

Preface

The failure of structures or (parts of) systems is a common problem in practice. In all sectors of industry, from transport (air, rail, water, and road) to process industry, energy generation and high tech manufacturing industry, complex capital assets are used and must be maintained to assure their failure-free operation. In many cases the failed parts can be repaired or replaced, after which the system can fulfil its intended function again. In other cases, failures must be prevented against all costs, as the consequences for the system or its surroundings can be significant or even disastrous. Examples of the latter are the failure of critical aero engine parts leading to aircraft crashes or failing safety systems in a nuclear plant.

For many other failures, a deliberation must be made between the costs of preventive replacements and the costs and collateral damage of a failure. However, to be able to make a solid consideration, it is important to understand why components fail and how they fail. Moreover, to effectively plan preventive measures, it is also crucial to be able to calculate when a component will fail. Especially those questions will be answered by this book.

The large variety of failure mechanisms, i.e. the ways in which parts or systems fail, will be treated extensively. Knowledge on these mechanisms, and especially the effect of the governing loads on failure, are essential to understand why, how and when components fail and how this can be prevented.

Goal—The main goal of this book is to make the reader aware of the relation between the operation of any asset or system, the resulting loads on (parts of) the system and the possible consequences in terms of failures. In addition to the awareness, it also aims to provide quantitative relations enabling more detailed analyses of failing systems.

Therefore, an overview of the most important failure mechanisms is provided, treating for each mechanism the basic failure processes on a material level, but also discussing the quantitative dependence on applied loads. The book does not claim to be complete in providing all the details on all specific mechanisms. For that purpose references to other books and papers are provided. However, the focus here is on providing an overview over the possible mechanisms and showing the similarities in the load-to-failure relations.

For students, Part I of the book provides a basic introduction to the field of loads and failure mechanisms and creates the important awareness for their interdependence. The contents fit well in courses on physics of failure, structural integrity, design, maintenance, and reliability.

For practitioners from industry, the book offers an accessible and rather complete overview of possible failure mechanisms and associated loads. This will assist them in solving practical problems on failures in all kinds of machines and systems. This is supported by the lists of common failures and the decision scheme in [Chap. 8](#).

For researchers, Part II of the book points out the interesting links between the multiple disciplines associated to failure and maintenance challenges. Where research on failure mechanisms is mostly limited to the fields of materials science and mechanical, thermal and electrical engineering, the chapters in Part II of this book show that there are interesting connections with many other disciplines like statistics, stochastics and reliability engineering, design, monitoring, and prognostics, but also non-technical disciplines like business and economics.

Outline—The book is organized as follows. First, it is divided into two parts. In Part I the basic principles of loads and failure mechanisms are treated. This part is particularly suitable for use in an introductory course on the physics of failure. Part II discusses how the detailed knowledge on loads and failure mechanisms can be applied in maintenance, reliability and design. In this part, existing practical methodologies are combined with recently developed concepts to provide innovative solutions to optimize maintenance and design processes. This part is therefore particularly interesting for both engineers/managers in industry and researchers/academics active in the fields of maintenance and reliability engineering and maintenance management, as well as for students taking more advanced courses on maintenance management and optimization.

Within each part, the following topics will be treated.

Part I—Basic Principles of Loads and Failure Mechanisms

In [Chap. 1](#) the balance between loads and load-carrying capacity will be discussed, which is the basic concept of the present book. Also, the difference between external and internal loads and the different load types will be introduced. [Chapter 2](#) will provide an overview of a large number of external loads that can act on systems or parts. For each load type, the generic load will be defined and the various specific sources for that load will be discussed. In [Chap. 3](#) the internal loads, i.e. the loads acting on the material level, will be treated. The external loads introduced in [Chap. 2](#) will be translated into internal loads, which govern the failure behaviour. Finally, in [Chap. 4](#) a rather extensive overview of failure mechanisms will be provided, ranging from mechanical mechanisms like fatigue, creep and wear to thermal and electric failure mechanisms.

Part II—Applications in Maintenance, Reliability and Design

[Chapter 5](#) introduces the basic concepts of maintenance, providing their definitions, but also giving an overview of the various maintenance policies. Many of the topics in consecutive chapters will build on the basics in [Chap. 5](#). [Chapter 6](#) then provides a detailed discussion of load and usage-based maintenance policies,

where the knowledge on failure mechanisms from Part I is demonstrated to yield a large potential in improving maintenance efficiency. In [Chap. 7](#) the link between failure mechanisms and reliability engineering methods is discussed, showing that combining these fields offers a large potential for maintenance improvements. [Chapter 8](#) focuses on the analysis of failures, either before or after they have occurred. Useful methodologies are discussed and case studies demonstrate the practical application. Also, a decision scheme to support the determination of the failure mechanism for an actual failure is provided here. Finally, [Chap. 9](#) treats the various aspects of the design process where knowledge of the failure mechanisms may play a role. Topics like life cycle management, design philosophies and probabilistic design are discussed here.

Examples—Especially, in Part I of the book, a considerable number of examples have been provided within the text. In these (worked) examples the theory treated in the text is translated into a practical problem, showing how the theory can be applied and what typical values the quantities introduced in the text could attain. These examples are typically useful for students in practising and rehearsing the treated topics.

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