PROFESSIONAL HIGHLIGHTS OF J. N. REDDY

Background

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 (recently, he is appointed as the holder of the O'Donnell Foundation Chair IV). Professor Reddy has been a prolific researcher and passionate teacher, and he served the profession admirably. Dr. Reddy, an ISI highly-cited researcher, is known for his significant contributions to the field of applied and computational mechanics through the authorship of nearly 700 journal papers and 21 textbooks.

Professor Reddy received his Bachelor of Engineering (B.E.) degree from Osmania University, Hyderabad, India in 1968, and Master of Science (M.S.) degree from Oklahoma State University, Stillwater, Oklahoma in 1970. He obtained his Ph.D. (1974) degree in Engineering Mechanics from University of Alabama in Huntsville. 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. He was promoted to the rank of associate professor in 1978. In 1980 he was recruited as a full-professor in the Department of Engineering Science and Mechanics at Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, Virginia. In 1986, he was named the inaugural holder of the Clifton C. Garvin Professorship in Engineering Science and Mechanics Department. In 1992, he was recruited in a nationwide search 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. In 1998 he was appointed as the University Distinguished Professor (only top 2% of the university faculty hold this honor); he was named as the Regents' Professor in 2010. He held the Distinguished Nanyang Visiting Professorship at Nanyang Technological University (NTU) in Singapore (2002-2005). During 2005-2007, he served (on leave) as the first Head of the Engineering Science Programme at the National University of Singapore. He was the Satish Dhawan Visiting Professor at Indian Institute of Science (2012); Distinguished Visiting Fellow of the Royal Academy of Engineering (2013); Distinguished Visiting Professor, Beihang University, China and City University of Hong Kong (2014); Chair of Excellence at Universidad Carlos III de Madrid, Spain (2014-2015); Visiting Professor of the Science without Boarders Program at University of Sao Paulo, Brazil (2014-2016); and Finland Distinguished Professor (FiDiPro), Aalto University and National Technology Agency of Finland (2014-2018). He also held the Simpson Distinguished Visiting Professorship at Northwestern University (2016) and the Arthur Newell Talbot Distinguished Lectureship at University of Illinois at Urbana-Champaign (2017).

His 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.

The highlights of Professor Reddy's contributions that attest for his qualifications as an **author** of research articles that received world-wide recognition and as an engineering **educator** (teacher and text book writer), especially in applied and computational mechanics, are summarized here.

Research Impact in Academia and Industry

Dr. Reddy has a very broad research background that includes applied mathematics and theoretical mechanics, with contributions to mathematics of finite elements, variational methods and principles in

theoretical mechanics, and computational methods with applications to heat transfer, fluid flow, and solid and structural mechanics (and coupled phenomena). As a researcher, Dr. Reddy cares about quality than quantity though the latter exceeds the norm in his field substantially; he has published steadily from the start of his career till now, often in the best journals of his field, spanning about 45 years. For him, writing is an integral part of doing research. He takes pride in seeing his work appear in print.

Dr. Reddy's research in early years (i.e., during his PhD and soon thereafter) was on the mathematical theory of finite elements and variational principles in theoretical mechanics. Since 1975 his work has been on the development of refined theories of laminated composite plates and shells and associated finite elements. The single most significant contribution of Dr. Reddy is the development of refined third-order and layer-wise plate and shell theories that bear his name in the literature. His plate and shell theories, which account for transverse shear deformation and interlaminar stresses in laminated composite materials are well-received by the composite materials and structures community all over the world and they are highly cited. The Defense Evaluation and Research Agency, DERA, Ministry of Defense of the United Kingdom contracted ABAQUS (HKS, Inc.) and Dr. Reddy as a consultant to incorporate his ideas on higher-order and layerwise theories into the Abaqus software, which is used by universities as well as most structural analysis companies around the world. Thus, his work in shear deformation theories has resulted in both scientific advancement as well as technological utility which have helped researchers and practicing engineers in the field of laminated composite structures to extend and apply to practical engineering problems.

Another topic that he worked on was a new paradigm in computational mechanics, namely, the least-squares finite elements. This paradigm shift from the conventional c^0-finite elements based on weak-form Galerkin formulations of the Navier-Stokes equations has proven to be far superior to the weak-form Galerkin formulations that employ ad hoc approaches like upwinding, artificial viscosity, reduced integration, stabilization, and other techniques. The weak-form Galerkin finite element formulations are not well-suited for the solution of the Navier-Stokes equations because they do not represent any physical principle. He and his collaborators have shown that the least-squares formulations provide a much more robust computational framework for the solutions of flows of Newtonian and non-Newtonian fluids. His works have been implemented into commercial software NISA (Engineering Mechanics Corporation) and HyperXtrude (Altair). He also derived the Mindlin's plate theory from the classical plate theory using the penalty function method and identified the penalty parameters in terms of the shear moduli and shear correction coefficients.

In recent years, Dr. Reddy has been working on three major fronts: (1) development of 7-, 8- and 12-parameter shell theories and their finite elements, (2) advancement of nonlocal and non-classical continuum mechanics, and (3) pioneering the *dual mesh finite domain method* (DMFDM). The first area is a continuation of many years of his works on shear deformation theories of plates and shells for large deformation analysis of laminated composite and functionally graded structures. The second one is a rejuvenation of ideas originated and advanced by Cosserat bothers, Green, Naghdi, Mindlin, Eringen, Hutchinson, and likes, and their implementation into structural theories. 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 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. The third topic deals with the DMFDM, where the domain is represented with a mesh of finite elements and a dual mesh is superimposed on the primal mesh such that the nodes of the primal mesh are at the center of the dual mesh of finite domains, on which the governing equation is satisfied in an integral sense The method, by very construction of the discretization procedure, does not involve isolating a finite element and satisfying the governing equations in weak sense (i.e., weighted-integral sense) over the element and assembling element equations to obtain the global equations. Instead, the DMFDM

results directly in a set of global equations in terms of the nodal values of the primary variables. Thus, the DMFDM brings the best features of the FEM and the FVM.

Impact on Engineering Education

Professor Reddy is a well-known author in mechanics education. He has authored a wide variety of mechanics books, beginning with variational principles and methods, mathematical theory of finite elements, engineering analysis, linear and nonlinear finite elements, finite elements in heat transfer and fluid dynamics, mechanics of composite materials and structures, plates and shells, continuum mechanics, and mechanics of materials. Professor Reddy developed teaching tools in the form text books that are adopted worldwide. Over the past four decades he has consistently written highly substantive, upper-level undergraduate and graduate level textbooks. He is the author of 21 books (and many with solutions manuals), some of them in their third and fourth editions from well-known publishing houses of engineering books (e.g., Cambridge University Press, Oxford University Press, McGraw-Hill, John Wiley, Springer-Verlag, Elsevier, Taylor & Francis, and CRC Press), which amply demonstrates that they are well-received text books and that he is a superior engineering textbook author. In fact, no one person in engineering, since S. P. Timoshenko, has written so many well-received textbooks as J. N. Reddy that have lasting impact on engineering education.

A close look at the textbooks written by Dr. Reddy show that his teaching philosophy is based on: (1) motivate students to fully understand fundamental concepts and mathematical tools necessary to formulate the problems of engineering, and (2) develop creative and critical thinking in students so as to build solutions to real-life engineering problems. He reminds his students time and again that engineering is a "problem-solving discipline" that requires an understanding of the fundamental principles/axioms of nature and their role in formulating the underlying mathematical models. He does not compromise, as judged from his books, on mathematical rigor and physical understanding required to address the problem to be solved. This is the part that most students, even though initially a bit scared of the mathematical tools he uses to explain the physics, appreciate the most.

An especially strong point of Dr. Reddy's classroom teaching is the clarity and physical insight of explanations of even the most difficult topics through relevant engineering examples, but without compromising on the mathematical rigor. Dr. Reddy personally prepares his assignments and illustrations for all of his undergraduate and graduate courses. He maintains his own course web sites where his meticulously prepared illustrations and learning aids have helped countless students grasp fundamental and advanced principles of mechanics and computational methods for which he is internationally known. He has won the departmental, university, and national (*Archie Higdon Distinguished Educator Award* from the American Society of Engineering Education) awards for his teaching of mechanics subjects.

An Introduction to the Finite Element Method, for example, had a large impact on four generations of engineering students. The reviewers acclaimed it as "an authoritative introduction to the finite element method." The book has received international recognition as one of the leading textbooks in undergraduate and graduate courses on the finite element method. The book is adopted as a textbook by many universities and used by hundreds of thousands of engineering students all over the world. *An Introduction to Nonlinear Finite Element Analysis* (2^{nd} ed., 2015), another book of Professor Reddy, is acclaimed as "a unique text book that fills the gap in the literature by providing a clear and easy-to-understand account of the theoretical formulations, finite element models, and their computer implementation of nonlinear problems arising in heat transfer, fluid mechanics, and solid and structural mechanics." About his book on *Theory and Analysis of Plates and Shells* (2^{nd} ed., Taylor and Francis), a reviewer commented that "this book by J. N. Reddy digests more than two decades of research by him in plate theories (specially for thick plates and laminated composites), variational methods and finite elements into an excellent textbook which can be used very well by beginning or advanced graduate students, or by many engineers who deal with aerospace, automotive and civil engineering structures, . . . This is the best textbook that this reviewer has seen for understanding the most important aspects of plate theory, and containing

modern, important aspects of plate theory which Timoshenko hardly could touch upon at all (in some cases they were not yet recognized topics); especially thick plates, laminated composites, and finite elements. And yet Reddy's book accomplishes good, useful introductions to all these topics in a mere 540 pages. *Theory and Analysis of Elastic Plates and Shells* (2nd ed.) is a textbook that clarifies the important aspects of plate theory, emphasizing its most important modern ones. For this purpose, it is the best book available, in this reviewer's experience. As such it belongs on the bookshelves of every technical library, and every graduate student or engineer seriously interested in plates, and should become a widely used textbook in graduate level courses." The book, *Mechanics of Laminated Composite Plates and Shells* (2nd ed., CRC Press) is considered to be a classic, and it covers anisotropic elasticity, classical and shear deformation theories, analytical solutions, and finite element analysis of laminated beams, plates, and shells. His book, *An Introduction to Continuum Mechanics* (Cambridge University Press) is already in its second edition, and translated into French.

The quality as well as the caliber of his research is strongly indicated by the placement of Dr. Reddy's doctoral recipients. Many of them hold faculty positions at U.S. universities (one is a department head, another endowed chair professor) as well as in institutions in other countries; others are research engineers in U.S. industries (US Air Force, General Electric, Lockheed, Ford, General Motors, etc.). Most of his postdoctoral fellows are faculty members in European and Asian universities. His impact on engineering education and research is truly extensive and, in good measure, fueled by the quality of his teaching and research.

Professional Service

One would think that someone who excels in research and teaching would not have much time to serve the institution and profession. Professor Reddy served his institution and profession admirably through Departmental, College, University, and national and international level technical committees, organizer of conferences and short courses, editor-in-chief of some major journals in his field. In particular, Dr. Reddy served as the president of US Association for Computational Mechanics, founding member of the General Council of international Association of Computational Mechanics, Secretary of Fellows of American Academy of Mechanics, member of the Board of Governors of the Society of Engineering Science, Chair of the Engineering Mechanics Executive Committee of the American Society of Civil Engineers, among others. He either served or currently serving on the editorial boards of over three-dozen professional journals. In addition, he served as the Editor-in-Chief of the *Applied Mechanics Reviews*, and the founding Editor-in-Chief of *Mechanics of Advanced Materials and Structures*, the *International Journal of Computational Methods in Engineering Science and Mechanics*, and the *International Journal of Structural Stability and Dynamics*. In addition, he organized/conducted numerous international conferences, advanced study institutes, workshops, and short courses.

Honors and Awards Received

Dr. Reddy is one of the original top 100 ISI Highly Cited Researchers in Engineering around world with over 32,000 citations and h-index of 82 as per Web of Science; the number of citations is over 76,635 with h-index of 110 as per Google Scholar. Dr. Reddy serves on the editorial boards of about two-dozen journals, including *Annals of Solid and Structural Mechanics, Composite Structures, International Journal for Numerical Methods in Engineering, International Journal for Numerical Methods in Biomedical Engineering, and International Journal of Non-Linear Mechanics*. He is the founding Editor-in-Chief of *Mechanics of Advanced Materials and Structures, International Journal of Computational Methods in Engineering Science and Mechanics*, and *International Journal of Structural Stability and Dynamics*.

Dr. Reddy also earned numerous national and international awards and they include:

- Ralph R. Teetor Education Award, Society of Automotive Engineers (1976)
- Walter L. Huber Civil Engineering Research Prize, American Society of Civil Engineers (1984)
- Worcester Reed Warner Medal, American Society of Mechanical Engineers (1992)

- Charles Russ Richards Memorial Award, American Society of Mechanical Engineers (1995)
- Archie Higdon Distinguished Educator Award, American Society of Engineering Education (1997)
- Nathan M. Newmark Medal, American Society of Civil Engineers (1998)
- Excellence in the Field of Composites, American Society for Composites (2000)
- Belytschko Medal, US Association for Computational Mechanics (2003)
- Distinguished Research Award, American Society for Composites (2004)
- Honorary Member, American Society of Mechanical Engineers (2011)
- Raymond D. Mindlin Medal, American Society of Civil Engineers (2014)
- O.C. Zienkiewicz Award, International Association of Computational Mechanics (2014)
- Member, US National Academy of Engineering (2015)
- Foreign Fellow, Indian National Academy of Engineering (2015)
- ASME Medal, American Society of Mechanical Engineers (2016)
- Prager Medal from the Society of Engineering Science (2016)
- Foreign Fellow, Canadian Academy of Engineering (2017)
- Foreign Fellow, Brazilian National Academy of Engineering (2017)
- John von Neumann Medal, US Association for Computational Mechanics (2017)
- JS Rao Medal in Vibration Engineering, Vibration Institute of India (2017)
- JN Reddy Medal in Mechanics of Advanced Materials and Structures (2018)
- Theodore von Karman Medal, American Society of Civil Engineers (2018)
- Eugenio Beltrami Senior Scientist Prize, the International Research Center for Mathematics & Mechanics of Complex Systems (M&MoCS), Università dell'Aquila, Italy (2019)
- Stephan P. Timoshenko Medal, American Society of Mechanical Engineers (2019)
- Foreign Member, The Chinese Academy of Engineering (2019)
- Corresponding Member, The Royal Academy of Engineering of Spain (2019)
- Honorary Member, the European Academy of Sciences (2020)