404-1412, 1997.

Simitses, G. J., "General Instability of Eccentrically Stiffened Cylindrical Panels," Journal of Aircraft, Vol. 8, No. 7, 1971, pp. 569–575. doi:10.2514/3.44285

G. J. Simitses and I. Sheinman. Optimization of geometrically imperfect stiffend cylindrical shells under axial compresion. Computers and Structures, 9(4):377–381, 1978.

A. Tabiei and G. Simitses (Department of Aerospace Engineering and Engineering Mechanics, University of Cincinnati, Cincinnati, OH 45221, U.S.A.), "Imperfection sensitivity of shear deformable moderately thick laminated cylindrical shells", Computers & Structures, Vol. 62, No. 1, January 1997, pp. 165-174, doi:10.1016/S0045-7949(96)00237-4
ABSTRACT: The problem of instability of imperfect, laminated, circular cylindrical shells under the action of uniform axial compression is investigated. The analysis is based on nonlinear kinematic relations where the effect of transverse shear deformation is taken into account. The buckling is assumed to be elastic and the geometry to have initial geometric imperfections. The kinematic relations, governing equations and the related boundary conditions for the nonlinear analysis are derived and presented. A solution methodology has been developed and employed in generating results. The imperfection sensitivity is investigated. The results obtained indicate that geometric imperfections have little effect on the limit point load for moderately thick cylindrical shells.

SIMITSES, G.J. (1983). "Effect of Static Preloading on the Dynamic Stability of Structures", AIAA Journal, Vol. 21, pp. 1174-1180.

TABIEI, A.,TANOV, R.R., and SIMITSES, G.J. (1998). "Numerical Simulation of Cylindrical Laminated Shells under Impulsive Lateral Pressure", Collection of Technical Papers – 39th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics & Materials Conference. V 1, 1998. AIAA, New York, NY, USA. pp 509-514.

Simitses, G. J., "Axisymmetric Dynamic Snap-Through Buckling of Shallow Spherical Caps," AIAA Journal, Vol. 5, May 1967, pp. 1019– 1021.

Sheinman, I. and Simitses, G.J., "Axially loaded stiffened and unstiffened cylindrical shells", Journal of Applied Mechanics. Vol. 49, pp. 666-669. Sept. 1982
ABSTRACT: A method is presented for solving the problem of both prelimit and postlimit point behavior of axially loaded stiffened and unstiffened cylindrical shells. The proposed solution makes it possible to obtain postlimit point equilibrium paths for every desired wave number, n (number of full waves around the circumference). The governing equations are expressed in terms of normal displacement components and Airy stress functions. Numerical results are presented for an unstiffened cylindrical shell and for a ring and stringer-stiffened cylindrical shell.

George J. Simitses (1) and Izhak Sheinman (2)
(1) School of Engineering Science and Mechanics, Georgia Institute of Technology, Atlanta, GA 30332, U.S.A.
(2) Department of Civil Engineering, Technion-Israel Institute of Technology, Haifa, Israel
"Dynamic buckling of shell structures Concepts and applications", Acta Astronautica, Vol. 9, No. 3, March 1982, pp. 179-182, doi:10.1016/0094-5765(82)90087-X
ABSTRACT: The analysis of imperfect, thin, circular, cylindrical shells, subjected to suddenly applied uniform axial compression, is presented. The concept of dynamic stability is discussed and critical conditions for such configurations are obtained. Results are presented for unstiffened configurations. The effects of several parameters on dynamic critical conditions are assessed.

I. Sheinman, D. Shaw and G.J. Simitses (School of Engineering Science and Mechanics, Georgia Institute of Technology, Atlanta, Georgia, U.S.A), "Nonlinear analysis of axially-loaded laminated cylindrical shells", Computers & Structures, Vol. 16, Nos. 1-4, 1983, pp. 131-137, doi:10.1016/0045-7949(83)90155-4
ABSTRACT: The nonlinear analysis of geometrically imperfect, thin, laminated, circular, cylindrical shells subjected to uniform axial compression, and for various in-plane and transverse supports, is presented. Moreover, the solution methodology is described, and results are generated for imperfect laminated (Boron/Epoxy) cylinders with symmetric, antisymmetric and asymmetric stacking of lamina. The applications deal with imperfection sensitivity studies and investigation of the effect of lamina stacking on the critical conditions. Finally, for some of the chosen geometries, experimental data is available and therefore these geometries serve as (partial) benchmarks for the developed solution scheme.

D. Shaw (1), G.J. Simitses (1) and I. Sheinman (2)
(1) Georgia Institute of Technology, Atlanta, GA 30332, U.S.A.
(2) Technion—Israel Institute of Technology, Haifa, Israel
"Imperfect, laminated, cylindrical shells in torsion and axial compression", Acta Astronautica, Vol. 10, Nos. 5-6, May-June 1983, pp. 395-400, doi:10.1016/0094-5765(83)90089-9
ABSTRACT: An imperfect, laminated, circular, cylindrical thin shell, simply supported at the boundaries, and subjected to a uniform axial compression and torsion (individually applied and in combination) is analyzed. The analysis is based on nonlinear, Donnell-type, kinematic relations, linearly elastic material behavior, and usual lamination theory. The laminate consists of orthotropic laminae, which typically characterize fiber reinforced composites. Numerical results (critical loads) are generated for several geometries and some of these results are compared to available experimental data. The imperfection sensitivity of the various geometries is studied. It is clearly shown that the laminated shell is more imperfection sensitive under pure axial compression than under pure torsion (same as for the isotropic geometry). The effect of the orientation of the laminae (stacking sequence) on the critical load is also studied.

G.J. Simitses (1), D. Shaw (1), I. Sheinman (2) and J. Giri (3)

(1) School of Engineering Science and Mechanics, Georgia Institute of Technology, Atlanta, Georgia 30332 USA
(2) Technion-Israel Institute of Technology, Haifa Israel
(3) Beech Aircraft Company, Wichita, Kansas USA
“Imperfection sensitivity of fiber-reinforced, composite, thin cylinders”, Composites Science and Technology, Vol. 22, No. 4, 1985, pp. 259-276, doi:10.1016/0266-3538(85)90064-8
ABSTRACT: The imperfection sensitivity of thin cylindrical shells, made out of fiber-reinforced composite material and subjected to uniform axial compression, and the effects upon it of certain parameters, are investigated. The methodology is based on linear constitutive relations, nonlinear kinematic shell equations (Donnell-type) and the usual lamination theory. The laminate consists of orthotropic laminae, stacked in a general manner (asymmetric laminate). The uniform axial compression is applied eccentrically, and the geometrically imperfect cylindrical shell can be supported in various ways at the boundaries. In this investigation a number of parametric studies are performed. The scope of these studies is to establish the effect of (a) in-plane and transverse boundary conditions and (b) load eccentricity, on the imperfection sensitivity of typical boron/epoxy laminated cylindrical shells with various stacking sequences of laminate. The sensitivity is established by calculating critical loads for various imperfection amplitudes and shapes.

G. J. Simitses, I. Sheinman and D. Shaw (Georgia Institute of Technology, Atlanta, GA 30332, U.S.A.), “The accuracy of Donnell's equations for axially-loaded, imperfect orthotropic cylinders”, Computers & Structures, Vol. 20, No. 6, 1985, pp. 939-945, doi:10.1016/0045-7949(85)90013-6
ABSTRACT: The accuracy of Donnell's equations for the buckling analysis of imperfect (limit point instability), circular, cylindrical, thin orthotropic shells under axial compression is investigated. This is accomplished by comparing critical loads obtained by employing Donnell-type kinematic equations with those based on the more accurate Sanders-type. For this purpose, a solution methodology is developed and described in the body of the paper. This methodology is then employed to generate critical loads for several orthotropic geometries, which cover a wide but practical range of parameters. These include cylinder length to radius ratios, radius to thickness ratios, two positions of the strong direction relative to the cylinder axis (_∏=0 and 90∞) and two shapes of the initial geometric imperfection, axisymmetric and symmetric. Classical simply supported boundaries are used for all configurations for which results are generated.

Simitses, G. J., Shaw, D. and Sheinman, I. (Georgia Tech and Technion), “Stability of Cylindrical Shells, by Various Nonlinear Shell Theories”, ZAMM - Journal of Applied Mathematics and Mechanics / Zeitschrift für Angewandte Mathematik und Mechanik, Vol. 65, No. 3, 1985, pp. 159–166. doi: 10.1002/zamm.19850650311
ABSTRACT: The buckling of axially-loaded, imperfect, circular, cylindrical, thin shells is studied. A solution methodology, based on two different shell theory approximations to the kinematic relations, is developed and described. The two approximations are those of Sanders and Donnell. Critical loads (limit point loads) are obtained for two shell geometries, one isotropic and one laminated. Several parametric studies are performed in order to establish the accuracy of the Donnell approximation. This is accomplished by comparison to the results obtained by the Sanders kinematic relations, which are considered to be very accurate for thin shells. The parametric studies include the effect of cylinder to radius ration on the critical loads, as well as the effect of the radius to thickness ratio. Moreover, the imperfection sensitivity of the two geometries is investigated by both shell theory approximations.

George J. Simitses (1) and Charles M. Blackmon (2)
(1) Georgia Institute of Technology, Atlanta, GA 30332, U.S.A.
(2) United States Weapons Laboratory, Dahlgren, Virginia, U.S.A.

“Snap-through buckling of eccentrically stiffened shallow spherical caps”, International Journal of Solids and Structures, Vol. 11, No. 9, September 1975, pp. 1035-1049, doi:10.1016/0020-7683(75)90046-3
ABSTRACT: The problem of snap-through buckling of a clamped, eccentrically stiffened shallow spherical cap is considered under quasi-statically applied uniform pressure and a special case of dynamically applied uniform pressure. This dynamic case is the constant load infinite duration case (step time-function) and it represents an extreme case of blast loading-large decay time, small decay rate. The analysis is based on the nonlinear shallow shell equations under the assumption of axisymmetric deformations and linear stress-strain laws. The eccentric stiff eners are disposed orthogonally along directions of principal curvature in such a way that the smeared mass, and extensional and flexural stiffnesses are constant. The stiffeners are also taken to be one-sided with constant eccentricity, and the stiffener-shell connection is assumed to be monolithic. The method developed in an earlier paper is employed. In this method, critical pressures are associated with characteristics of the total potential surface in the configuration space of the generalized coordinates. In addition, buckling of the complete thin eccentrically stiffened spherical shell under uniform quasi-statically applied pressure is considered, and these results are used to check the numerical answers. The complete spherical shell is stiffened in the same manner as the shallow cap. The results are presented in graphical form as load parameter vs initial rise parameter. Geometric configurations corresponding to isotropic, lightly stiffened, moderately stiffened and heavily stiffened geometries are considered. By lightly stiffened geometry one means that most of the extensional stiffness is provided by the thin shell. A computer program was written to solve for critical pressures. The Georgia Tech Univac 1108 high speed digital computer was used for this purpose.

George J. Simitses (Georgia Institute of Technology, Atlanta, GA 30332, U.S.A.) and Izhak Sheinman (Technion-Israel Institute of Technology, Haifa, Israel), “Optimization of geometrically imperfect stiffened cylindrical shells under axial compression”, Computers & Structures, Vol. 9, No. 4, October 1978, pp. 377-381, doi:10.1016/0045-7949(78)90124-4
ABSTRACT: A procedure is outlined for optimizing stiffened, thin, circular, cylindrical shells under uniform axial compression against general instability, in the presence of initial geometric imperfection. The procedure consists of two parts (a) optimization on the basis of a linear buckling analysis and perfect geometry, and (b) parametric studies on a reasonable region in the design space surrounding the optimum point (as obtained from part (a)) to assess the effect of initial geometric imperfections. This procedure is demonstrated through two design examples, for which it is concluded, that the presence of initial geometric imperfections does not alter the optimum weight and the corresponding design variables appreciably.

I. Sheinman and G. J. Simitses (Georgia Institute of Technology, Atlanta, GA 30332, U.S.A), “Buckling and postbuckling of imperfect cylindrical shells under axial compression”, Computers & Structures, Vol. 17, No. 2, 1983, pp. 277-285, doi:10.1016/0045-7949(83)90016-0
ABSTRACT: A solution methodology is described for the complete analysis of a geometrically imperfect, thin, circular, cylindrical shell loaded by a uniform axial compression. The analysis includes pre-limit point behavior, the establishment of critical conditions (limit point) and post-limit point behavior. The solution scheme is then utilized to study the effects of various geometrical parameters (radius to thickness and length to radius ratios) on the response characteristics of an imperfect, unstiffened, thin, cylindrical shell. These effects are assessed for a virtually axisymmetric-type of geometric imperfection.

G. J. Simitses (1) and D. Shaw (1) and I. Sheinman (2)
(1) Georgia Institute of Technology, Atlanta, Georgia 30332, USA
(2) Technion-Israel Institute of Technology, Haifa, Israel

"Imperfection sensitivity of laminated cylindrical shells in torsion and axial compression", Composite Structures, Vol. 4, No. 4, 1985, pp. 335-360, doi:10.1016/0263-8223(85)90032-7
ABSTRACT: The imperfection sensitivity of thin cylindrical shells, made out of fiberreinforced composite material and subjected to either uniform axial compression or torsion, and the effects upon it of certain parameters, are investigated. The sensitivity is established through plots of critical loads (limit point loads) versus imperfection amplitude. The larger the drop in critical load value with increasing amplitude, the greater the sensitivity. Results are presented for four- and six-ply laminates with simply supported boundaries and various stacking sequences. These sequences lead to symmetric, antisymmetric and asymmetric configurations with respect to the laminate midsurface. The material for all configurations is boron/epoxy. The parametric studies include primarily the effect of lamina stacking and length-to-radius ratio on the critical loads. Among the important findings are that (a) laminated cylindrical shells are more imperfection sensitive under axial compression than under torsion, (b) the imperfection sensitivity decreases as the length-to-radius ratio increases and (c) lamina stacking has a pronounced effect on the imperfection sensitivity of the laminated shell.

S. Sallam and G. J. Simitses (School of Engineering Science and Mechanics, Georgia Institute of Technology, Atlanta, Georgia, USA), "Delamination buckling of cylindrical shells under axial compression", Composite Structures, Vol. 7, No. 2, 1987, pp. 83-101, doi:10.1016/0263-8223(87)90001-8
ABSTRACT: A model is developed for the study of delamination buckling of axially loaded cylindrical shells. Delamination is assumed to exist before load application, it spans the entire circumference, and it lies on the contact surface of neighboring laminae. The mathematical model employs Donnell-type kinematic relations and linearly elastic material behavior. Furthermore, each lamina is assumed isotropic, and the emphasis is on studying the effect of delamination size and position on the critical load. Two sets of boundary conditions are used with the model: simply supported and clamped. The study reveals several important conclusions. Among them, one may list the following: (a) the critical load is primarily controlled by the position of the delamination from the reference surface, provided that the delamination is not very close to the boundaries; and (b) for long delaminations (relative to the cylinder length), the critical load is not appreciably affected by the boundary conditions.

George J. Simitses (1) and Ziqi Chen (2)
(1) School of Aerospace Engineering, Georgia Institute of Technology, Atlanta, GA 30332, U.S.A.
(2) School of Engineering Science and Mechanics, Georgia Institute of Technology, Atlanta, GA 30332, U.S.A.
"Buckling of delaminated, long, cylindrical panels under pressure", Computers & Structures, Vol. 28, No. 2, 1988, pp. 173-184, doi:10.1016/0045-7949(88)90037-5
ABSTRACT: Delamination is one of the basic defects inherent to laminar materials. The investigation of the buckling characteristics of delaminated cylindrical shells or panels, when subjected to external pressure, is presented herein. The geometry is such that it covers a wide range of length to radius ratios as well as panels of different widths. Results are presented only for very long cylinders and panels. The boundaries are either simply supported or clamped. Furthermore, the material is such that it leads to (quasi) isotropic laminates for all sections involved, the overall as well as the ones separated by the delamination. Finally, the geometry is free of initial geometric imperfections. Because of the last two assumptions, a primary membrane state exists and bifurcational buckling is possible. Buckling loads are calculated for a wide range of parameters. The width and the through-the-thickness position of delamination greatly affect the bifurcation load.

George J. Simitses and Yeoshua Frostig (Georgia Institute of Technology, Atlanta, Georgia, 30332, USA), "Radially compressed laminated circular plates", Composite Structures, Vol. 9, No. 1, 1988, pp. 1-17, doi:10.1016/0263-8223(88)90028-1

ABSTRACT: The paper deals with buckling of complete and annular circular plates, made of symmetric laminates with general orientation of the lamina fibers. The plate is subjected to an in-plane, symmetric, destabilizing load. The load is applied at the outer edge for the complete plate and at the outer and inner edges for the annular one. The plate is supported in various ways along its boundaries. The paper includes the derivation of the governing equations and discusses the various methods of solution. Numerical results are presented for a clamped plate.

George J. Simitses (1) and Byoungkee Han (2)
(1) Department of Aerospace Engineering and Engineering Mechanics, University of Cincinnati, Cincinnati, OH 45221, USA
(2) Department of Mechanical Engineering, Hong-Ik University, Seoul 121-791, Korea
"Analysis of anisotropic laminated cylindrical shells subjected to destabilizing loads. Part I: Theory and solution procedure", Composite Structures, Vol. 19, No. 2, 1991, pp. 167-181, doi:10.1016/0263-8223(91)90021-P
ABSTRACT: The analysis of laminated cylindrical shells of general stacking, but of symmetric construction (there is no coupling between extension and bending), when acted upon by the destabilizing heads of lateral pressure, hydrostatic pressure, uniform axial compression and torsion, is presented. Sanders-type equations are employed in deriving the buckling equations. A solution procedure is developed for computer-generated numerical results. This procedure is based on the Galenkin method. Extensive parametric studies are performed and presented in Part II. Justification for the work is provided in the Introduction section of the paper.

George J. Simitses and John S. Anastasiadis (University of Cincinnati, Cincinnati, OH 45221, USA), "Buckling of axially-loaded, moderately-thick, cylindrical laminated shells", Composites Engineering, Vol. 1, No. 6, 1991, pp. 375-391, doi:10.1016/0961-9526(91)90042-Q
ABSTRACT: A higher-order theory is developed (kinematic relations, constitutive relations, equilibrium equations and boundary conditions), which includes initial geometric imperfections and transverse shear effects, for a laminated cylindrical configuration, under the actions of lateral pressure, axial compression and torsion. Through the perturbation technique, buckling equations and boundary conditions are derived for a symmetric laminated configuration, for a higher-(third) order shear-deformation theory as well as for the cases of first-order shear-deformation theory and classical theory. Critical axially-compressive loads are computed for finite length cylinders for several stacking sequences, several radius-to-total-thickness ratios and length-to-radius ratios and for all the above three theories. The material that was employed in generating results was boron/epoxy.

G.J. Simitses, Z.Q. Chen and S. Sallam (Georgia Institute of Technology, Atlanta, Georgia 30332, USA), "Delamination buckling of cylindrical laminates", Thin-Walled Structures, Vol. 11, Nos. 1-2, 1991, pp. 25-41, Special Issue on Aerospace Structures, doi:10.1016/0263-8231(91)90009-8
ABSTRACT: Models for predicting delamination buckling of laminated complete thin cylindrical shells and cylindrical panels are presented. The load cases are uniform axial compression and uniform pressure, applied individually. The models are different for the two load cases and by design they are kept as simple as possible, to keep the mathematical representation of the model and the associated solution simple enough to permit extensive parametric studies. Through these studies one can identify important structural parameters and fully assess their effect on the critical load. Among the general conclusions are the following: (a) the most influential parameters for a given laminated geometry are the size of the delamination and its through-the-thickness position for both load cases; and (b) the effect of boundary conditions (along the straight edges) is important for

the case of pressure, whereas for axial compression the effect of boundary conditions (ends) is small for large delaminations.

J.S. Anastasiadis and G.J. Simitses (School of Aerospace Engineering, Georgia Institute of Technology, Atlanta, Georgia, USA), "Spring simulated delamination of axially-loaded flat laminates", Composite Structures, Vol. 17, No. 1, 1991, pp. 67-85, doi:10.1016/0263-8223(91)90061-3
ABSTRACT: A general one-dimensional model of a delaminated composite structural element under axial loading is used for predicting the classical buckling load, with the bending-stretching coupling effect. Two cases are examined. In the first case the delamination is such that it does not cause any resistance in the motion of the two detached laminae, due to the applied axial loads. In the second case, the delamination is such that both laminae feel the existence of a spring distribution along the length of the delamination.

G.J. Simitses, A. Tabiei and J.S. Anastasiadis (Department of Aerospace Engineering and Engineering Mechanics, University of Cincinnati, Cincinnati, OH 45221, U.S.A.), "Buckling of moderately thick, laminated cylindrical shells under lateral pressure", Composites Engineering, Vol. 3, No. 5, 1993, pp. 409-417, doi:10.1016/0961-9526(93)90078-X
ABSTRACT: The problem of instability of laminated circular cylindrical shells under the action of lateral pressure is investigated. The analysis is based on higher-order shear-deformation theory where the effect of transverse shear is taken into account. The buckling is elastic for moderately thick composite shells and the geometry is assumed to be free of initial imperfections. The equilibrium equations and the related boundary conditions are derived by variational methods. The buckling equations are derived through the perturbation technique. Critical lateral pressures are computed for finite- and infinite-length cylinders for several stacking sequences and several radius-to-thickness ratios. The numerical results are presented in tabular and in graphical form.

John S. Anastasiadis (1) and George J. Simitses (2)
(1) School of Aerospace Engineering, Georgia Tech, Atlanta, Georgia 30332, USA
(2) Department of Aerospace Engineering and Engineering Mechanics, University of Cincinnati, Cincinnati, Ohio 45221-0070, USA
"Buckling of pressure-loaded, long, shear deformable, cylindrical laminated shells", Composite Structures, Vol. 23, No. 3, 1993, pp. 221-231, doi:10.1016/0263-8223(93)90224-E
ABSTRACT: A higher-order shell theory was developed (kinematic relations, constitutive relations, equilibrium equations and boundary conditions), which includes initial geometric imperfections and transverse shear effects for a laminated cylindrical shell under the action of pressure, axial compression and in-plane shear. Through the perturbation technique, buckling equations are derived for the corresponding 'perfect geometry' symmetric laminated configuration. Critical pressures are computed for very long cylinders for several stacking sequences, several radius-to-total-thickness ratios, three lamina materials (boron/epoxy, graphite/epoxy, and Kevlar/epoxy), and three shell theories: classical, first-order shear deformable and higher- (third-) order shear deformable. The results provide valuable information concerning the applicability (accurate prediction of buckling pressures) of the various shell theories.
G.J. Simitses, "Delamination buckling of flat laminates", Chapter 9 in Buckling and postbuckling of composite plates, edited by G. J. Turvey and I. H. Marshall, 1995, Chapman & Hall, ISBN 0 412 59120 0
PARTIAL INTRODUCTION: The constant demand for lighter and more efficient structural configurations has led the structural engineer to the use of new man-made materials. At the same time, this demand has forced upon him very sophisticated methods of testing, analysis and design, as well as of fabrication and manufacturing. …

George J. Simitses (University of Cincinnati, Cincinnati, OH 45221., USA), “Buckling of moderately thick laminated cylindrical shells: a review”, Composites Part B: Engineering, Vol. 27, No. 6, 1996, pp. 581-587, Special Issue on Thick Composites, doi:10.1016/1359-8368(95)00013-5
ABSTRACT: The present paper is a review article on the problem of buckling of moderately thick, laminated, composite shells subjected to destabilizing loads. The loads consist of uniform axial compression, uniform lateral pressure and torsion applied individually or in combination. In all the works reported in the literature, the analysis is based on higher-order shear deformation (HOSD) shell theory and/or first-order shear deformation (FOSD) shell theory with or without a shear correction factor. Results obtained by these two shell theories and by employing classical thin shell theory are compared to determine the range of applicability of each in predicting critical conditions. The effect of stacking sequence, radius-to-thickness ratio and length-to-radius ratio is assessed. Typical numerical results are presented in tabular form. Moreover, some limited results, which are based on limit point analysis are also presented (imperfection sensitivity studies).

J. Rezaeepazhand, G. J. Simitses, J. H. Starnes Jr, “Scale models for laminated cylindrical shells subjected to axial compression”, Composite Structures, Vol. 34, No. 4, April 1996, pp. 371-379, doi:10.1016/0263-8223(95)00154-9
ABSTRACT: This study investigates problems associated with the design of scaled down models. Such study is important since it provides the necessary scaling laws, and the factors which affect the accuracy of the scale models. For better understanding the applicability of scaled down models in designing laminated composite structures, an analytical investigation was undertaken to assess the feasibility of their use. Employment of similitude theory to establish similarity among structural systems can save considerable expense and time, provided that the proper scaling laws are found and validated. In this study the limitation and acceptable interval of all parameters and corresponding scale factors are investigated. Particular emphasis is placed on the case of buckling of cross-ply cylindrical shells under uniaxial compressive loads. Both complete and partial similarity are discussed. This analytical study indicates that distorted models with a different number of layers and geometries than those of the prototype can predict the behavior of the prototype with good accuracy. However, it is shown that a scaled down model with different material properties than those of the prototype is incapable of predicting the response of the prototype.

George J. Simitses, “Buckling of Pressure-Loaded, Delaminated, Cylindrical Shells and Panels”, Key Engineering Materials, Vols. 120-121, 1996, pp. 407-426, doi: 10.4028/www.scientific.net/KEM.120-121.407
ABSTRACT: This work deals primarily with the question of buckling of delaminated curved structural elements subjected to external pressure, and how the presence of the delamination affects the global load carrying capacity of the structure. A review of the effect of the presence of imperfections and defects on buckling in laminated configurations is presented. The emphasis is then placed on delaminations, and the simple mathematical models that have been used for the buckling analysis of delaminated shells. Through these models the parameters that have the largest effect on the buckling load are identified. It is concluded that the two most influencing parameters are the size of delamination and the through-the-thickness position of the delamination. Areas of future research are identified, through the critical review of the reported studies.

J. Rezaeepazhand and G. J. Simitses (Department of Aerospace Engineering and Engineering Mechanics, University of Cincinnati, Cincinnati, OH 45221-0070, USA), “Structural similitude for vibration response of laminated cylindrical shells with double curvature”, Composites Part B: Engineering, Vol. 28, No. 3, 1997, pp. 195-200, doi:10.1016/S1359-8368(96)00046-7

ABSTRACT: In order to understand the applicability of scaled down models in designing laminated composite structures, an analytical investigation was undertaken to assess the feasibility of their use. Employment of similitude theory to establish similarity among structural systems can save considerable expense and time, provided the proper scaling laws are found and validated. The developed methodology is demonstrated through application of similitude theory to laminated cylindrical shells. Particular emphasis is placed on the case of free vibration of cross-ply laminated cylindrical shells with double curvature. The results presented herein indicate that, for free vibration responses of laminated cylindrical shells of double curvature, based on structural similitude, a set of scaling laws can be found which are used to develop design rules for designing small scale models. This analytical study indicates that distorted models with a different number of layers, geometries and material properties than those of the prototype can predict the behavior of the prototype with good accuracy. However, it is shown that a scaled down model with distorted curvature is incapable of predicting the response of the prototype.

G.J. Simitses (1) and G.A. Kardomateas (2)
(1) Aerospace Engineering and Engineering Mechanics, University of Cincinnati, Cincinnati, OH 45221, USA
(2) Aerospace Engineering, Georgia Institute of Technology, Atlanta, GA 30332-10150, USA
“Imperfection sensitivity of moderately thick composite cylindrical shells”, (publisher/date not given, 1998?)
ABSTRACT: The problem of instability of imperfect, moderately thick, circular cylindrical shells under the action of uniform lateral pressure is investigated. Two approaches are followed: First, an analysis is done based on nonlinear kinematic relations, where the effect of transverse shear is taken into account and an imperfection function is assumed. The Galerkin procedure is employed to solve the resulting partial differential equations. The second method is based on applying Koiter's general postbuckling theory. To this extent, the objective is the calculation of imperfection sensitivity by relating to the initial post-buckling behavior of the perfect structure. Again, a shear deformation theory which accounts for transverse shear strains and rotations about the normal to the shell midsurface is employed to formulate the shell equations. The initial postbuckling analysis indicates that the range of imperfection sensitivity depends strongly on the material anisotropy, and also on the shell thickness and whether the end pressure loading is included or not.

Victor Birman (1) and George J. Simitses (2)
(1) University of Missouri-Rolla, Engineering Education Center, 8001 Natural Bridge Road, St. Louis, MO 63121, USA
(2) Department of Aerospace Engineering, and Engineering Mechanics, University of Cincinnati, Cincinnati, OH 45221-0070, USA
“Elliptical and Circular Cylindrical Sandwich Shells with Different Facings”, Journal of Sandwich Structures and Materials, April 2000, vol. 2, no. 2, pp. 152-176, doi: 10.1177/109963620000200204
ABSTRACT: The Sanders-type theory of elliptical sandwich shells with different facings is formulated. The governing equations account for transverse shear strains and for rotations about the normal to the middle surface of the shell. The constitutive equations correspond to a sandwich shell where each facing is formed of an even number of regular symmetrically laminated layers. Accordingly, the matrix of extensional, coupling and bending stiffnesses is fully populated, except for the elements A16 and A26 that are equal to zero. In addition, a geometrically nonlinear formulation is presented for an elliptical facing resting on an elastic foundation, based on the Sanders nonlinear shell theory. In this formulation, the rotations about the normal to the middle surface as well as transverse shear strains are disregarded. Both the governing equations for the sandwich shell and the nonlinear solution for a facing are reduced to the corresponding results for a circular cylindrical shell if the

radius of curvature of the shell is constant. Numerical examples are presented for the problem of buckling of a long cylindrical shell subjected to a lateral pressure. This solution, developed by using the energy method, illustrates the penalty involved in using different facings, which may nevertheless be necessary to improve the design by reinforcing the facing exposed to low-velocity impact and other loads.

Jea-Hyeong Han, George A. Kardomateas, George J. Simitses, “Elasticity, shell theory and finite element results for the buckling of long sandwich cylindrical shells under external pressure”, Composites: Part B 35 (2004) 591–598.
ABSTRACT: The buckling of a sandwich cylindrical shell under uniform external hydrostatic pressure is studied in three ways. The simplifying assumption of a long shell is made (or, equivalently, ‘ring’ assumption), in which the buckling modes are assumed to be two-dimensional, i.e. no axial component of the displacement field, and no axial dependence of the radial and hoop displacement components. All constituent phases of the sandwich structure, i.e. the facings and the core, are assumed to be orthotropic. First, the structure is considered a three- dimensional (3D) elastic body, the corresponding problem is formulated and the solution is derived by solving a set of two linear homogeneous ordinary differential equations of the second-order in r (the radial coordinate), i.e. an eigenvalue problem for differential equations, with the external pressure, p the parameter/eigenvalue. A complication in the sandwich construction is due to the fact that the displacement field is continuous but has a slope discontinuity at the face-sheet/core interfaces, which necessitates imposing ‘internal’ boundary conditions at the face-sheet/core interfaces, as opposed to the traditional two-end-point boundary value problems. Second, the structure is considered a shell and shell theory results are generated with and without accounting for the transverse shear effect. Two transverse shear correction approaches are employed, one based only on the core, and the other based on an effective shear modulus that includes the face-sheets. Third, finite element results are generated by use of the ABAQUS finite element code. In this part, two types of elements are used: a shear deformable shell element and a solid 3D (brick) element. The results from all these three different approaches are compared.

G. A. Kardomateas and G. J. Simitses (Georgia Institute of Technology, Atlanta, GA 30332-0150), “Buckling of Long Sandwich Cylindrical Shells Under External Pressure”, J. Appl. Mech., Vol. 72, No. 4, July 2005, pp. 493-499, doi:10.1115/1.1934513
ABSTRACT: An elasticity solution to the problem of buckling of sandwich long cylindrical shells subjected to external pressure is presented. In this context, the structure is considered a three-dimensional body. All constituent phases of the sandwich structure, i.e., the facings and the core, are assumed to be orthotropic. The loading is a uniform hydrostatic pressure, which means that the loading remains normal to the deflected surface during the buckling process. Results are produced for laminated facings, namely, boron/epoxy, graphite/epoxy and kevlar/epoxy laminates with 0 deg orientation with respect to the hoop direction, and for alloy-foam core. Shell theory results are generated with and without accounting for the transverse shear effect. Two transverse shear correction approaches are compared, one based only on the core, and the other based on an effective shear modulus that includes the face sheets. The results show that the shell theory predictions without transverse shear can produce highly non-conservative results on the critical pressure, but the shell theory formulas with transverse shear correction produce reasonable results with the shear correction based on the core only being in general conservative (i.e., critical load below the elasticity value). The results are presented for four mean radius over shell thickness ratios, namely 15, 30, 60, and 120 in order to assess the effect of shell thickness (and hence that of transverse shear). For the same thickness, the differences between elasticity and shell theory predictions become larger as the mean radius over thickness ratio is decreased. A comparison is also provided for the same shell with homogeneous composite construction. It is shown that the sandwich construction shows much larger differences between elasticity and shell theory predictions than the homogeneous composite construction. The

solution presented herein provides a means of a benchmark for accurately assessing the limitations of shell theories in predicting stability loss in sandwich shells.

.Chen, Z. Q., and Simitses, G. J., "Delamination BuckIing of Pressure-Loaded Cross-Ply Laminated Cylindrical Shells," Zeitschrift fur Angewandte Mathematik und Mechanik. Vol. 68, No. 10, 1988, pp. 491-501.

Simitses, G., An Introduction to the Elastic Stability of Structures, Kreiger Publishing. Malabar, FL, 1986, Chap. 7.

Simitses G.J., Sallam S. and Yin W.L., 1985, "Effect of Delamination of Axially Loaded Homogeneous Laminated Plates", AIAA Journal, vol. 23, no. 9, pp. 1437-1444

Simitses, G. 1., and Aswani, M. (1974). "Buckling of thin cylinders under uniform lateral loading." J. Appl. Mech., 827-829.

Birman V, Simitses GJ. Dynamic stability of long cylindrical sandwich shells and panels subject to periodic-in-time lateral pressure. J Compos Mater 2004;38:591–607.

Simitses, G. J., Shaw, D., and Sheinman, I., "Stability of Cylindrical Shells, by Various Shell Theories", ZAMM-Z. Angew. Math. u. Mech, Vol. 65, No. 3, 1985, pp. 159-166.

Simitses GJ, Shaw D, Sheinman I. Stability of imperfect laminated cylinders: a comparison between theory and experiment. AIAA J 1985;23:1086 – 1092.

Tabiei, A. and Simitses, G.J., “Buckling of Moderately Thick Laminated Cylindrical Shells under Torsion”, AIAA Journal, 21, 639-647, 1994.

Kounadis A.N., Gantes C., Simitses G.J., Nonlinear dynamic buckling of multi-dof structural dissipative system under impact loading, Int. J. Impact Engineering, 19 (1), 63-80, 1997.

Sallam, S., Simit