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Challenges in Composites for Marine Structures in Extreme Environments

Yapa D.S. Rajapakse

Program Manager, Solid Mechanics (ONR 332)

Office of Naval Research

875 N. Randolph Street (Suite 1425)

Arlington, VA 22203-1995. U.S.A.

ABSTRACT

The Solid Mechanics Research Program of the Office of Naval Research (ONR) provides the scientific basis for the effective design and utilization of affordable and reliable Naval structures operating in severe environments. These structures are designed to withstand complex multi-axial loading conditions, including highly transient loads, in severe environments. The analysis of these structures requires the incorporation of the effects of sea water and moisture, temperature extremes, time-dependent three-dimensional loading, high sea states, hydrostatic pressure, and fluid-structure interaction. The current research focus is on mechanics of marine composite materials and composite sandwich structures. The program deals with understanding of, and establishing physically based models for, the physical processes involved in the response of glass-fiber and carbon-fiber reinforced composite materials and composite sandwich structures, to static, cyclic, and dynamic, multi-axial loading conditions, in severe environments. The establishment of these models, with predictive capabilities, requires multi-scale, multi-physics analysis. Avenues for enhancing the performance of marine composite structures through the introduction of nanoparticles, and through the incorporation of novel design concepts, are also being explored. Research on multifunctional composites seeks to enhance performance through the incorporation of additional beneficial attributes, without compromising on the mechanical properties. Some recent research accomplishments will be summarized. Examples include: Effect of hydrostatic pressure on sea water absorption; Combined effect of sea water absorption and temperature extremes; Establishment of three-dimensional static/dynamic failure criteria; Dynamic response of composite structures with fluid-structure interaction; Low velocity impact and shock response at cold temperatures; Shock/blast effects on composite sandwich structures: Hydrostatic pressure induced implosions in composite structures; Explosion induced implosions in composite structures; Combined effects of extreme cold temperatures and sea water absorption on shock/blast response; Blast mitigation in composite structures. The presentation will include a discussion of future directions of research in mechanics of marine composites for affordable naval structures with enhanced performance and reduced life-cycle costs. Areas of increased emphasis include: structure/fluid interactions; shock, blast, and implosion effects; and coupled effects of sea water absorption, temperature extremes (especially Arctic), and highly dynamic loading.

Yapa D. S. Rajapakse
Solid Mechanics, Office of Naval Research, USA

SHORT BIO

Dr. Rajapakse is the Program Manager, Solid Mechanics, at the Office of Naval Research (ONR). The major focus of the Solid Mechanics Program is on the performance of Marine Composites and Composite Sandwich Structures in extreme environments and extreme loading conditions. Dr. Rajapakse received his Ph. D. degree in Applied Mechanics under the guidance of the late Professor J. N. Goodier, and a M. S. degree in Mathematics, from Stanford University. He has been elected Fellow of the four technical societies: American Society of Mechanical Engineers (ASME), Society of Engineering Science (SES), American Academy of Mechanics (AAM), and American Society for Composites (ASC.)He has served on the Editorial Boards of eight technical journals, including Composites Science and Technology, Journal of Sandwich Structures and Materials, Journal of Composite Materials, and Composites Part B. Dr. Rajapakse has served as President, Vice-president, Member of Board of Directors, of SES. He has served as Chairman of the Composite Materials Committee of the Applied Mechanics Division of ASME, and the Polymer-Matrix Composites Division of ASC. He has organized ONR Symposia at several past ICCMs including ICCM16, ICCM17, ICCM18, and ICCM19. He has edited/coedited 32 books, including recently: “Dynamic Failure of Materials and Structures,” “Blast Mitigation: Experimental and Numerical Studies,” and “Durability of Composites in a Marine Environment.”