Structural Response Under Extreme Underwater Loadings

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Brief Biographical Sketch

Dr. Shukla is the Simon Ostrach Professor of Mechanical Engineering at the University of Rhode Island (URI). He is also the co-founder and inaugural co-director of the National Institute for Undersea Vehicle Technology at URI. Dr. Shukla was elected to the European Academy of Sciences and Arts in 2011 and the Russian Academy of Engineering in 2015. He is a Fellow of the American Society of Mechanical Engineers (ASME), American Academy of Mechanics, Shock Wave Society (India) and the Society for Experimental Mechanics (SEM). He received the M.M. Frocht and the B.J. Lazan Award from the SEM for "outstanding technical contributions." In 2003 he served as the President of SEM and in 2011 delivered the prestigious Murray Lecture at SEM. He has served as the Technical Editor of Experimental Mechanics and currently serves on the Editorial Boards of key engineering journals. Dr. Shukla has received the Distinguished Alumnus Award from his alma mater, IIT Kanpur. In 2023, he received the prestigious Drucker Medal from the ASME, and the Theocaris Award from the SEM. He is the recipient of the URI Scholarly Excellence Award and the URI Graduate School Outstanding Mentoring Award. He has served as the Clark B. Millkan Visiting Professor of Aerospace at the California Institute of Technology, USA and as the Satish Dhawan Visiting Chair at the Indian Institute of Sciences, Bangalore India. He has also served as the chair of ASME's Applied Mechanics Division, Executive Committee. Along with his many Ph.D. and M.S. students, he has published more than 450 papers in journals and proceedings. Dr. Shukla has also authored and edited 10 books. Dr. Shukla is currently visiting IIT Kanpur as the Distinguished Visiting Professor.

Abstract

This seminar presents recent advances in understanding the mechanics of underwater implosion and strategies for mitigating the resulting pressure pulses. Experimental investigations of sympathetic implosions and the interaction between an imploding cylinder and nearby structures are discussed. State-of-the-art pressure vessel facilities are employed to study the implosion process. These vessels are equipped with multiple optical windows to enable three-dimensional Digital Image Correlation (3D-DIC). Pressure histories generated during implosion events are recorded using dynamic pressure transducers positioned near the test specimens and are correlated with real-time deformation and velocity measurements of the shells. High-speed imaging combined with 3D-DIC provides detailed insight into deformation mechanisms and collapse modes.

The second part of the talk focuses on experimental studies of fluid–structure interaction between the gas bubble produced by an underwater explosion (UNDEX) and nearby rigid or flexible plates. Plates are clamped to support structures that are either air-backed or water-backed. While the initial shockwave from detonation can cause significant damage, the subsequent collapse of the gas bubble can be even more destructive. Results demonstrate that explosive standoff distance, plate rigidity, and hydrostatic pressure strongly influence bubble shape, size, migration velocity and direction, jetting behavior, and the resulting structural damage. For the dimensionless standoff parameters investigated, bubble collapse and associated jetting are identified as the primary mechanisms responsible for plate rupture and failure.