SEMTE seminar

Deformation Mechanisms and Energy Absorption in the Crushing of Cellular Solids

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abstract

Cellular solids, such as foamed polymers and metals, microtrusses and honeycombs are commonly used in Aerostructural components as sandwich panels cores owing to high stiffness-to-weight ratio and high transverse shear strength. These core materials also aid in increasing energy absorption under crush loading conditions. This is possible because of the localized and progressive mode of failure that occurs over a lengthy region of a fairly constant plateau load. The out-of-plane crush response of circular cell honeycombs is considered in this presentation. These honeycombs are essentially thin-walled cylindrical shells that are bonded together in a hexagonal packing arrangement. The high rate axial response of honeycombs is studied using two experimental techniques modified from the traditional split-Hopkinson pressure bar, namely, a wave loading device (WLD method) and a Direct Impact Method (DIM). These two methods make crush velocities available in the range of 4000 – 11,000 mm/s. Rate dependency in the crush response is observed in these experiments while the mode of crushing is similar to the concertina-diamond mode seen in the static crush experiments. This is attributed to the rate dependency of the polycarbonate material. The experimental results are analyzed with the aid of finite element simulations. The crush mechanism of these honeycombs can be modified by adding a filler material such as a soft elastomer. Filled honeycomb specimens with 3-cell, 7-cell and 19-cells, are examined experimentally, and it is found that a synergistic energy absorption mechanism due to changes in the mode of failure is at play. Unlike the concertina-diamond mode seen in the unfilled specimens, the folding mode is more diffused because the filler material stabilizes collapse. Moreover, the first point of collapse is more stable than the abrupt drop seen in unfilled specimens at the onset of collapse. Finite element computations capture this effect and provide insight on designing the honeycomb collapse mechanism.

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biosketch

Anthony M. Waas is the Felix Pawlowski Collegiate Professor of Aerospace Engineering and Professor of Mechanical Engineering, and Director, Composite Structures Laboratory at the University of Michigan. He received his B.Sc. (first class honors) from Imperial College, Univ. of London, U.K., in 1982, the M.S. in 1983 and Ph.D in 1988 with a minor in Applied Mathematics from the California Institute of Technology, all in Aeronautics. He joined the faculty of the Department of Aerospace Engineering at the University of Michigan in 1988, where he has risen through the ranks, Associate Professor in 1994, Professor in 2000, and Felix Pawlowski Collegiate Professor, 2009. His current research interests are related to lightweight aerostructures, with a focus on automated manufacturability, structural integrity and damage tolerance. He is also researching ceramic matrix "hot" structures, nano-composites, and multi-material structures. Several of his projects have been funded by numerous US government agencies and industry. In addition, he has been a consultant to several industries in various capacities, most recently with the Boeing Company in connection with the 787 Dreamliner airplane. Dr. Waas has served and chaired several AIAA and ASME committees. He is a recipient of several best paper awards, the American Academy of Mechanics Junior Research Award (1997), The UM College of Engineering David Liddle Award for Research Excellence (2006), an AIAA Sustained Service Award (2006), and most recently, the American Society of Composites Outstanding Researcher Award (2013). He is a Fellow of AIAA, ASME, and the AAM, and a member of the American Society of Composites and the American Association for the Advancement of Science. He has served on the editorial boards of several journals, notably, as an Associate Editor of the AIAA Journal (1995-02), the Editorial Advisory Board of the AIAA Journal of Aircraft (1995-00), The ASME Journal of Applied Mechanics (2007-2013), and the International Journal of Engineering Science. He is author or co-author of more than 200 refereed journal papers, and numerous conference papers and presentations.

February 7, 2014 at 9:15am in ERC 490