ON SEVEN- AND TWELVE-PARAMETER SHELL FINITE ELEMENTS AND NON-LOCAL THEORIES FOR COMPOSITE STRUCTURES

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ABSTRACT

In this lecture, two separate topics are discussed: (1) shell finite elements based on seven-parameter and twelve-parameter shell theories for large deformation analysis of composite shell structures and (2) non-local continuum mechanics theories. The seven-parameter shell element is based on a modified first-order shell theory using a seven-parameter expansion of the displacement field [1-3]. The twelve-parameter shell element is developed using third-order thickness stretch kinematics. The non-local theories discussed include higher gradient to truly nonlocal. An overview of the author's recent research on nonlocal elasticity and couple stress theories in formulating the governing equations of functionally graded material beams and plates is presented. Two different nonlinear gradient elasticity theories that account for (a) geometric nonlinearity and (b) microstructure-dependent size effects are discussed to establish the connection between them. The first theory is based on modified couple stress theory of Mindlin and the second one is based on Srinivasa↖Reddy gradient elasticity theory [4]. These two theories are used to derive the governing equations of beams and plates [5]. In addition, the graph-based finite element framework (GraFEA) suitable for the study of damage and fracture in brittle materials will be discussed briefly. GraFEA stems from conventional finite element method (FEM) by transforming it to a network representation based on the study by Khodabakhshi, Reddy, and Srinivasa [6].

References

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Brief Vitae of J.N. Reddy

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Dr. Reddy is a Distinguished Professor, Regents' Professor, and inaugural holder of the *Oscar S. Wyatt Endowed Chair* in Mechanical Engineering at Texas A&M University, College Station, Texas. Dr. Reddy earned a Ph.D. in Engineering Mechanics in 1974 from University of Alabama in Huntsville. He worked as a Post-Doctoral Fellow in Texas Institute for Computational Mechanics (TICOM) at the University of Texas at Austin, Research Scientist for Lockheed Missiles and Space Company, Huntsville, during l974-75, and taught at the University of Oklahoma from 1975 to 1980, Virginia Polytechnic Institute & State University from 1980 to 1992, and at Texas A&M University from 1992.

Dr. Reddy, an ISI highly-cited researcher, is known for his significant contributions to the field of applied mechanics through the authorship of over 650 journal papers and 21 textbooks and the development of shear deformation plate and shell finite elements for accurate determination of interlaminar stresses in composite structures, which have had major impact on engineering education and practice. His pioneering work on the development of shear deformation theories (that bear his name in the literature as the *Reddy third-order plate theory* and the *Reddy layerwise theory*) have had a major impact on engineering education and practice and have led to new research developments and applications. No one since S.P. Timoshenko, has the same impact on engineering mechanics education as Reddy through his well-received textbooks on variational methods, continuum mechanics, linear and nonlinear finite element analysis, plates and shells, and composite materials and structures.

In recent years, Reddy's research has focused on the development of robust shell finite elements and nonlocal and non-classical continuum mechanics problems — problems involving couple stresses, surface stress effects, discrete fracture and flow, micropolar cohesive damage, and continuum plasticity of metals from considerations of non-equilibrium thermodynamics.

Dr. Reddy has received numerous honors and awards (too many to list here). He is an elected member of the **US National Academy of Engineering** and a **Foreign Fellow of the Canadian Academy of Engineering, the Indian National Academy of Engineering**, and **the Brazilian National Academy of Engineering**. Also, he received the *Prager Medal* of the Society of Engineering Science, the 2016 *ASME Medal* from the American Society of Mechanical Engineers, the 2017 *John von Neumann Medal* from the US Association for Computational Mechanics, and the *Theodore von Karman Medal* from the American Society of Civil Engineers.