BOOK REVIEW

Life-Cycle of Structures Under Uncertainty

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The performance, functionality and safety of civil and marine structures have been deteriorating due to age, increase in external loadings, corrosion, fatigue and other physical and chemical mechanisms. According to the various reports of the American Society of Civil Engineers published during the past three decades, the amount of deterioration in civil infrastructure has increased, the overall grade for the civil infrastructure in the United States has been degraded from C (fair) in 1988 to D (poor) in 2017, and the budget required to eliminate all existing and future structural deficiencies has grown substantially. As the age of a deteriorating structure increases and its service life reaches its design threshold life, there is a mounting risk associated with unsatisfactory performance under both normal and extreme loading conditions. The unexpected loss of functionality or failure of civil and marine structures can lead to severe economic, social and environmental impacts. For this reason, natural and financial resources should be allocated consistently and rationally to maintain the structural performance of deteriorating civil and marine structures above certain threshold levels.

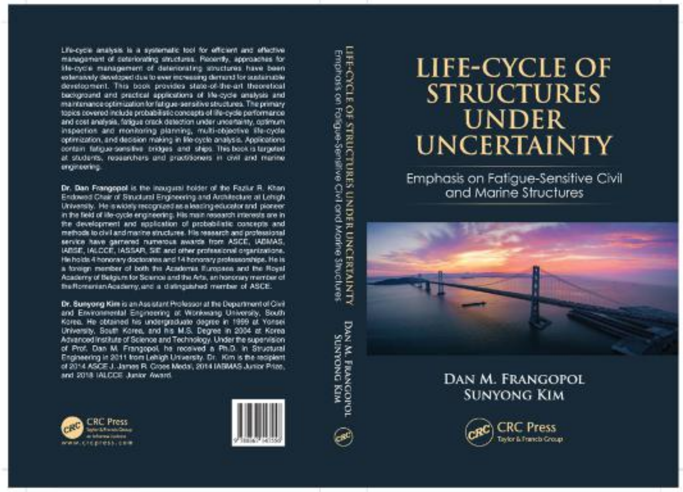
Life-cycle analysis is a systematic tool for efficient and effective service life management of deteriorating structures. In the last few decades, theoretical and practical approaches for life-cycle performance and cost analysis have been developed extensively due to increased demand on structural safety and service life extension. This book presents the state-of-the-art in life-cycle analysis and maintenance optimization for fatigue-sensitive structures. Both theoretical background and practical applications have been provided for academics, engineers and researchers.

The primary topics covered in this book include (a) probabilistic concepts of life-cycle performance and cost analysis, (b) inspection and monitoring in life-cycle analysis, (c) fatigue crack detection under uncertainty, (d) optimum inspection and monitoring planning, (e) multi-objective life- cycle optimization, and (f) decision making in life-cycle analysis. For illustrative purposes, these topics have been applied to fatigue-sensitive details of bridges and ships.

This book includes eight chapters.

Chapter 1 provides the fundamental concepts of life-cycle analysis under uncertainty. Structural performance deterioration mechanisms such as corrosion and fatigue, the effects of maintenance actions on structural performance, cost and service life, and structural performance indicators related to structural condition, safety, tolerance to damage and cost are described. Furthermore, recent investigations on life-cycle optimization for fatigue-sensitive structures are reviewed.

Chapter 2 presents the role of inspection and monitoring in life-cycle analysis. This chapter covers the representative inspection, monitoring and maintenance methods for fatigue-sensitive structures, the effects of inspection and monitoring on life-cycle performance and cost under



uncertainty, and statistical and probabilistic concepts associated with the efficient use of inspection and monitoring data including availability of monitoring data, loss function, Bayesian updating, and probabilistic importance indicators.

Chapter 3 describes the probabilistic concepts and methods related to fatigue crack damage detection, where the time-dependent fatigue crack propagation, probability of damage detection under multiple inspections, expected damage detection delay, and damage detection time-based probability of failure are provided. The concepts and approaches presented in this chapter are used for probabilistic optimum service life management in Chapters 4, 5 and 6.

In Chapter 4, the optimum inspection and monitoring planning for fatigue- sensitive structures is addressed using the fatigue crack damage detection- based objectives. The associated objectives are to maximize the lifetime probability of fatigue crack damage detection, minimize the expected fatigue crack damage detection delay, and minimize the fatigue crack damage detection time-based probability of failure. The formulations of these objectives are based on the probabilistic concepts provided in Chapter 3.

Chapter 5 deals with the optimum inspection and monitoring planning, considering the effects of inspection, monitoring and maintenance on service life extension and life-cycle cost. The objectives used in this chapter include minimizing the expected maintenance delay, maximizing the expected extended service life, and minimizing the expected life-cycle cost. The relationships among the number of inspections and monitorings, expected maintenance delay, expected extended service life and expected life-cycle cost are investigated.

Chapter 6 presents the multi-objective probabilistic optimum inspection and monitoring planning for fatigue-sensitive structures. The bi-, tri- and quad-objective optimization problems are investigated using the objective functions formulated in Chapters 4 and 5. Furthermore, the six objectives for optimum inspection planning and five objectives for optimum monitoring planning are used simultaneously to investigate the multi- objective optimization.

Chapter 7 addresses the decision-making framework for optimum inspection and monitoring planning in order to deal with a large number of objectives efficiently and to select the best single optimum

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inspection and monitoring plan for practical applications. In this framework, there are two decision alternatives such as decision making before and after solving multi-objective life-cycle optimization.

Chapter 8 serves as conclusions of this book. A summary of the book and future directions of the field of life-cycle performance and cost analysis and optimization for civil and marine structures under fatigue are also provided.

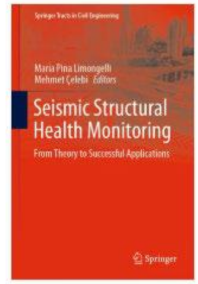
This book will help engineers engaged in civil and marine structures including students, researchers and practitioners with reliable and cost-effective maintenance planning of fatigue-sensitive structures, and to develop more advanced approaches and techniques in the field of life-cycle maintenance optimization and safety of structures under various aging and deteriorating conditions. Since the book is self-contained it can be used by all concerned with civil and marine structures, and probability and optimization concepts for fatigue-sensitive structures, including students, researchers and practitioners from all areas of engineering and industry. It can also be used for an advanced undergraduate course or a graduate course on life-cycle performance and cost of structures under uncertainty with emphasis on fatigue-sensitive structures. The areas to which the concepts and approaches presented in this book can be applied include not only civil structures, such as buildings, bridges, roads, railways, dams, and ports, and marine structures, such as naval vessels, offshore structures, submarines, submersibles, pipelines, and subsea systems, but also aerospace structures, nuclear power plants, and automotive structures.

The cover photo is the San Francisco-Oakland Bay Bridge located in San Francisco, California, over the San Francisco Bay. All the bridge components are constructed of steel. The authors would like to thank Dr. Man-Chung Tang, T.Y. Lin International's Chairman of the Board, designer of more than 100 major bridges across the globe. The photo was taken by Engel Cheng/Shutterstock.com.

BOOK REVIEW

Seismic Structural Health Monitoring: From Theory to Successful Applications

Maria Pina Limongelli and Mehmet Çelebi, editors



This book includes a collection of state-of-the-art contributions addressing both theoretical developments in, and successful applications of, seismic structural health monitoring.

During the last three decades, Seismic Structural Health Monitoring (herein S2HM) has grown due to the needs of owners, managers, occupants and users as well as great interest by both researchers and professionals. The maturity of this important discipline is also well evidenced by the development of sensing systems that - when deployed, configured, and installed properly—enable retrieval of requisite data during significant seismic events. Such data then are post-processed using damage identification algorithms—implemented in structure-specific configured software - to assess serviceability, functionality and/or the structure's suitability for occupancy.

One of the main reasons for increased adoption of S2HM is that it is a superior and significant alternative to other traditional observational and/or intrusive methods which are costly, time-consuming, and—due to dependency on the operator—may be subjective and thus associated with large uncertainties.

Several research efforts have been dedicated to these topics, as shown by the ever-increasing number of related journal and conference publications. However, there is a requisite need in the literature for a focused collection of works dedicated to S2HM.

The primary motivation for this book is to fill this gap by presenting a unified state of the art on theoretical developments and successful applications of S2HM around the world, compiled by leading researchers and academicians.

The book's 17 chapters, prepared by leading international experts, are divided into four major sections. Each section comprises several chapters by authors experienced in different aspects of S2HM. Section A collects six chapters devoted to the description of the specific requirements of S2HM systems for different types of civil structures and infrastructures (buildings, bridges, cultural heritage, dams, structures with base isolation devices) and different phenomena to monitor (e.g. soil-structure interaction and excessive drift). Four chapters covering the methods and the computational tools available for the data processing—needed to retrieve information about the structural health from the signals provided by the sensor network—are grouped in Section B. In Section C, hardware and software tools for S2HM are described in two chapters. Finally, in Section D, five chapters report on several state-of-the-art applications of S2HM around the world.

The book is aimed to be useful to researchers, practicing engineers, and students and to benefit owners and managers with potential applications of S2HM in their properties.