PhD Program in Security, Risk and Vulnerability

Course Offerings

Core- Curriculum Courses

Risk and Resilience Engineering for the Natural, Industrialized and Built Environments

Academic Year 2023-24

Università
di Genova

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Core-Curriculum Course

Risk and Resilience Engineering for the Natural, Industrialized and Built Environments

Processing tools and techniques for Digital Elevation Models and extraction of parameters for flood hazard analysis

Title: Processing tools and techniques for Digital Elevation Models and extraction of parameters for flood hazard analysis

Teacher(s): Giorgio Boni, Bianca Federici, Giorgio Roth and Domenico Sguerso

Email: giorgio.boni@unige.it ; **bianca.federici@unige.it**

Duration: 20 hours

Credits: 5 CFU

When: January-February 2023. Further detail will be given to applicants. Registration must be done via e-mail to Prof. Boni and/or Prof. Federici by 10 January 2023

Curriculum: Risk and Resilience Engineering for the Natural, Industrialized and Built environments

Where: to be defined

Exam: the final examination will be an oral presentation of a theoretical deepening or an application on processing DEM and extracting parameters for flood hazard analysis. The date of the exam will be agreed upon with the students.

Abstract:

The aim of the course is to provide theoretical and practical insights into GIS-based methodologies for the processing of Digital Elevation Models (DEMs). Special focus is put on the extraction of features to evaluate and map flood hazard.

Program:

The course deals with:

- An outline of numerical cartography, data models, spatial, topological and semantic components, nominal scale and resolution, metadata, GeoWebService for the access to geographic data by the web;
- DEM data structures and features in terms of resolutions and accuracies (Italian CISIS guidelines); DEM available on the web; Interpolation techniques to create DEM from contour level and sparse points/sensors;

- Limits and potentialities of the existing instrumentation and methodologies (Photogrammetry also from UAV, LiDAR,...) for DEM production and integration;
- Reference frames and cartographic representations, the EPSG codes;
- The basics of flood hazard mapping: common terminology, indicators of hazard magnitude, basics of mapping techniques;
- The theoretical basis of the morphological description of a river basin;
- The main state-of-the-art approaches to extract information about flood hazard from DEM (geomorphological models).

Practical exercises deal with:

- Introduction to the Free and Open Source QGIS Software, import, visualize and query raster and vector data, manage data in different reference frames, access to GeoWebService and Open Map data;
- DEM on GIS: Morphological analysis of DEM; Interpolation techniques applied to contour lines and sparse points/sensors to create DEM; Filter and classify LiDAR-derived DEM;
- Hydrological analysis at basin scale: extraction of river network with state of the art methodologies, extraction of morphological parameters for flood hazard mapping. Evaluation and mapping of flood hazard level combining morphological and hydrological parameters.

At the end of the course the student is expected to be able to:

- Know the functions of Open Source software and GIS for the manipulation of geographic data
- Process geographic data to derive DEMs
- Process DEMs with open source GIS and extract morphological and hydrological information
- Combine morphological and hydrological information to derive flood hazard intensity
- Draw a flood hazard map for a small river basin using geomorphological methods

References:

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Core-Curriculum Course

Risk and Resilience Engineering for the Natural, Industrialized and Built Environments

Forecasting approaches and vulnerability analysis for slopes and structures in relation to landslide risk

Title: ***FORECASTING APPROACHES AND VULNERABILITY ANALYSIS FOR SLOPES AND STRUCTURES IN RELATION TO LANDSLIDE RISK***

Teachers: Riccardo Berardi (riccardo.berardi@unige.it) - Rossella Bovolenta (rossella.bovolenta@unige.it)

Duration: 26 hours

Credits: 6 CFU

When: October, 2023

Curriculum: Risk and Resilience Engineering for the Natural, Industrialized and Built Environments

Where: DICCA Department (rooms to be defined)

Exam: oral discussion

Abstract:
The course aims to describe and analyse geotechnical methodologies for the study and assessment of landslide risk in natural and man-made slopes.

Issues that will be addressed are: *i)* small-scale zoning (landslide zoning over large areas); *ii*) the assessment of landslide susceptibility, especially concerning soil-subsoil-atmospheric events interaction; *iii)* the effects of landslide-triggered displacements on existing structures and the assessment of possible induced damages; *v)* the choice of possible intervention methodologies.

These issues are of relevance in terms of resilience of the slope-anthropic environment system, vulnerability of the exposed elements and sustainability of risk mitigation interventions.

In addition to the discussion of the more general themes, a specific seminar (held by Dr. Diana Bianchi) will be given on the soil hydro-mechanical behaviour, important issue at the basis of the modelling of a landslide triggered by rain. Discussion of actual case histories will be provided as well.

Syllabus and dates of lectures:

October 4	Landslide classification and landslide risk. General and introductory aspects	3 hours	Bovolenta
October 5	Mechanical behaviour of soil, rock and rock masses	3 hours	Berardi
October 6	Mechanical behaviour of partially saturated soils	2 hours	Bianchi
October 11	Bottom-up and top-down approaches. Large and small scale analyses	2 hours	Bovolenta

October 12	Site specific analyses: limit equilibrium methods and numerical analyses	3 hours	Bovolenta
October 13	Parameters for slope and landslide modelling: Vulnerability assessment	2 hours	Berardi
October 18	Site exploration and investigation	2 hours	Berardi
October 19	Slope stabilization methods (part 1): geotechnical engineering works	3 hours	Berardi
October 25	Slope stabilization methods (part 2): soil bioengineering. Case histories - discussion	2 hours 1 hour	Bovolenta
October 26	Case histories - discussion	3 hours	Bovolenta -Berardi

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Risk and Resilience Engineering for the Natural, Industrialized and Built Environments

Science of storms

Title:
Science of Storms

Teachers:
Dr. Djordje Romanic

Email:
djordje.romanic@mcgill.ca

Duration:
12 hours

Credits:
2.5 credits

When:
Summer 2024

Where:
University of Genoa

Curricula:
RRENIB and RCCSD

Link:

Exam:
At the end of the course, a final oral examination will be held.

Abstract:
Extreme weather phenomena can harm people and cause disasters. In the period 1980–2022, extreme weather caused economic losses of approximately €650 billion in the European Union Member States. Out of this figure, the losses were €59.4 billion in 2021 and €52.3 billion in 2022. Science of Storms is an introductory course to the topics of physical processes associated with severe and hazardous weather affecting the Earth. Most of the topics are taught at a fundamental level to provide a complete and up-to-date understanding of such extreme events as thunderstorms, tornados, flooding,

heatwaves, cold waves, hurricanes and extra-tropical cyclones, hail, and lightning. In addition to the physical processes that govern extreme weather, Science of Storms will also introduce the students to the topics of natural hazard modeling, resilience, and risk assessment. While the course will focus on fundamental aspects of extreme weather and hazard modeling, lectures will also present some of the latest advancements in these fields.

Program:

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References:

- Ahrens C.D and Henson R. 2021. *Meteorology Today: An Introduction to Weather, Climate and the Environment*. Brooks Cole. ISBN: 0357452070.
- Markowski P and Richardson Y. 2010. Mesoscale Meteorology in Midlatitudes. John Wiley & Sons, Ltd. ISBN: 9780470682098.

References to other specific textbooks, journal/conference articles and video resources will be provided during lectures.

Core-Curriculum Course

Risk and Resilience Engineering for the Natural, Industrialized and Built Environments

Seismic losses and consequences: evaluation procedures and data from recent earthquakes in Italy

Title: Seismic losses and consequences: evaluation procedures and data from recent earthquakes in Italy

Teacher(s): Serena Cattari, Marco Di Ludovico (University of Federico II – Naples), Ciro del Vecchio (University of Benevento)

Email: serena.cattari@unige.it

Duration: 16 hours

Credits: 4 CFU

When: July 2023 (in Genoa)

Curriculum: Risk and Resilience Engineering for the Natural, Industrialized and Built environments . The course is made in collaboration with the PhD Program on Structural Engineering,Geotechnics and Seismic RIsk of the University of Naples - Federico II.

Where: hybrid mode, via TEAMS platform and in person (in Naples or Genoa, at alternate years)

Exam: tests with questions on the topics examined during the lessons

Abstract:
The aim of the course is to provide theoretical and practical insights into the procedures available in literature for the evaluation of seismic losses and consequences.
Loss estimation is usually based on the definition of consequence functions, representing the distribution of the loss on a set of discrete performance or damage levels. Loss may involve casualties, repair costs, and downtime. The consequence functions can be derived from different approaches: i) experimental tests; ii) empirical data from post-earthquake survey; iii) analytical data related to the building structural response.

Program:
In the course, the pros and cons of the approaches for assessing seismic losses will be discussed and practical tools available in literature will be shown (as those proposed in FEMA P-58 [2012]).
Particular attention will be devoted to the economic losses since the attention to this aspect is increasing in risk analyses for different scopes: cost-benefit evaluations; reparability decisions; the knowledge of the economic impact and the resilience of a society after the occurrence of an earthquake; and the calibration of insurance premia.
The valuable data collected after the L'Aquila 2009 earthquake (Di Ludovico et al. 2017a, 2017b) will be examined in detail since they provided a unique dataset to calibrate functions

based on the empirical approach (approach ii). The restoration policy and the procedures regulating the reconstruction process will be illustrated together with their outcomes in first phase of the reconstruction process (the so-called “light damage” reconstruction), addressed to recover the usability of slightly damaged buildings and, then, in the second phase (the so-called “heavy damage” reconstruction) that involved buildings outside the historical centres assessed as unusable due to high structural and/or non-structural risk. A simple methodology for assessing reparability through scenario-based simulation of building damage state and expected repair costs is also presented. The data presented support in establishing priorities and reconstruction policies for use in the aftermath of future earthquakes.

MODULE I - Seismic loss assessment: basics on fragility and consequence functions (Marco Di Ludovico, Serena Cattari)
MODULE II – Empirical approach: experience of damage assessment and recovery policies from L’Aquila 2009 earthquake (Marco Di Ludovico)
MODULE III – Seismic loss scenarios accounting for direct and indirect costs (Marco Di Ludovico)
MODULE IV– Actual repair costs using the FEMA P-58 methodology (Marco Di Ludovico, Ciro Del Vecchio)
MODULE V– Critical issues on the development of fragility curves and risk analyses (Serena Cattari)

References:

1. Del Vecchio, C., Di Ludovico, M., Pampanin, S., and Prota, A. [2018] “Repair costs of existing rc buildings damaged by the l’aquila earthquake and comparison with FEMA P-58 predictions,” *Earthquake Spectra*, Vol. 34, No. 1, pp 237-263.
2. Di Ludovico, M., Prota, A., Moroni, C., Manfredi, G., and Dolce, M. [2017a] “Reconstruction process of damaged residential buildings outside historical centres after the L’Aquila earthquake: Part I—"light damage" reconstruction,”*Bulletin of Earthquake Engineering*, Vol. 15, No.2, pp. 667-692.
3. Di Ludovico, M., Prota, A., Moroni, C., Manfredi, G., and Dolce, M. [2017b] “Reconstruction process of damaged residential buildings outside historical centres after the L’Aquila earthquake: Part II—“heavy damage” reconstruction”, *Bulletin of Earthquake Engineering*, Vol. 15, No.2, pp. 693-729.
4. Dolce, M. , Di Bucci, D. [2017] “Comparing recent Italian earthquakes”, *Bulletin of Earthquake Engineering*, Vol. 15, No.2, pp. 497-533.
5. FEMA P58-1. [2012] Seismic Performance Assessment of Buildings: Volume 1 – Methodology (P-58-1), Washington, DC.

6. Polese M., Di Ludovico M., Marcolini M., Prota A., Manfredi G., (2015) Assessing reparability: simple tools for estimation of costs and performance loss of earthquake damaged R.C. buildings, Earthq Eng and Struct Dyn, 44, 1539-1557

7. Dolce, M., Prota, A., Borzi, B., da Porto, F., Lagomarsino, S., Magenes, G., ... & Zuccaro, G. (2020). Seismic risk assessment of residential buildings in Italy. Bulletin of Earthquake Engineering, 1-34, https://doi.org/10.1007/s10518-020-01009-5

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Core-Curriculum Course

Risk and Resilience Engineering for the Natural, Industrialized and Built Environments

Multi-hazard Risk: definitions and methodologies

Title: Multi-(hazard)-risk: definitions and methodologies

Teachers: Silvia De Angeli

Email: silvia.deangeli@unige.it

Duration: 10 hours

Credits: 3 CFU

When: May 2024

Where:
Online via TEAMS platform, and in person (University of Genoa, DICCA, Via Montallegro 1, 16145, Genoa)

Curricula: RRENIB and RCCSD

Link: TEAMS Code: **ua1x5je**

Exam:
Submit a short research proposal (from 1 to 3 pages, excluding references) in which the student will discuss an innovative research idea supported by the literature. This idea will exploit how to apply the concepts of multi-hazard and/or multi-risk to one or more aspects of their current research.

Abstract:
The aim of this module is to provide fundamentals of multi-hazard and multi-risk from the perspective of natural hazards.
At the end of the course, the student will be able to apply multi-hazard and multi-risk concepts and definitions and describe the available approaches for qualitative and quantitative multi-hazard risk modeling. Furthermore, the student will be able to discuss the challenges in implementing multi-hazard disaster risk reduction (DRR) strategies. The knowledge of risk assessment and management approaches that consider multiple hazards and their potential interactions will help the student to better understand and capture the real risk that many areas of the world are prone to, allowing them to identify more successful DRR measures.

Program:

The course will focus on qualitative and quantitative multi-hazard modeling, and how this is used in analyzing and managing multi-hazard risk, considering the losses due to multiple and/or interacting natural hazards. Multi-hazard and multi-risk concepts, definitions, and approaches will be introduced and discussed using available literature as support.

I part – Multi-hazard interactions

In the first part of the course, the different interaction mechanisms between hazards - including triggering, influence, and coincidence - will be analyzed, exploring available modelling approaches, and introducing the concept of multiple event probabilities.

II part – Multi-hazard impact assessment

In the second part, multi-vulnerability, multi-hazard exposure, and multi-hazard damage assessment will be investigated.

III part – Multi-hazard Disaster Risk Management

In the final part, multi-hazard approaches in the different phases of the disaster risk management cycle (preparedness, emergency, recovery) will be explored and multi-hazard disaster risk reduction measures able to successfully reduce the impacts of disasters across different hazards will be investigated, including the analysis of potential asynergies among hazards.

References:

- Ciurean, R., Gill, J., Reeves, H. J., O'Grady, S., & Aldridge, T. (2018). Review of multi-hazards research and risk assessments, British Geological Survey Open Report, OR/18/057. 86pp.
- De Angeli, S., Malamud, B. D., Rossi, L., Taylor, F. E., Trasforini, E., & Rudari, R. (2022). A multi-hazard framework for spatial-temporal impact analysis. International Journal of Disaster Risk Reduction, 73, 102829.
- de Ruiter, M. C., Couasnon, A., Van den Homberg, M. J. C., Daniell, J. E., Gill, J. C., & Ward, P. J. (2020). Why we can no longer ignore consecutive disasters, Earths Future, 8, e2019EF001425.
- de Ruiter, M. C., de Bruijn, J. A., Englhardt, J., Daniell, J. E., de Moel, H., & Ward, P. J. (2021). The asynergies of structural disaster risk reduction measures: Comparing floods and earthquakes. Earth's Future, 9(1), e2020EF001531.
- Gill, J. C., & Malamud, B. D. (2014). Reviewing and visualizing the interactions of natural hazards. Reviews of Geophysics, 52(4), 680-722.

- Tilloy, A., Malamud, B. D., Winter, H., & Joly-Laugel, A. (2019). A review of quantification methodologies for multi-hazard interrelationships. Earth-Science Reviews, 196, 102881.
- Terzi, S., De Angeli, S., Miozzo, D., Massucchielli, L. S., Szarzynski, J., Carturan, F., & Boni, G. (2022). Learning from the COVID-19 pandemic in Italy to advance multi-hazard disaster risk management. Progress in disaster science, 16, 100268.