Chapter 62
Lifecycle Assessment of Structures and Probabilistic Performance Approaches

Alfred Strauss
University of Natural Resources and Life Sciences Vienna, Austria

Roman Wendner
University of Natural Resources and Life Sciences Vienna, Austria

ABSTRACT

This contribution is particularly focused on the lifetime assessment of structures where the concept of risk informed decision is based on the structural performance. Regarding the lifetime performance of structures general aspects such as structural system, component-system performance assessment, the concept of robustness in the component-component-system interaction and its assessment framework are introduced. Furthermore, aspects of both deterministic and probabilistic performance evaluation approaches were investigated, while extra emphasis is given to the probabilistic performance assessment approaches. This illustration of the probabilistic performance approaches includes the concepts of uncertainty quantifications, hazard identification methods and techniques, and the formulation of random variables and stochastic structural deterioration processes. In addition, lifecycle performance assessment and prediction methods, approaches and tools for engineering structures are presented.

INTRODUCTION

In recent decades, the issue of predicting and extending the "life time of aging structures" has become increasingly important. This applies both to the field of research as well as practical implementation, including national and international standardization.

Relevant associated research activities that are funded by the "Deutsche Forschungsgemeinschaft (DFG) and running in parallel are:

1. SFB 398, Bochum 1996-2008, "Lebensdauerorientierte Entwurfskonzepte unter Schädigungs- und Deteriorationsaspekten"

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2. SFB 477, Braunschweig, „Sicherstellung der Nutzungsfähigkeit von Bauwerken mit Hilfe innovativer Bauwerksüberwachung“;
3. SFB 524, Weimar, „Revitalisierung von Bauwerken“.

In addition, a number of research projects have been carried out by the authors in Vienna together with international partners:

1. “Strukturanalyse und Zuverlässigkeitsbewertung von Ingenieurbauwerken, Structural Analysis and Reliability Assessment (SARA).”
2. “Risk based Performance Prediction and Lifetime Assessment of Concrete Structures (RLACS).”
3. “Inspection and Lifetime Assessment Tool for Arch Structures (ILATAS).”
4. “Sustainable use of arch bridges (NANUB).”
5. “Monitoring -based software products for lifetime evaluation of fatigue dangered concrete structures (MLEB).”
6. “Comprehensive Infrastructure Life-Cycle Assessment (CILIA).”

In addition, the research fields “sustainability and resource conservation”, “existing buildings” and “resource-oriented construction - Vienna”, belong to this topic.

Furthermore, a variety of international activities in the field of life cycle management and the sustainability of engineering structures originated. As an example, the “Third International Symposium on Life-Cycle Civil Engineering” under the auspices of the International Association on Life Cycle Civil Engineering (IALCCE) was organized by the authors, attended by more than 400 leading scientists and practitioners in October 2012 in Vienna. The mission of IALCCE 2012 was to bring together all cutting edge research in the field of Life-Cycle Civil Engineering and so to advance both the state-of-the-art and the state-of-practice in the field. The “International Association for Structural Health Monitoring” of *fib* commission 2 on “Performance Monitoring” provides current knowledge on life cycle engineering.

The consideration of a structure over the entire life implies the conscious consideration of life-sustaining measures in the planning, construction and during the service life. The useful life control of new buildings as well as the assessment of the remaining lifetime and its extension presupposes that a future structural performance can be inferred from a status-quo performance.

This requires appropriate methods, for example, status-quo-analyses, such as the determination of the material and the structural quality at a given time, visual inspection recording the consideration of environmental and other conditions and the development of structural reliability assessment methods.

Time evolution analyses need also long-term deterioration simulationen for predictions of future reliabilities. They must incorporate blurring, uncertainties, variations and so on, which has to be addressed by the design engineer, in particular he has to try to keep them as small as possible. In the Life cycle assessment the quality assurance - in planning, execution and maintenance – is of high importance.

This chapter aims to provide answers and support to some of this complex problem in the lifetime and lifetime analysis, forecasting and control of engineering structures.

The aim in Life cycle engineering must be the sensitization on life cycle aspects already in the design, planning and construction phase considering the entire life accordingly and their simulation based on mechanically, chemically and physically comprehensible models.

A good structural design is evident in the detail design work a good inspect ability of the components and a low maintenance work.