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A First Principles Approximation of Composite Material Response to Shock Tube Pulse

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Abstract

Extreme loads such as earthquakes and explosions can cause enormous human and infrastructure losses. Considering the high cost of dynamic monitoring and experimentation, computer models are the keys to reducing physical test requirements. With improved computational capacities, engineers in various fields have undertaken complicated modeling for structures under abnormal loads. However, an efficient and accurate model is necessary to more rapidly address dangerous shock problem. Thanks to superior shock resistance properties, composite materials have replaced metals in various defense applications. This investigation particularly relates to the usage on naval ships to achieve better blast survivability with the additional benefit of lower cost. A relatively simple model will be detailed herein for the approximate centerline response prediction of the specific complex case of composite materials tested in a shock tube. A modal analysis simulation of a beam is performed using the gross properties of Young's modulus and material density as well as physical geometry and arbitrary shock load. Closed form equations have been employed to derive the eigenproblem that generates mode shapes and natural frequencies, and the resulting responses are compared to experimental shock tube test results. The best outcome was generated by the simplest model which included a shock pressure pulse averaged into two divisions and applied over the entire beam span. For this case, the simulation and experimental responses had excellent correlation for fractured composite specimens with reinforcement. This model is also a conservative estimation for the shock test range for all other specimens.

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