RECENT DEVELOPMENTS in Computational Approaches

to Model Laminated Composite Shells and Damage and Fracture in Solids

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ABSTRACT

In this lecture, two different topics of considerable interest to composite materials and structural mechanics communities are discussed. The first topic deals with the development of locking-free shell finite elements with thickness stretch for the nonlinear analysis of isotropic and laminated composite shells [1,2]. The shell finite elements are based on seven-parameter and twelve-parameter shell theories, and account for change in shell thickness and 3-D constitutive relations. The element is found to be robust (i.e., does not require any ad-hoc approaches like reduced integration and stabilization to eliminate thickness, shear, and membrane locking). The second topic is concerned with a graph-based finite element framework (GraFEA) for the study of fracture in solids [3-6]. The major difference between GraFEA and other continuum-based approaches to study fracture is that instead of placing the focus on the elements and introducing a displacement discontinuity either between or inside the elements, GraFEA focuses on nodes and the distance between the nodes. Fracture is merely introduced by breakage of the edges (or any link between any two distinct nodes). Fracture and breakage of an edge is introduced into GraFEA using the idea of weakest link statistics, where the edge-based failure criterion is imposed directly on the discretized body. The fracture criterion chosen in our study is a strain-based criterion; however, this is not a limitation of the method and other fracture criteria can be applied. Numerical examples are presented to illustrate the robustness of the shell element and the workings of GraFEA.

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B I O

Professor Reddy received his Bachelor of Engineering (1968) degree from Osmania University, Hyderabad, India, Master of Science (1970) degree from Oklahoma State University and his Ph.D. (1974) degree in Engineering Mechanics from University of Alabama in Huntsville under the supervision of Professor J.T. Oden. He worked for a short period for Lockheed Missiles and Space Company in Huntsville, Alabama, before joining the University of Oklahoma as an assistant professor in 1975. In 1980 he was recruited as Professor of the Department of Engineering Science and Mechanics at Virginia Polytechnic Institute and State University (Virginia Tech). In 1992, he was appointed as the inaugural holder of the Oscar S. Wyatt Jr. Endowed Chair in the Department of Mechanical Engineering at Texas A&M University, College Station, Texas. Recently, he was appointed as the holder of the O'Donnell Foundation Chair IV.

Dr. Reddy's pioneering works 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 and have led to new research developments and applications. Another profound contribution of Professor Reddy has been in education and knowledge that impacted the educational and professional lives of scoreless young people around the world through his text books, short courses, and workshops. In recent years, Dr. Reddy has been working on two major fronts: (1) development of 7-, 8- and 12-parameter shell theories for composite laminates and their finite elements and (2) nonlocal and non-classical continuum mechanics. The nonlocal and non-classical continuum ideas can be used to study architected and meta materials and efficient modelling of large or mega structures, by bringing material as well as structural length scales into structural theories. One of the highlights of his recent research on nonlocal models is GraFEA, which is capable of studying fracture, without the user input in creating finite element meshes and, at the same time, eliminating mesh dependency.

Dr. Reddy is one of the original top 100 ISI Highly Cited Researchers in Engineering around world with citations of over 76,700 and h-index of 110 as per Google Scholar. He serves on the editorial boards of about two-dozen technical journals. Dr. Reddy also earned numerous national and international awards. Most recent ones are: John von Neumann Medal, US Association for Computational Mechanics (2017); Theodore von Karman Medal, American Society of Civil Engineers (2018); and Stephan P. Timoshenko Medal, American Society of Mechanical Engineers (2019). He is a member of the US National Academy of Engineering, and foreign member of the Brazilian National Academy of Engineering, Canadian Academy of Engineering, the Chinese Academy of Engineering, the European Academy of Sciences, the Indian National Academy of Engineering, and the Royal Academy of Engineering of Spain.