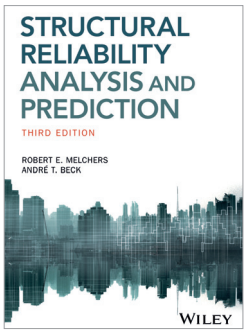
Review

This in-depth book on structural reliability will be useful to those involved in the design and risk assessment of structures subjected to extreme loading, concludes Shashank Gupta.

Structural reliability analysis and prediction (3rd ed.)

Authors: Robert E. Melchers and André T. Beck
Publisher: Wiley
Price: £77.50 (paperback); £69.99 (e-book)
ISBN: 978-1-119-26599-3



The subject of 'structural reliability' has gained importance due to the fact that catastrophic failures continue to occur worldwide, leading to considerable monetary loss as well as loss of life. Due to uncertainties in loading on structures, as well as in their strength/resistance, it is difficult to define safety of structures in absolute terms. Therefore, 'probability of failure (p_f)' or 'probability of survival ($p_s = 1 - p_f$)' are more realistic indicators of structural safety/reliability. Reliability considerations become particularly important for structures subjected to extreme loading.

The primary aim of any book on structural reliability should be to enable an evaluation of probability of failure (or survival). Such an approach will be useful in designing new structures, assessing safety levels and the residual life of existing (deteriorating) structures, and in developing/improving design codes. The third edition of this book by Melchers and Beck meets the above objectives more than adequately.

The book deals with a difficult and highly mathematical subject. Firstly, the probabilistic concepts are more difficult to comprehend than the deterministic ones. Secondly, real-life structures, such as high-rise buildings, towers and bridges, are themselves complex, having many subsystems, joints/connections, multiple material usage and uncertainty associated with each of the design variables. The book provides lucid exposition of underlying concepts in structural reliability. Its contents are systematically organised in 11 chapters and six appendices.

The concept of the 'limit state' and its violation, representing the condition of failure of a structure, is explained in Chapter 1. Deterministic measures of limit state violation, such as factor of safety and load/partial factors, are introduced. These are Level 1 methods in the hierarchy of reliability measurement. Uncertainties in assessment of reliability and risk acceptance criteria for structures from various perspectives are discussed in Chapter 2.

Chapters 3–6 are devoted to various integration and simulation methods for evaluation of p_f. The powerful, though computationally intensive, Monte Carlo simulation is discussed in detail. Level 2 methods based on probabilistic information of variables, such as first-order second-moment (FOSM) and its advanced versions, are explained. FOSM implies linearized representation of limit state (failure) function and up to second-moment (mean and variance) representation of random variables.

Failure and survival mode approaches are introduced for structural systems in series, parallel and mixed configurations. Expressions for the lower and upper bounds of reliability are derived. The concept of time-dependent (instantaneous) probability, the frequency domain (spectral) approach and aspects of fatigue and fracture for reliability analysis are introduced in Chapter 6.

Statistical characteristics of various loads on structures and of the various strength-related variables are discussed in Chapters 7 and 8 respectively. The safety checking formats of various design codes are compared in Chapter 9. Code calibration procedures and performance-based design of structures are discussed.

Issues pertaining to assessment of reliability, acceptance criteria and life-cycle considerations of existing structures, which are subject to deterioration, are taken up in Chapter 10. Reliability-based design optimisation (RBDO) of structures using FOSM and other simulation-based approaches is explained in Chapter 11. This important topic is added as a separate chapter in the revised edition.

The book is practically free of errors, although there are a few typographical errors, e.g. in Eq. 1.15(d) where the inequality should be ≤0. A careful proofreading would help iron out similar mistakes elsewhere. Also, it would have been desirable to have more illustrative solved examples in Chapters 7–11.

The book requires a patient reading of elaborate explanations of various concepts. Its unique feature is the breadth and depth of the topics covered, and therefore it targets a wide audience. It can be used as a textbook for a course at undergraduate and postgraduate levels by a judicious selection of contents. Practising engineers involved in the design and risk assessment of structures subjected to extreme loading will find the book very useful. Researchers will find it extremely useful as a resource material, with elaborate explanations of advanced concepts and an up-to-date bibliography.

In summary, this book is a good contribution to the literature. It complements other books on structural reliability with its in-depth and elaborate explanations of both fundamental and advanced concepts.

Shashank Gupta
PhD, CEng, MIStructE, FHEA

Dr Gupta is Senior Lecturer in the Department of Civil Engineering at the University of Wolverhampton, specialising in structural dynamics and resilient design of structures for extreme loads such as blast and earthquake. He previously worked in industry, where he was involved in consultancy projects in various sectors.