Proceedings of the 16th International Conference on Soil Mechanics and Geotechnical Engineering

doi:10.3233/978-1-61499-656-9-3513

Administrative report: TC32 - Engineering practice of risk assessment and management

Compte rendu sur la CT-32

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ABSTRACT

The Technical Committee 32 (TC32), "Engineering Practice of Risk Assessment and Management Committee", of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) is charged with promoting and enhancing professional activities in geotechnical and geo-environmental engineering in areas related to geostatistics and probabilistic site characterization, quantification of uncertainties in performance prediction, reliability-based design, risk-based decision analysis and calibration of LRFD-type geotechnical design codes. This report provides a brief summary of the TC32 activities during the period 2001 – 2005

RÉSUMÉ

Le comité technique 32, "Pratique de l'analyse et gestion du risque", de la Société Internationale de Mécanique des Sols et Fondations (SIMSF) a pour objectif de promouvoir et augmenter les activités professionnelles géotechniques et géo-environnementales relativs aux géostatistiques et la caractérisation probabilistes des sites, la quantification des incertitudes dans la prévision de la performance, le dimensionnement probabiliste, l'analyse de décision basée sur le risque et la calibration de codes géotechniques de type LRFD. Ce rapport donne un bref résumé des activités du CT32 durant la période 2001 – 2005

1 TERMS OF REFERENCE OF TC32

The terms of reference of TC32 for the period 2001 – 2005 were agreed upon by the Core Members in March 2002. The terms of reference are listed below.

The goals of TC32 are to promote and enhance professional activities and education in geotechnical and geo-environmental engineering, in areas related to:

- Geostatistics and probabilistic site characterisation
- Quantification of uncertainties in performance prediction
- Reliability-based design
- Risk-based decision analysis
- Calibration of LRFD-type geotechnical design codes

These goals are to be achieved through the following activities:

- Arrange special sessions and short courses in connection with relevant international conferences and seminars
- Create a Glossary of risk terms and definitions by December 2004
- Develop Guidelines for risk assessment and management in geotechnical engineering by December 2004
- Liaison and co-operation with other risk-related committees
- Provide relevant information on the web to the geotechnical community

2 MEMBERS OF TC32

2.1 *Core Members*

The core members of TC32 during 2001 – 2005 are listed in Table 1.

Table 1 Core Members of TC32 during 2001-2005.

Name	Country
Farrokh Nadim (Chair)	Norway
Gordon Fenton (Secretary)	Canada
Albert Bolle	Belgium
Ken Ho	Hong Kong, PRC
William Roberds	USA
Marcus Pacheco	Brazil

2.2 *Regular Members*

The regular members of TC32 during 2001 – 2005 are listed in Table 2.

Table 2 Regular Members of TC32 during 2001-2005.

Name	Country
Frans B.J. Barends	The Netherlands
Bo Berggren	Sweden
Martin S.H. Bonifazi-Garcia	Argentine
Philippe Bourdeau	USA
Denys Breysse	France
Laura Caldeira	Portugal
Leonardo Cascini	Italy
Claudio Cherubini	Italy
Victor F.B. de Mello	Brazil
Antonio Gens	Spain
Kaare Höeg	Norway
Mark Jaksa	Australia
Turlough Johnston	Ireland
Gerhard Keyter	South Africa
Leena Korkiala-Tanttu	Finland
Nagy Laszlo	Hungry
J. Lorincz	Hungry
Bak Kong Low	Singapore
Farimah Masrouri	France
Tony O'Brien	United Kingdom
Jacobo Ojeda	Colombia

Lars Olsson	Sweden
V.I. Sheinin	Russia
Babu G.L. Sivakumar	India
Wilson Tang	Hong Kong, PRC

3 TC32 ACTIVITIES DURING 2001 – 2005

3.1 *Website*

The activities of TC32 in the period 2001 – 2005 are described on the TC32 web site:
<http://www.engmath.dal.ca/tc32/index.html>.

3.2 *Meetings*

Prior to the 16th ICSMGE in Osaka, 3 TC32 meetings held were in this period:

- Graz, Austria, 16 September 2002
- San Francisco, USA, 7July 2003
- Rio de Janeiro, Brazil, 29 June 2004

The minutes of the meetings are posted on the TC32 website. The final meeting of the TC32 in the current period is planned for Osaka, Japan, during the 16th ICSMGE in September 2005.

3.3 *Glossary of terms for risk assessment and management*

The most significant achievement of TC32 in this period was the development of a general glossary of terms for risk assessment and management. After over a decade of discussionns, the "official" TC32 glossary of terms for risk assessment and management was finally agreed upon and issued in 2004.

The glossary of terms, which is posted on the TC32 website, was adopted as the official terminology for the JTC1 International Conference on Landslide Risk Management, which was held in Vancouver, Canada, in May 2005. The glossary is provided as an appendix to this report.

3.4 *Liaison with other groups*

TC32 has established liaison with following groups:

- ASCE GeoInstitute's Risk Assessment and Management Committee, which is chaired by Prof. K.K. Phoon of National University of Singapore. TC32 Core Members W. Roberds and G. Fenton are long-standing members of this committee.
- Joint Committee JTC1 of ISSMGE – IAEG – ISRM on Landslides (chaired by Prof. Robin Fell, Australia).
- Joint Committee on Structural Safety (chaired by Prof. Ton Vrouwenvelder, The Netherlands).

4 RECOMMENDATIONS FOR FUTURE ACTIVITIES

The following activities are still on-going in TC32:

- Organising or sponsoring a prediction symposium
- Developing a bibliography for risk assessment and management
- Assembling an extensive set of case studies
- Assembling a set of course notes

The Core Members of TC32 strongly recommend that these activities are continued in the period 2005 – 2009.

APPENDIX

RISK ASSESSMENT – GLOSSARY OF TERMS

Acceptable risk: A risk which everyone impacted is prepared to accept. Action to further reduce such risk is usually not required unless reasonably practicable measures are available at low cost in terms of money, time and effort.

ALARP (As Low As Reasonably Practicable) principle: That principle which states that risks, lower than the limit of tolerability, are tolerable only if risk reduction is impracticable or if its cost is grossly in disproportion (depending on the level of risk) to the improvement gained.

Annual exceedance probability (AEP): The estimated probability that an event of specified magnitude will be exceeded in any year.

Bayes theorem: A theorem that provides the logical basis for updating a probability on the basis of new information.

Conditional probability: The probability of an outcome, given the occurrence of some event. For example, given that a flood has reached the crest of an embankment dam, the probability of the dam failing is a conditional probability.

Consequence: In relation to risk analysis, the outcome or result of a hazard being realised.

Countermeasures: All measures taken to counter and reduce a hazard or consequences of a hazard. They most commonly refer to engineering (structural) measures but can also include other non-structural measures and tools designed and employed to avoid or limit the adverse impact of natural hazards and related environmental and technological disasters.

Cumulative distribution function (CDF): The integral of the probability density function calculated in the direction of increasing values of the random variable. Thus the probability that the random variable takes on values less than or equal to a particular value can be read from the CDF.

Danger (Threat): The natural phenomenon that could lead to damage, described in terms of its geometry, mechanical and other characteristics. The danger can be an existing one (such as a creeping slope) or a potential one (such as a rockfall). The characterisation of a danger or threat does not include any forecasting.

Decision-maker: The person or organizational unit who decides on a course of action in relation safety.

Deterministic: Describing a process with an outcome that is always the same for a given set of inputs, i.e. the outcome is "determined" by the input. Deterministic contrasts with random, which describes a process with an outcome that can vary even though the inputs are the same. Deterministic analysis contrasts with probabilistic analysis.

Disaster: A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources.

A disaster results from the combination of hazards, vulnerability, and insufficient capacity or measures to reduce the negative consequences of risk.

Elements at risk: Population, buildings and engineering works, infrastructure, environmental features and economic activities in the area affected by a hazard.

Emergency preparedness plan: Document which contains procedures for dealing with various emergencies which could result from a disaster.

Environmental risks: Risks to natural ecosystems or to the aesthetics, sustainability or amenity of the natural world.

Event tree analysis: Inductive analysis process that utilises an event tree graphical construct that shows the logical sequence of the occurrence of events in, or states of, a system following an initiating event.

Expected value: The average or central tendency of a random variable. In risk analysis, the product of the probability of an

event and of its consequences, aggregated over all possible values of the variable.

Extreme event: Event, which has a very low annual exceedance probability (AEP). Sometimes defined as an event beyond the credible limit of extrapolation and therefore dependent on the length of record and the quality of the data available.

Factor of Safety: The ratio of system resistance to the peak design loads, often calculated in accordance with established rules.

Failure: The inability of a system, or part thereof, to function as intended. In the context of structural safety (including geotechnical structures), failure is generally confined to issues of structural integrity, and in some contexts to the special case of collapse of the structure or some part of it.

Failure mechanism: A mechanism describing the physical processes and states that must occur for failure to develop.

Failure mode: A way that failure can occur, described by the means by which element or component failures must occur to cause loss of the sub-system or system function.

Fault tree analysis: A systems engineering method for representing the logical combinations of various system states and possible causes which can contribute to a specified problematic (fault) event (called the top event).

f, N pairs: Refers to "f', the probability of life loss due to failure for each scenario studied, and "N", the number of lives expected to be lost in the event of such a failure scenario. The term "N" can be replaced by any other quantitative measure of failure consequences, such as monetary measures.

F-N curves: Curves relating the probability per year of causing N or more fatalities (F) to N. This is the complementary cumulative distribution function. Such curves may be used to express societal risk criteria and to describe the safety levels of particular facilities.

Fragility curve: Defines the probability of failure as a function of an applied load level; a particular form of the more general system response.

Frequency: A measure of likelihood expressed as the number of occurrences of an event in a given time or in a given number of trials (see also likelihood and probability).

Hazard: Probability that a particular danger (threat) occurs within a given period of time.

Human factors: Human factors refer to environmental, organisational and job factors, and human and individual characteristics which influence behaviour in a way which can affect safety.

Individual risk to life: The increment of risk imposed on a particular individual by the existence of a hazard. This increment of risk is an addition to the background risk to life, which the person would live with on a daily basis if the facility did not exist.

Involuntary risk: A risk imposed on people by a controlling body and not assumed by free choice of the people at risk.

Joint probability: The probability that two or more variables will assume certain values simultaneously or within particular time intervals.

Judgement: Contribution to decision-making which depends on a person's experience, technical know-how, and ethical or moral values.

Land-use planning: Branch of physical planning that determines the means and assesses the values or limitations of various options in which land is to be utilised, with the corresponding effects on different segments of the population or interests of a community taken into account in resulting decisions.

Land-use planning involves mapping, analysis of data acquired, formulation of alternative land-use decisions and design of a long-range plan for different geographical and administrative scales.

Land-use planning can help to mitigate disasters and reduce risks by discouraging settlements and construction of key installations in hazard prone areas, control of population density and expansion, and in the siting of life lines such as service routes for transport, power, water, sewage and other critical facilities.

Likelihood: Conditional probability of an outcome given a set of data, assumptions and information. Also used as a qualitative description of probability and frequency.

Limit: In relation to level of risk, that level which, when exceeded, is unacceptable. Higher risks cannot be justified except in extraordinary circumstances (typically where the continuation of the risk has been authorised by government or a regulator in the wider interests of society).

Loss: Any negative consequence, financial or otherwise.

Mitigation: Measures undertaken to limit the adverse impact of, for instance, natural hazards, environmental degradation and technological hazards.

Monte Carlo simulation: A procedure, which seeks to simulate stochastic processes by random selection of input values to an analysis model in proportion to their joint probability density function.

Owner: Legal entity which either holds a government license to operate a facility or retains the legal property title on the facility, and which is responsible for the safety of the facility.

Population at risk: All those persons who would be directly exposed to the consequences of failure of a structure or facility if they did not evacuate.

Preparedness: Activities and measures taken in advance to ensure effective response to hazards and their consequences.

Prevention: Activities to provide outright avoidance of the hazards and their consequences.

Probabilistic: A description of procedures, which are based on the application of the laws of probability. Contrasts with deterministic.

Probability: A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event.

There are two main interpretations:

i) Statistical - frequency or fraction – The outcome of a repetitive experiment of some kind like flipping coins. It includes also the idea of population variability. Such a number is called an "objective" or relative frequentist probability because it exists in the real world and is in principle measurable by doing the experiment.

ii) Subjective probability (degree of belief) – Quantified measure of belief, judgement, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgement regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes.

Probability density function: A function describing the relative likelihood that a random variable will assume a particular value in contrast to taking on other values.

Random variable: A quantity, the magnitude of which is not exactly fixed, but rather the quantity may assume any of a number of values described by a probability distribution.

Regulatory agency (synonymous with Regulator): Usually a government ministry, department, office, directorate or other unit of government entrusted by law or administrative act with the responsibility for the general supervision of the safe design, construction and operations of structures or facilities, as well as any entity to which all or part of the executive or operational tasks and functions have been delegated by legal power.

Reliability: Likelihood of successful performance of a given project element. Mathematically, Reliability = 1 - Probability of failure. See definitions of “probability” and “failure”.

Residual risk: The remaining level of risk at anytime before, during and after a program of risk mitigation measures has been taken.

Risk: Measure of the probability and severity of an adverse effect to life, health, property, or the environment. Quantitatively, Risk = Hazard × Potential Worth of Loss. This can be also ex-

pressed as "Probability of an adverse event times the consequences if the event occurs".

Risk analysis: The use of available information to estimate the risk to individuals or populations, property or the environment, from hazards. Risk analyses generally contain the following steps: definition of scope, danger (threat) identification, estimation of probability of occurrence to estimate hazard, evaluation of the vulnerability of the element(s) at risk, consequence identification, and risk estimation. Consistent with the common dictionary definition of analysis, viz. "A detailed examination of anything complex made in order to understand its nature or to determine its essential features", risk analysis involves the disaggregation or decomposition of the system and sources of risk into their fundamental parts.

Qualitative risk analysis: An analysis which uses word form, descriptive or numeric rating scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur.

Quantitative risk analysis: An analysis based on numerical values of the probability, vulnerability and consequences, and resulting in a numerical value of the risk.

Risk assessment: The process of making a decision recommendation on whether existing risks are tolerable and present risk control measures are adequate, and if not, whether alternative risk control measures are justified or will be implemented. Risk assessment incorporates the risk analysis and risk evaluation phases.

Risk-based decision-making: Decision-making, which has as a main input the results of risk assessment. It involves a balancing of social and other benefits and the residual risks.

Risk control: The implementation and enforcement of actions to control risk, and the periodic re-evaluation of the effectiveness of these actions.

Risk evaluation: The stage at which values and judgement enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks.

Risk management: The systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, mitigating and monitoring risk.

Risk mitigation: A selective application of appropriate techniques and management principles to reduce either likelihood of an occurrence or its adverse consequences, or both.

Safety coefficient: See “Factor of Safety”.

Scenario: A unique combination of states. A scenario defines a suite of circumstances of interest in a risk assessment, for example loading scenarios or failure scenarios.

Sensitivity analysis: An analysis to determine the range over which the result varies, given unit change in one or more input parameters.

Societal risk: The risk of widespread or large scale detriment from the realisation of a defined risk, the implication being that the consequence would be on such a scale as to provoke a socio/political response.

Standards-based approach: The traditional approach to engineering, in which risks are controlled by following established rules as to design events and loads, structural capacity, safety coefficients and defensive design measures.

System: Assembly that consists of interacting elements.

System response: How a system responds. May be expressed as a conditional probability of failure, to a given scenario of applied loads and concurrent conditions (see also fragility curve).

Temporal probability: The probability that the element at risk is in the area affected by the danger (threat) at the time of its occurrence.

Tolerable risk: A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.

Uncertainty: Describes any situation without certainty, whether or not described by a probability distribution. Uncertainty is caused by natural variation and/or incomplete knowledge (lack of understanding or insufficient data). In the context of structural safety, uncertainty can be attributed to (i) *aleatory uncertainty:* inherent variability in natural properties and events, and (ii) *epistemic uncertainty:* incomplete knowledge of parameters and the relationships between input and output values.

Voluntary risk: A risk that a person faces voluntarily in order to gain some benefit.

Vulnerability: The degree of loss to a given element or set of elements within the area affected by a hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss).

Also, a set of conditions and processes resulting from physical, social, economic, and environmental factors, which increase the susceptibility of a community to the impact of hazards.