MODULE DESCRIPTION FORM

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

CL527 Structural Reliability Analysis and Design Under Uncertainty

Module Registrar: Edoardo Patelli	**Taught To (Course):** MEng Civil Engineering / MEng Civil and Environmental Engineering / MSc Civil Engineering / MSc Civil Engineering with Industrial Placement		
Other Lecturers Involved:	**Credit Weighting: 10**	**Semester: 1**	
Assumed Prerequisites: UG Students: CL329, and CL418 PG Students: fundamentals of structural analysis, fundamentals of probability and statistics	**Compulsory** for the MSc Civil Engineering / MSc Civil Engineering with Industrial Placement	**Academic Level: 5/MSc**	**optional**

Module Format and Delivery (HOURS i.e. 1 credit = 10hrs of study):

Lecture	Tutorial	Laboratory	Groupwork	External	Online	Project	Assignments	Private Study	**Total**
22	12		6				20	40	100

Educational Aim

This module aims to introduce the fundamentals of risk analysis, resilience engineering, and design under uncertainty with application to structural reliability analysis. The module develops understanding and appreciation of uncertainties in engineering and present applications and practical examples.
Qualitative risk assessment methods and modern quantitative assessment methods of the uncertainty in engineering are presented. These tools are essential to improve the robustness and sustainability of engineering systems and provide effective methods for climate adaptation.

The qualitative risk assessment includes an understanding of the most common tools adopted in industry and practical sessions. It also includes an introduction to the problem of risk perception and communication.

Analytical approaches and numerical simulation techniques (i.e. Monte Carlo simulation) are presented for the quantification of the uncertainty with applications to structural reliability analysis as well as the associated concepts for code-compliant verification and design.

The methods and the approaches presented in the module have a general applicability to different field of engineering.

Learning Outcomes

On completion of the module the student is expected to be able to

LO1 Understand the importance of risk analysis in engineering and risk communication

LO2 Accurate and realistic management of risk and appraisal of the theoretical elements of risk and uncertainty

LO3 Quantify the effect of uncertainty by means analytical and approximate methods

LO4 Use numerical codes to quantify the reliability of structures and systems subjected uncertainty (e.g. due to climate change, extreme load conditions)

Syllabus

The module will include the following:

- **Topic 1: Introduction to Risk Analysis**
  Definition of Risk, Effect of Uncertainties, Risk perception and communication, Challenges in Engineering
- **Topic 2: Qualitative Risk Assessment**
  Hazard identification and risk assessment, Failure mode effects and criticality analysis, Event Tree and Fault Tree, the ALARP principle and acceptable risk. Human reliability analysis.
- **Topic 3: Modelling uncertainty for Engineers:**
  Random events and their representation, Expected values and moments of distributions, Statistical inference, Bayesian approaches for Structural Health Monitoring
- **Topic 4: Structural Reliability methods with applications**
  Analytical methods for structural reliability: the concept of the design point, First order second moment (FOSM) approach and first order reliability method (FORM).
- **Topic 5: Monte Carlo simulation method for quantifying uncertainty with applications**
  Concepts of scientific computing and numerical simulation, sampling approaches and simulation of random events. Numerical analysis and advantages over traditional approaches. Application to structural reliability. Simulation approaches for the reliability and safety analysis of systems and structures.

Assessment of Learning Outcomes

Criteria

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

LO1 Understand the importance of risk analysis in engineering

C1 Determine the risk associated to extreme weather conditions
C2 Compare and rank typical risks and identify appropriate communication tools

LO2 Understand how risk and uncertainty can be managed effectively and knowledge of the theoretical elements of risk and uncertainty

C1 Derive the event tree of the risk of fire in a tall building
C2 Identify and solve the Event Tree and Fault Tree of systems

LO3 Understand how to quantify the effect of uncertainty by means analytical and approximate methods

C1 Compute safety factors of a simple structure
C2 Compute the reliability of structure using analytical and approximate approaches

LO4 Use numerical codes to analyse the reliability of structures and systems subjected uncertainty (e.g. due to climate change, extreme load conditions)

C1 Analyse probability of extreme weather event and return period
C2 Compute reliability of a structure using numerical simulation
C3 Simulate and analyse engineering systems

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

Principles of Assessment and Feedback
*(within Assessment and Feedback Policy at: https://www.strath.ac.uk/staff/policies/academic/*http://www.strath.ac.uk/learnteach/informationforstaff/staff/assessfeedback/12principles/ *)*

Principle 1. Assessment and feedback practices promote effective student learning
Feedback is provided in real-time in an interactive fashion. Students are asked to solve problems of different level of complexity during the lecture and the lecture is tuned to the gaps shown by the students. In tutorials sessions, students are asked to become teachers by explaining tasks

Principle 2. Assessment and feedback practices are appropriate, fair, and transparent
These are discussed with the students at the beginning of the course and students' comments are taken into account

Principle 3. Assessment and feedback practices are clearly communicated to students and staff
These are discussed with the students at the beginning of the course and any point during the course should practices be revised

Principle 4. Assessment and feedback practices are continuously reviewed
We made use of mid-term questionnaires design to possibly adjust teaching approach

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

	Examinations				**Courseworks**		**Projects**	
	Number	Month(s)	Duration	***Weighting***	Number	***Weighting***	Number	***Weighting***
					C/work 1 C/work 2 C/work 4	30% 30% 15%	C/work 3	25%
L/Outcomes					LO1, LO2, LO3		LO4	

Indicate which learning outcomes (L01, L02 etc) are to be assessed by exam/coursework/project as required.

Coursework / Submissions deadlines (*academic weeks*):
C/work 1 – Handout week 3, Submit week 4
C/work 2 – Handout week 6, Submit week 7
C/work 3 – Group project 7, Submit week 11
C/work 3 – Group project 9, Submit week 11

Resit Assessment Procedures:
Resubmission of coursework prior to commencement of the August exam diet.

PLEASE NOTE:
Students must gain a summative mark of 50% to pass the module. Students who fail the module at the first attempt will be re-examined during the August diet. This re-examination will consist entirely of coursework. No marks from any previous attempts will be transferred to a new resit attempt.

Recommended Reading

*****Purchase recommended **Highly recommended reading *For reference**

** Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, Alfredo H-S. Ang, Wilson H. Tang

** Structural Reliability Analysis and Prediction. Robert E. Melchers, Andre T. Beck
Risk Analysis, Terje Aven, John Wiley & Sons 2015.

*The Monte Carlo Simulation Method for System Reliability and Risk Analysis (Springer Series in Reliability Engineering), Enrico Zio, 2013, ISBN-13: 978-1447145875

Additional Student Feedback
(Please specify details of when additional feedback will be provided)

Date	Time	Room No
Week 4,8,11		

Session:

Approved:

Course Director Signature:
Date of Last Modifications: August 2022

(Updated May 2018)

MODULE TIMETABLE

Module Code:	**CL527**	**Module Title:**	**Structural Reliability Analysis and Design Under Uncertainty**

Brief Description of Assessment:	The coursework 1,2 and 4 consist in online quizzes. The third assessment is a group project.

Assessment Timing:-

Indicate on the table below the start/submission dates for each assignment/project and the timing of each exam/assessment using the dropdowns provided. Dropdowns can be left blank. Add extra notes below the dropdowns.

Please note: Timings can and will change, this should only be used as a guide.

Semester One	W&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Set Choose an item.	Online Test Choose an item.	Choose an item. Choose an item.	Course work Set Choose an item.	Online Test Project Set	Choose an item. Choose an item.	Course work Set Choose an item.	Choose an item. Choose an item.	Project Submission Online Test	Choose an item.

Semester Two	C&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item.