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Explosion Blast Response of Composites

Edited by Adrian P. Mouritz
and Yapa D. S. Rajapakse

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Explosion Blast Response of Composites deals with an important and contemporary topic due to the extensive use of composites in applications where explosive blasts are an ever-present threat, such as military aircraft, armored vehicles, naval ships and submarines, body armour, and other defense applications. Also, terrorist attacks that occur in subways, trains, buses, aircraft, buildings and other civil infrastructure made of composite materials as well as the growing use of IEDs and other types of explosives used to attack civilian and military targets highlights the need for this book.

In one comprehensive volume, contains all the key information about the effects of explosions, shock waves, and detonation products (e.g. fragments, shrapnel) on the deformation and damage to composites. The book considers the blast response of laminates and sandwich composites as well as blast mitigation of composites.

Explosion Blast Response of Composites provides the essential information to designers, engineers, and terrorism experts to protect civilians, military personnel, and assets from explosive blasts.

Professor Adrian P. Mouritz is the Executive Dean of Engineering at RMIT University, Melbourne, Australia. He is a world-leading authority on the explosive blast response of composite materials and structures, having worked in the field as an academic and defense researcher for over 25 years. He has published five books, nearly twenty book chapters, and over 180 journal papers on composites.

Dr. Yapa D.S. Rajapakse is currently the Program Manager in Solid Mechanics at the United States Office of Naval Research in Arlington, Virginia. He has led the solid mechanics research program at the Office of Naval Research for over 20 years. He is a world-leading expert on composite materials for naval ships and has led one of the largest research programs into the explosive blast response and blast mitigation of composite materials.

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PREFACE

This book deals comprehensively with the important topic of the response of fiber-reinforced polymer laminates and sandwich composite materials to explosive blast loading. Composites are used in a wide range of military, commercial, and civil applications where extreme dynamic loading from an explosive blast is an ever-present risk. Composite materials are used in military fighter aircraft, helicopters, heavy-lift transport aircraft, unmanned aerial vehicles, and other types of air platforms at risk from missiles and other anti-aircraft attack. Composites are used in major structural components to naval ships, including the hull, superstructure, masts, bulkheads, and decks, at risk of blast loads from both air and underwater explosions. Composites are being used increasingly in armored vehicles which are at risk from land mines and improvised explosive devices (IEDs). It is essential that the deformation and damage experienced by composites used in military assets when subjected to an explosive blast is thoroughly understood. Composites are also used extensively for non-military applications, including passenger and cargo aircraft, helicopters, ferries, building facades, bridges, rail carriages, motor cars, and busses. With the rise of terrorism and the use of IEDs and other explosive charges, it is important that the explosive blast response of composites used for commercial and civil applications are well understood.

This book covers the essential topics related to the explosive blast response of laminates and sandwich composite materials. The response of composites to blast loading is examined over multiple length scales ranging from the micrometer scale (e.g., individual fibers, fiber—matrix interfaces) to the material level (e.g., multiple ply layers) to the component level up to full-scale structures. The fundamental physics of the dynamic loads generated by shock waves, detonation products, and other blast-related phenomenon (e.g., cavitation) is described for both air and underwater explosive events. The book also contains the latest, state-of-the-art research into the computational analysis, analytical modeling, and experimental testing and evaluation of composites subjected to explosive blasts. This research provides new and important insights into the deformations, damages, and failure of a variety of laminates and sandwich composites exposed to different types of blast loading events. Also described in the book are new finite element and analytical models to predict the response of composites to air and underwater explosions. An important aspect of the book is a description of new procedures to experimentally test and evaluate the response of composites to explosive blasts. While the focus of this book is on the blast response of composite materials, other materials (e.g., steel) are considered.

The book contains essential information to improve the resistance of composites to explosive blasts. Increasing the deformation and damage resistance of laminates and the face skins to sandwich composites via the judicious choice of fiber type, fiber–matrix interface, and polymer matrix is described. Improving the energy absorption and damage resistance of sandwich composites via the design and properties of the core material is also described. Other approaches to increasing the explosive blast tolerance of composites are outlined, such as bio-inspired design and through-the-thickness reinforcement. The mitigation of the blast wave energy via elastomer coatings and energy-absorbing containers is also described.

The scope, comprehensive nature and in-depth detail of this book ensures it will be of great interest to researchers into the explosive blast response of advanced materials, military personal, designers of blast resistant military, commercial or civil structures made of composite materials, people interested in shock and dynamic loading events, and those interested in composite materials and their applications.

Most of the research performed into the explosive blast loading of laminates and composite materials has been sponsored by the US Office of Naval Research (ONR) under the Solid Mechanics Program led by Dr. Yapa Rajapakse. ONR, working in partnership with US and international defense agencies, has led much of the worldwide research into blast loading effects of composites and improving the explosive blast resistance of these materials. This book stems from an international collaborative activity sponsored by ONR culminating in a 3-day forum titled "*International Workshop on the Explosive Blast Response of Naval Composite Materials and Structures*" held at RMIT University, Melbourne, Australia, in April 2016. The workshop delegates were among the leading academic, defense, and military

Figure 1 Delegates to the international workshop on the explosive blast response of naval composite materials and structures.

researchers in explosive blast loading effects of composite materials (Fig. 1). The outstanding support of ONR and ONR Global under the direction of Dr. Rajapakse (Grant No. N62909-15-1-2000) is greatly appreciated.

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