Composites are used extensively in engineering applications. A constant concern is the effect of foreign object impacts on composite structures because significant damage can occur and yet be undetectable by visual inspection. Such impacts can range from the most ordinary at low velocity – a tool dropped on a product – to the hypervelocity impact of space debris on a spacecraft.

This book brings together the latest developments in this important new research area. It explains how damage develops during impact, the effect of impact-induced damage on the mechanical behavior of structures, and methods of damage prediction and detection. Numerous examples are included to illustrate these topics.

Written for graduate students, as well as for researchers and practicing engineers working with composite materials, this book presents state-of-the-art knowledge on impact dynamics, yet requires only basic understanding of the mechanics of composite materials.

IMPACT ON COMPOSITE STRUCTURES

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Preface

As composite materials are used more extensively, a constant source of concern is the effect of foreign objects impacts. Such impacts can reasonably be expected during the life of the structure and can result in internal damage that is often difficult to detect and can cause severe reductions in the strength and stability of the structure. This concern provided the motivation for intense research resulting in hundreds of journal and conference articles. Important advances have been made, and many aspects of the problem have been investigated. One would need to study a voluminous literature in order to get an appreciation for this new research area. After writing three comprehensive literature reviews on the topic of impact on composite materials, I felt that there was a need to present this material in book form. The study of impact on composite structures involves many different topics, including contact mechanics, structural dynamics, strength, stability, fatigue, damage mechanics, and micromechanics. Impacts are simple events with many complicated effects, and what appears as a logical conclusion in one situation seems to be completely reversed in another. This variety and complexity have kept me interested in this area for several years, and I hope to communicate that to the readers.

This book attempts to present this new body of knowledge in a unified, detailed, and comprehensive manner. It assumes only a basic knowledge of solid mechanics and the mechanics of composite materials and can be used as a text for a graduate-level course or for self-study. Exercise problems are proposed in order to challenge the user's understanding of the material. It is hoped that, after each section, the reader will gain an appreciation of the problems being addressed and the methods available and will be able to implement some of these methods. For example, after Chapter 3, "Impact Dynamics," the reader should understand what is involved in the selection of a mathematical model for predicting the contact force history and should be able to implement what appears to be the logical choice for the particular problem being considered.

Researchers and practitioners in industry would appreciate this comprehensive presentation of the state of the art in this area and use this book as a reference. A long list of references is included for those interested in more details.

Current knowledge in certain areas has reached a certain level of maturity. For example, there is a general agreement on how to model the local indentation of a composite plate by smooth indentors. In other areas, current methods are not completely satisfactory, particularly in the areas of damage prediction and the prediction of the residual properties of impact-damaged composites. The book covers both low-velocity and ballistic impacts. Hypervelocity impacts encountered when spacecraft are hit by meteorites or space debris are in a different class, where impact velocities are measured in km/s. Too few studies dealing with this type of impacts on composite structures can be found, so this aspect of the problem was omitted. Recently, a new area of research dealing with smart materials and smart structures has developed, and one of the objectives has been to use distributed sensors and actuators to monitor the health of the structure. Several attempts were made to determine if and where an impact occurred or to determine the location and size of impact damage. This type of study is beyond the scope of this book, because it would require discussing the modeling of such sensors and actuators, control methods, and identification procedures. However, the methods for modeling the impact dynamics and for modeling the behavior of damaged structures discussed in this book will be very useful for modeling such smart structures.

Upon reading this book, it will be obvious that I am indebted to the numerous investigators who have contributed to the development of this body of knowledge. I have made an effort to include every significant development and to acknowledge the source. A book is usually a reflection of the author's choices regarding what needed to be included and what could be omitted. A balance must be struck between the desire to be clear and comprehensive and the risk of overburdening the reader. In this case, almost every chapter could have been expanded to full book length, making it sometimes difficult to choose. However, I hope readers will gain a sufficient understanding of each aspect of the problem that they will be able to pursue its study on their own. The extensive list of references and the several available literature surveys should be helpful in this regard.

Finally, I would like to thank my editor, Florence Padgett, for being so supportive of me in this endeavor. My wife Jayne and my sons Denis and Marc deserve thanks for allowing me to devote much of my free time to this project. Special thanks to my parents, who encouraged me to pursue my dreams and helped me get the best education. I wish my father were still with us to see this book completed. He would have been very proud.