Preface

This volume addresses the issue of uncertainty in civil engineering from design to construction. Failures do occur in practice. Attributing them to a residual risk or a faulty execution of the project does not properly cover the range of causes. A closer scrutiny of the design, the engineering model, the data, the soil-structure-interaction and the model assumptions is required. Usually, the uncertainties in initial and boundary conditions as well as material parameters are abundant. Current engineering practice often leaves these issues aside, despite the fact that new scientific tools have been developed in the past decades that allow a rational description of uncertainties of all kinds, from model uncertainty to data uncertainty.

It is the aim of this volume to have a critical look at current engineering risk concepts in order to raise awareness of uncertainty in numerical computations, shortcomings of a strictly probabilistic safety concept, geotechnical models of failure mechanisms and their implications for construction management, execution, and the juristic question as to who has to take responsibility. In addition, a number of the new procedures for modelling uncertainty are explained.

Our central claim is that doubts and uncertainties must be openly addressed in the design process. This contrasts certain tendencies in the engineering community that, though incorporating uncertainties by one or the other way in the modelling process, claim to being able to control them.

In our view, it is beyond question that a mathematical/numerical formalization is needed to provide a proper understanding of the effects of the inherent uncertainties of a project. Available information from experience, in situ measurements, laboratory tests, previous projects and expert assessments should be taken into account. Combining this with the engineering model(s) - and a critical questioning of the underlying assumptions -, insight is generated into the possible behavior, pitfalls and risks that might be encountered at the construction site. In this way workable and comprehensible solutions are reached that can be communicated and provide the relevant information for all participants in a complex project.

This approach is the opposite of an algorithm that would provide single numbers pretending to characterize the risks of a project in an absolute way (like safety margins or failure probabilities). Such magic numbers do not exist. Instead of seducing the designing engineer into believing that risks are under control, we emphasize that understanding the behavior of the engineering system is the central task and the key to responsible decisions in view of risks and imponderables.

The book is the result of a collaborate effort of mathematicians, engineers and construction managers who met regularly in a post graduate seminar at the University of Innsbruck during the past years. It contains contributions that shed light on the central theme outlined above from various perspectives and thus subsumes the state of discussion arrived at by the participants over those years. Except for three reprints of foundational papers, all contributions are new and have been written for the purpose of this collection.

The book starts with three papers on geotechnics. The first two articles by Fellin address the problem of assessment of soil parameters and the ambiguity of safety definition in geotechnics. The third paper by Oberguggenberger and Fellin demonstrates the high sensitivity of the failure probability on the choice of input distribution. This sets the stage for the theoretically oriented paper by Oberguggenberger providing a survey of available models of uncertainty and how they can be implemented in numerical computations. The mathematical foundations are complemented by the following paper of Fetz describing how the joint uncertainty in multi-parameter models can be incorporated. Next, Ostermann addresses the issue of sensitivity analysis and how it is performed numerically. This is followed by a reprint of a paper by Herle discussing the result of benchmark studies. Predictions of deformations obtained by different geotechnicians and numerical methods in the same problem are seen to deviate dramatically from each other. Lehar et al. present an ultimate load analysis of pile-supported buried pipelines, showing the extensive interplay between modelling, laboratory testing and numerical analysis which is necessary to arrive at a conclusive description of the performance of the pipes. The paper by Lessmann and Vieider turns to the implications of the geotechnical model uncertainty to construction management. It discusses the type of information the construction manager would need as well as the question of responsibility in face of large model uncertainties. The following paper by Oberguggenberger and Russo compares various uncertainty models (probability, fuzzy sets, stochastic processes) at the hand of the simple example of an elastically bedded beam, while the article by Oberguggenberger on queueing models ventures into a similar comparison of methods in a theme relevant for project planning. The book is completed by a reprint of a survey article showing how fuzzy sets can be used to describe uncertainty throughout civil engineering.

Innsbruck,
May 2004

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Analyzing Uncertainty in Civil Engineering
Fellin, W.; Lessmann, H.; Oberguggenberger, M.;
Vieider, R. (Eds.)
2005, IX, 242 p., Hardcover
ISBN: 978-3-540-22246-0