Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 77 (1998)

Artikel: Reliability-based evaluation concept for everyday use

Autor: Tanner, Peter

DOI: https://doi.org/10.5169/seals-58191

Reliability-Based Evaluation Concept for Everyday Use

Peter TANNER
Research Engineer
Inst. of Constr. Science, IETcc-CSIC
Madrid, Spain

A graduate of ETH Zürich, in 1989 Peter Tanner joined ICOM (Steel Structures) of the Swiss Fed. Inst. of Technology, Lausanne where he worked in the fields of fatigue and fracture mechanics. Since 1992 he has worked with consultants, before joining IETcc in 1996. His research fields are durability of concrete structures and reliability of existing structures.

Summary

This paper describes an approach for the development of a method for considering actual loads and resistance during the evaluation of existing building structures. The method is based on the use of a live load model and partial safety factors for loads and resistance, calibrated by applying reliability methods, which can be determined as a function of site characteristics. The method enables the accurate evaluation of existing building structures for which the degree of uncertainty related to loads and resistance can be reduced compared to that assumed by design codes. Due to this reduction, acceptable reliability may be verified even for structures that are damaged or deteriorated, thus avoiding the need for strengthening or live load restriction.

Keywords: structural reliability, probability of failure, assessment, probabilistic analysis, deterministic analysis, site characteristics, model updating, calibration

1. Motivation

When assessing the safety of an existing structure, the information is different from that available during design, because many characteristics may be measured from the structure under consideration which, at the time of its design, were just anticipated quantities. It is always possible to improve the level of accuracy for the load and resistance models, which are needed for the assessment, by collecting more data about a particular structure. In most cases, the cost of updating of information by collecting site data is outweighed by a significant reduction in the cost of intervention: possible consequences of an over-conservative evaluation of an existing structure include unnecessary live load restrictions, strengthening or demolition.

The most accurate way for an engineer to consider actual load and resistance would be to carry out a probabilistic analysis using site data. However, this is a time consuming process, involving a considerable understanding of probabilistic methods, and is possibly not aimed at the practising engineer for everyday use. A simplified deterministic method for the assessment of structural safety should therefore be available, based on the same partial factor formulation adopted in codes for structural design.

Applying reliability methods, a procedure for the calibration of site specific deterministic load and resistance models for the assessment of existing building structures is proposed in the present paper.

2. Calibration of site specific load and resistance models

The calibration of site specific load and resistance models for deterministic assessment is based on the *axiom* that a correct application of the current codes results in a safe structure. Partial safety factors, which can be introduced in a deterministic assessment of an existing structure, are derived for action effects and resistance. In the case of self-weight, permanent actions and resistance, the obtained partial safety factors are presented according to the type of structure, as a function of the coefficient of variation used when modelling each variable. Partial safety factors used in a deterministic assessment are thus based on the coefficient of variation of the corresponding variable. This represents the change in the associated uncertainty (due to the collection of site specific data) in relation to the models that are assumed to lie behind the rules of codes. For the purpose of obtaining a simple set of values for practical evaluation of a particular type of structure, it is proposed to determine maximum factors as a function of only the coefficient of variation of the corresponding variable (Figure 1). It would however be possible to make more distinction between different types of specific use, the type of load effect, and possibly even the span length. For live loads, it is proposed that the calculated partial safety factors are presented according to the type of specific use as a function of the tributary area only.

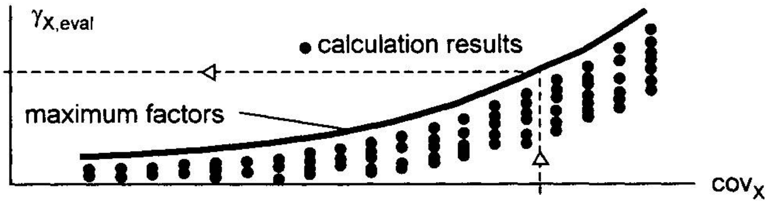

Fig. 1 Schematic representation of partial safety factors for deterministic assessment, $\gamma_{X,eval}$, as a function of the coefficient of variation of the corresponding variable, cov_X

3. Deterministic assessment with site specific models

Partial safety factors, which are attributed individually to the basic variables in a Limit State Function, derived by applying reliability methods, can be introduced in a deterministic evaluation of an existing structure, using the partial factor formulation adopted in design codes. These factors ($\gamma_{S,eval}$ and $\gamma_{R,eval}$ for action effects and resistance, respectively) are to be used together with the actual nominal values for action effects, $S_{eval,nom}$, and resistance, $R_{eval,nom}$, as described below. The requirement for structural safety in its simplest form can be expressed by the following condition:

$$\gamma_{S,eval} \cdot S_{eval,nom} \leq \frac{R_{eval,nom}}{\gamma_{R,eval}}$$

In the case of self-weight, permanent actions and resistance, site specific data is used to determine the coefficient of variation of the corresponding variable and its actual nominal value (mean values for permanent actions and cross-sectional properties, characteristic values based on a 5% fractile with a confidence level of 75% for material properties). The partial safety factor to be used in a deterministic assessment can be selected as a function of the associated uncertainty, represented by the coefficient of variation determined from site data as mentioned before. Figure 1 shows schematically the relationship to be used for selecting a partial safety factor, $\gamma_{X,eval}$, as a function of the measured coefficient of variation, cov_X. Variables that are not measured should be considered along with those of the default models (nominal value and partial safety factor) prescribed in current design codes. Live loads can vary significantly with the tributary area. Therefore, the live load model (characteristic value of the equivalent uniformly distributed load and partial safety factor) to be applied in a deterministic assessment is selected as a function of site characteristics, which can be represented by the specific use of the building and the tributary area for the element under consideration. The tributary area can be determined from available information about the structure, updated by visual inspection.