



# **GEOTECHNICAL RISKS IN LARGE CIVIL ENGINEERING PROJECTS**

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## **ABSTRACT**

All civil engineering projects (buildings, roads, bridges, dams, tunnels and water tanks ..) are constructed on , with, or in the ground. Engineers are required to identify and avoid the major risks posed by ground conditions. During the last decade there has been an increasing societal concern on sustainable developments focusing on the conservation of the environment, the welfare and safety of the individual and at the same time the optimal allocation of the available natural and economical resources of society. This problem complex may easily be realized to be a complex decision problem highly influenced by the possible consequences of our actions and the probabilities that these consequences will occur – the product of which is known as the risk. This presentation provides an overall view of risks posed by ground giving examples from real case histories. The impact of geotechnical risk is well understood by most ground engineering practitioners but the problem and methods for mitigation are frequently misjudged or undervalued by other construction professionals. The main focus of this paper is to mitigate geotechnical risk is restricting the integration of geotechnical risk management within overall project risk management and the construction industry is missing out on opportunities to minimize ground related failures.

***Keywords: Civil Engineering, Geo technical risks, Geo technical risk management***

## **I. INTRODUCTION**

Risk management concerns the analysis, assessment and decision-making in regard to the risks involved in a given activity or associated with a given hazard. The risk management process includes the joint consideration of all uncertainties prevailing the problem and all possible consequences.

Several important tasks are lying ahead, not least in the area of civil engineering. As always new civil engineering projects should be planned, designed and executed in a cost optimal manner taking into consideration the benefit of the projects as well as the possible adverse consequences such as loss of lives, damage to the environment and of course the direct costs. Future safeguarding, maintenance and decommissioning of the infrastructure of society will even more likely demand an intensified focus on risks. Not least in the view of the seemingly ongoing and expected climatic changes and the enormous efforts they may initiate to safeguard our existing infrastructure. The methods of risk and reliability analysis in civil engineering, mainly developed during the last three decades, are increasingly gaining importance as decision support tools in civil engineering applications. Their value in connection with the quantification and documentation of risks and the planning of risk reducing and mitigating measures is by now fully appreciated in the civil engineering

profession. In the time to come the importance of risk and reliability methods will increase for the civil engineer – a fact reflected by the increasing normative and legislative requirements for the documentation of acceptable risks in the planning and execution of civil engineering activities. Risk and reliability analysis is in fact a multi-disciplinary engineering field requiring a solid foundation in one or several classical civil engineering disciplines in addition to a thorough understanding of probability, reliability analysis and decision analysis.

The modern Society is installed in structures and buildings constructed by Civil Engineers and it constantly uses these structures to live, work, exchange, communicate. The significant feeling of safety of our Western societies is probably partially based on the fact that a given number of risks affecting the structures in which we live and work has been correctly anticipated and tackled by engineers who provided satisfactory designs against most probable risks. Historically, civil engineering is the first engineering activity. Beside houses and buildings, impressive symbolic and religious buildings such as the Egyptian pyramids (4540BP) constitute significant engineered structures. Old engineered structures include roads and bridges and fortifications as the China GreatWall (started 2700 BP).

## **II. THE SAFETY OF STRUCTURES**

Resulting from a very long trial and error process that started with the first known historical structures that have been built many centuries ago, engineers found a way to guarantee the safety of structures through the progressive development of relevant mechanical models that are supposed to adequately reproduce their behaviour. Basically, the idea of the contemporary mechanical approach is that the materials that constitute the structure and on which the structure is founded have a maximum mechanical resistance above which they break. Engineers do their best to ensure that the forces induced in these materials once assembled within the structure are low enough to avoid breakage. Beside gravity, it is difficult to predict other mechanical forces that will affect structures. They come from natural hazards such as wind, earthquake, sea waves or river flood. Recent developments in statistical analysis obviously provide a method of predicting more precisely the hazards to be faced by the structures, but they need to be efficient a sufficiently rich data base gathered by rigorous observation along a significant period of time.

It is difficult to completely identify the exact nature and properties of the ground on which structures are built. As other materials, soil and rocks have maximum admissible resistance and may fail if higher forces are applied. They are also variable in nature, and even slight changes in their properties between two points may have significant consequences on the stability of the structure. It is not always possible to completely identify and control the properties of the material used or concerned (steel, masonry, concrete, soil, rock).

Once probable dangerous mechanical actions are supposed to be known, it is difficult to know how forces distribute along the structures, because structures are complex in nature and because the models used are hence not completely adapted.

Once the structure is built, reasonably adequate maintenance dispositions may be altered by new aggressive mechanical, physical or chemical phenomenon (unexpected corrosion of steel, alkali-reaction in concrete) that threaten and sometimes may condemn the structure.



Other features that include financial and societal aspects also characterize the civil engineering structures and their safety. Their failure can be very dangerous for the human, natural or man-made environment.

As in other cases, such an example led to intense thinking in terms of risk analysis, structure behavior, correcting measures and preventive dispositions. Beside the consideration of natural hazards in relation with the resistance of structures, the human factor, including terrorists behavior, is to be accounted for more and more seriously. However, it is a fact that all similar buildings are definitely unable to resist to such attack and that no correction measure exists. In such case, the only solution is preventive protection. Another conclusion drawn was that the effect of fire on structures and buildings materials had to be taken into account more deeply, leading to significant research programs in many developed countries. Intense investigations are presently carrying out in this topic, together with a reassessment of the safety of all tunnels presently in function.

### III. THE FAILURE OF CIVIL ENGINEERING STRUCTURES

The failure of civil engineering structures has still been examined with utmost attention by engineers. Probably because they were the source of major accidents involving significantly high numbers of victims, dams have been examined in terms of safety with particular attention.

### IV. ABOUT THE IMPACTS OF FAILURES

The gravity of a failure is related to the possible occurrence of loss in human lives and properties, i.e. it is unconsciously analysed in terms of vulnerability. In a natural way, a failure that does not significantly and directly affect the social environment does not significantly interest the Society through the media. Logically, it is considered as a technical problem for specialists with no significant impact. Conversely, when dramatic failures with significant impact involving loss of lives occur, people attempt to elaborate some technical analyses of the failure. This phenomenon is amplified by the media that sometimes provide exaggerated or even false technical interpretations.

### V. NEW TECHNOLOGIES AND NEW RISKS

In bridges, optimisation was achieved by increasing the span of the bridge, through an optimisation of a given technique and the development of novel techniques (use of steel, reinforced concrete, prestressed concrete, high performance concrete).

New technologies are associated with other physico-chemical actions that are not completely known at the beginning. Unexpected phenomenon may affect noticeably the lifespan of the structure. Among other examples, this was the case of strip corrosion for reinforced concrete, in a geotechnical innovation called Reinforced Earth, corrosion under stress for prestressed concrete and alkali-reaction in concrete.

Obviously, adopting a new technology is still corresponding to a new risk due to unknown phenomena, with probably higher level of risk associated with more sophisticated techniques.



## **VI. SAFETY, RISK AND RELIABILITY MANAGEMENT**

Many of the accidents could have been prevented with greater attention to safety and reliability in the design, construction and maintenance processes. Additionally, the growing technical complexity of large engineering projects and the public concern regarding their safety and reliability have aroused great interest in the development and application of safety assessment procedures.

### **The objectives of the research on engineering safety risk and reliability management are to**

1. Develop and apply more rational and sustainable safety, reliability and decision-making techniques and methods to facilitate safety and reliability analysis so that safety and reliability aspects can be taken into account in engineering design, construction and maintenance processes.
2. Develop the advanced procedures for minimising risks by improved design aspects, construction and maintenance strategies based on safety and reliability assessment. Several workshops have been delivered to transfer the research results to civil, offshore oil & gas, nuclear, transportation, railway, road, bridge and other industries.

### **The research theme focuses on**

- target risk and reliability
- Safety-cost analysis based decision making
- Life cycle analysis
- Uncertainty analysis
- Safety-critical software assessment
- Dynamic and static finite element analysis, and
- Overall safety case preparation for industry

## **VIII. CONCLUSION**

Some particularities of risk issues in civil engineering have been presented and illustrated. Obviously, their importance in terms of risk is probably not completely integrated in the Society. Natural hazards that may threaten civil engineering structures are difficult to predict, but engineers progressively managed in ensuring a satisfactory level of safety of the structure. For various reasons described in the text and that also include the effects of human behavior, periodic catastrophes occur. The conclusions drawn from their detailed analysis allow to improve the safety of structure in an attempt to reduce the level of risk “as low as reasonably achievable”.

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