DELTARES ACADEMY COURSE:

Reliability and Risk in Geotechnical Engineering Practice

15-16 September 2022 in Delft

Deltares

Course description

Geotechnical engineering deals with large uncertainties compared to other engineering domains. Our estimates of soil and rock properties are typically based on a limited amount of site investigation unlike steel or concrete, which undergo quality control. Hence, it is not surprising that reliability and risk approaches have undergone a rapid development in academia in the last decades, but there are also increasing numbers of applications to practical projects. For example, the safety assessments of flood defenses in the Netherlands are fully probabilistic from 2017. Also, reliability-based design is increasingly being applied to complex geotechnical structures such as LNG terminals. As infrastructures age and many structures approach their design life, another rapidly growing issue of concern is the reliability assessment of existing structures. Such assessments call for the use of observations of performance, measurements, and monitoring data to update reliability estimates.

This course focuses provides geotechnical practitioners and (graduate) students with the reliability and risk analysis basics, as well as an overview of recent applications and developments. Course participants will be able to carry out basic reliability analyses of geotechnical applications themselves, and they will be enabled to critically judge and interpret the results of reliability analyses carried out by others. Our aim is to provide a stepping stone to use reliability concepts to your advantage in your geotechnical engineering practice, providing added value to your clients and stakeholders.

Topics covered include probability, reliability and risk fundamentals and application of reliability and reliability updating to pile foundations, dikes and levees, as well as deep foundations. Lectures on the theoretical backgrounds will be accompanied by hands-on exercises and demonstrations of state-of-the-art applications.

For whom?

The course is targeted at practicing engineers who would like to extend their toolbox by developing and enhancing their probabilistic skills, as well as (PhD)students working in in geotechnical reliability and risk. The course starts with the basics of reliability analysis extending further to advanced applications. Participants are expected to have undergraduate-level knowledge of statistics and probability theory (will be recapped briefly). The course will be in English in case there are English speakers, otherwise the course will be in Dutch.

Course leaders

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Provisional Course Outline – Day 1 (Probability and reliability)

09:30	Course begins
09:30-10:00	**Block 1: Opening, course objectives, outline and introduction**
Schweckendiek Kanning	• Introduction to risk-based decision making and design • Historical perspective on geotechnical reliability and risk • Recent developments and applications
	Break (15 min.)
10:00-10:45	**Block 2: Probability basics (recap)**
Schweckendiek	• What is probability in geotechnics? • Sources of uncertainty • Basic probability calculus • hand-on examples
	Break (15 min.)
11:00-12:00	**Block 3: Uncertainty in geotechnical parameters**
Schweckendiek	• Probability distribution types and characteristics (3a) • Spatial variability and averaging • Characteristic values and default values
12:00-13:00	Lunch break
13:00-13:30	**Block 4: Probabilistic site characterization**
Mavritsakis	• data-driven uncertainty modelling • dealing spatial variability, measurement/transformation uncertainty • BaySiC (Bayesian Site Characterization)
13:30-14:15	**Block 5: Reliability analysis**
Kanning	• The concept of reliability • Reliability analysis levels I, II and III • Monte Carlo simulation (incl. example pile axial capacity) • First-order reliability method (FORM)
	Break (15 min.)
14:30-15:15	**Block 6: Hands-on reliability exercises**
Kanning	• Introduction to software (Probabilistic Toolkit) • Z = R-S (MCS & FORM with Probabilistic Toolkit) • Component reliability for uplift (dikes)
	Break (15 min.)
15:30-16:15	**Block 7: System reliability and time-dependence**
Kanning	• Series and parallel systems • Fault trees, event trees and bow-tie • Probability bounds for parallel and series systems • System reliability with simulation methods • Hands-on: System reliability uplift and piping (dikes)
16:15-16:30	**Block 8: Closure of day 1**
Schweckendiek Kanning	• Summary of lessons learnt • Questions and discussion

Provisional Course Outline – Day 2 (applications & special topics)

09:30 – 12:00	**Block 9: Case study: Basal heave metro station (hands-on)**
Schweckendiek Kanning Brinkman van der Meer	• introduction to case (North-South metro line Amsterdam) • introduction to assignment • participants work in groups of 2 to 3 persons on reliability analysis • lecturers provide assistance • lecturers provide model solution • how did the real case play out?
12:00-13:00	Lunch break
13:00-13:45	**Block 10: Bayesian Updating**
Schweckendiek	• Bayesian updating for reliability problems • example case: pile capacity (incomplete load test)
	Break (15 min.)
14:00-15:00	**Block 11: Slope reliability with PTK-DGeostability**
Kanning	• use of the Probabilistic Toolkit (PTK) with external models • hands-on example: dike slope stability (with DGeostability)
	Break (15 min.)
15:15-16:00	**Block 12: Risk assessment and decision analysis**
Schweckendiek	• risk acceptance criteria • risk-based decision making • example: anomaly detection with CPTs
16:00-16:30	**Block 13: Closing session**
Schweckendiek Kanning	• Summary of lessons learnt • Evaluation