



## EXTREME LOADING ANALYSIS OF PETROCHEMICAL PLANTS AND DESIGN OF METAMATERIAL-BASED SHIELDS FOR ENHANCED RESILIENCE

<http://r.unitn.it/en/dicam/xp-resilience>

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# Short Course on Methods of risk analysis and resilience estimation

26<sup>th</sup> June – 2<sup>nd</sup> of July 2019,

Institute of Structural Engineering, Earthquake Engineering and Construction IT, Faculty of Civil and Geodetic Engineering, University of Ljubljana  
Jamova 2, SI1000 Ljubljana, Slovenia

### Course objective

The societal well-being is dependent on services provided by the built environment which, however, cannot be absolutely guaranteed due to different hazards that threaten the quality of life of citizens and the functionality of large-scale interdependent networks systems. Therefore the question arises how to design new facilities and systems and if it is necessary to upgrade the performance of existing facilities and systems in order to enhance societal-well being in the long term?

In order to answer the question, it is necessary to have an insight into the hazards which threaten the built environment, the fragility of the built environment and the methods and tools for decision making about the acceptable performance of basic units of the built environment as well as its complex network systems.

The objective of this short course is to provide basics of risk analysis and resilience estimation, which are becoming increasingly popular for performance measures in the design or retrofitting process of structures and network systems. The emphasis will be on the methods which account for the seismic hazard, but flood hazard and multiple hazards will also be addressed. More specific lectures will address:

- the risk-based decision models for design of units of built environment using response history analysis, pushover analysis or force-based design,
- the probabilistic seismic hazard analysis for multiple sites and spatially distributed infrastructure including the effect of aftershocks and
- the reliability and resilience of civil infrastructure systems subject to multiple hazards as well as the design of sustainable and resilient Infrastructure.

### Who should attend

Graduate students of engineering (primarily civil engineering), postdoctoral researchers and practitioners interested in risk and resilience estimation. Some topics may be interesting for undergraduate students of the 2<sup>nd</sup> Cycle Study Programmes.

## Course schedule

Lectures		
26 <sup>th</sup> June 9:00-12:00	Peter Fajfar	<b>Introductory lectures</b> - Earthquake resistant structures – The key element of seismic resilience
	Matjaž Dolšek	- Is the state of engineering practice suitable for enhancing community resilience? - Course summary: Objectives, Topics, Tutorials
14:00-17:00	Matjaž Dolšek	<b>Basics of seismic fragility analysis of a structure and decision models for the design and assessment of structures</b> - Response history analysis methods (IDA, multiple stripe analysis) - Pushover-based methods (fundamentals of pushover analysis, N2 method, IDA using SDOF model) - Target fragility function - Decision models for the intensity-based assessment using response history analysis, pushover analysis or linear elastic analysis (3R method, risk-targeted safety factor, risk-targeted behaviour factor) - Five-grade grading system

\* 45 min of effective lectures per hour

Lectures		
June 27 <sup>th</sup> 9:00-12:00	Iunio Iervolino	<b>Probabilistic seismic hazard analysis</b> - Earthquake occurrence processes - Ground motion intensity occurrence process at specific sites, PSHA - PSHA for multiple sites and spatially distributed infrastructure - PSHA including aftershocks
June 27 <sup>th</sup> 14:00-16:00	Iunio Iervolino	<b>Risk assessment</b> Seismic risk assessment - Probability of failure given an earthquake event - Failure rates - Expected seismic loss and distributions Principles of flooding risk assessment - Rainfall probability curves - Basin response - Flooding fragility
16:00-17:00	Matjaž Dolšek	<b>Loss estimation methods</b> - Pushover-based loss estimation

Lectures		
June 28 <sup>th</sup> 9:00-12:00  14:00-16:00	Paolo Gardoni	<b>Sustainable and Resilient Infrastructure: Emerging Needs, Engineering Tools and Interdisciplinary Considerations</b> - Reliability and Resilience of Civil Infrastructure Systems subject to Multiple Hazards - Promoting Societal Well-being by Designing Sustainable and Resilient Infrastructure
June 28 <sup>th</sup> 16:00-17:00	Matjaž Dolšek	<b>Introduction to tutorials</b> - Tutorial 1 - Tutorial 2

Tutorials		
1 <sup>st</sup> July 9:00-12:00 14:00-17:00	Jure Žižmond, Anže Babič, Matjaž Dolšek	<b>Tutorial 1</b> - Evaluation of safety collapse check of structure using 3R method and estimation of risk-targeted behaviour factor of a reinforced concrete frame building
2 <sup>nd</sup> July 9:00-12:00 14:00-17:00	Jure Žižmond, Anže Babič, Matjaž Dolšek	<b>Tutorial 2</b> - Estimation and evaluation of expected annual losses of a reinforced concrete building

## Suggested readings/references:

1. Babič A, Dolšek M. A five-grade grading system for the evaluation and communication of short-term and long-term risk posed by natural hazards. *Structural Safety* 2019; 78:48–62.
2. Chioccarelli E., Cito P., Iervolino I., Giorgio M. (2019) REASSESS V2.0: software for single- and multi-site probabilistic seismic hazard analysis. *Bulletin of Earthquake Engineering*, 17:1769–1793.
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6. Doorn, N., Gardoni, P., and Murphy, C., (2018). "A multidisciplinary definition and evaluation of resilience: the role of social justice in defining resilience," *Sustainable and Resilient Infrastructure*, DOI: 10.1080/23789689.2018.1428162.
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9. Gardoni, P., and LaFave, J., (Eds.) (2016). *Multi-hazard Approaches to Civil Infrastructure Engineering*, Springer.
10. Gardoni, P., and Murphy, C., (2018). "Society-based design: promoting societal well-being by designing sustainable and resilient infrastructure," *Sustainable and Resilient Infrastructure*, DOI: 10.1080/23789689.2018.1448667.
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18. Jia, G., and Gardoni, P. (2018). "State-dependent stochastic models: A general stochastic framework for modeling deteriorating engineering systems considering multiple deterioration processes and their interactions," *Structural Safety*, 72, 99-110.
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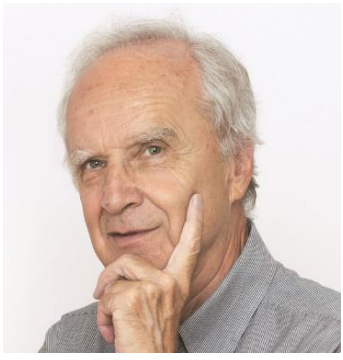

## Registration

Please register by sending email to [mdolsek@fgg.uni-lj.si](mailto:mdolsek@fgg.uni-lj.si). The deadline for the registration is 10<sup>th</sup> of June 2019. There is no registration fee.

## Short Biography of lecturers



<p><b>Paolo Gardoni</b></p>	<p><b>Professor of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign, USA</b></p>
  <p><b>ILLINOIS</b> UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN</p>	<p>Paolo Gardoni is a Professor and Excellence Faculty Scholar in the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign. He is the Director of the MAE Center that focuses on creating a Multi-hazard Approach to Engineering, and the Associate Director of the NIST-funded Center of Excellence for Risk-based Community Resilience Planning. Dr. Gardoni is the founder and Editor-in-Chief of the international journal Sustainable and Resilient Infrastructure published by Taylor and Francis Group. He is a member of the Board of Directors of the International Civil Engineering Risk and Reliability Association (CERRA), of the Advisory Council of the International Forum on Engineering Decision Making (IFED), and of a number of national and international committees and associations that focus on risk and reliability analysis. Dr. Gardoni's research interests include sustainable and resilient infrastructure; reliability, risk and life cycle analysis; decision making under uncertainty; performance assessment of deteriorating systems; ethical, social, and legal dimensions of risk; and policies for natural hazard mitigation and disaster recovery. He is the author of over 140 refereed journal papers and 7 edited volumes. He has received over \$29 million in research funding from multiple national and international agencies, and has given over 40 invited and keynote lectures around the world.</p>



<p><b>Iunio Iervolino</b></p>	<p><b>Professor of Earthquake Engineering and Structural Dynamics at the Università degli Studi di Napoli Federico II, Italy</b></p>
  <p><b>UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II</b></p>	<p>Iunio Iervolino is full professor of earthquake engineering and structural dynamics at the University of Naples Federico II. He holds two masters, one in structural engineering and one in management engineering, and one Ph.D. in seismic risk. Since his Ph.D. thesis on the topic of seismic risk assessment of process industry facilities, he has authored more than three hundred publications in the field of risk assessment for civil structural and infrastructural systems and earthquake early warning methods. He has among the largest bibliometric indices in his field in Europe. Among awards and honors, he received the AXA research fund grant in 2011, and in 2014 he was appointed Fulbright visiting professor at Stanford University. Iunio Iervolino has been or is consultant for risk analysis to national and international public authorities or industries.</p>

<b>Peter Fajfar</b>	<b>Professor of Structural and Earthquake Engineering at the Faculty of Civil and Geodetic Engineering, University of Ljubljana, Slovenia</b>
 <p> University of Ljubljana  Faculty of <i>Civil and Geodetic Engineering</i>  Institute of Structural Engineering, Earthquake Engineering and Construction IT </p> 	<p>Peter Fajfar is Professor at the University of Ljubljana. His main research interest is seismic analysis and design of structures. He was a visiting professor at several prestigious universities, including Stanford University. In the period 2003-2015 he was one of three Editors of the journal Earthquake Engineering and Structural Dynamics. He served on the Board of Directors of the International Association of Earthquake Engineering and was a member of the Executive Committee of the European Association of Earthquake Engineering, where he is now an Honorary Member. He has been involved in the development of the European standard Eurocode 8 and leads the implementation of this standard in Slovenia, which was the first country where Eurocode 8 became compulsory. As a designer, consultant and/or reviewer, he has participated in a large number of projects for industry. He received several awards, among them the highest award for the scientific work in Slovenia and Prof. Nicholas Ambraseys Distinguished Lecture Award. P.Fajfar is a member of the Slovenian Academy of Sciences and Arts, of the Slovenian Academy of Engineering, of the European Academy of Sciences (Belgium), and of the National Academy of Engineering (USA).</p>

<b>Matjaž Dolšek</b>	<b>Professor of Civil and Environmental Civil Engineering at the Faculty of Civil and Geodetic Engineering, University of Ljubljana, Slovenia</b>
 <p> University of Ljubljana  Faculty of <i>Civil and Geodetic Engineering</i>  Institute of Structural Engineering, Earthquake Engineering and Construction IT </p> 	<p>Matjaž Dolšek is Professor of Civil Engineering and Environmental Engineering at Faculty of Civil and Geodetic Engineering, University of Ljubljana, Slovenia, and Head of research program Earthquake Engineering. He has participated in several European projects (SPEAR, LESSLOSS, SERIES, STREST, NEWREBAR, XP-RESILIENCE) and was the project leader of three national basic research projects. He is the project leader of the research project Seismic stress test of the built environment. He is a member of the Slovenian Chamber of Engineers, a member of the Slovenian and the European Association for Earthquake Engineering. He was a member of Project Team 1 (CEN/TC250/SC8-PT1) who drafted the second generation of standard for earthquake-resistant design of structures - Eurocode 8 and a member of technical committees of Slovenian Institute for Standardization. He is the (co)author of more than 100 publications in peer-reviewed Journal or Conference proceedings. He participated in around 30 consulting projects in the field of evaluation of the seismic resistance of structures, determination of earthquake parameters for the design of structures and fragility analysis including for structures important for nuclear safety.</p>

## Short Biography of Assistants

<p><b>Jure Žižmond</b></p>	<p><b>Assistant of Civil and Environmental Civil Engineering at the Faculty of Civil and Geodetic Engineering, University of Ljubljana, Slovenia</b></p>
 <p>University of Ljubljana Faculty of Civil and Geodetic Engineering Institute of Structural Engineering, Earthquake Engineering and Construction IT</p> 	<p>Jure Žižmond is Assistant of Civil Engineering and Environmental Civil Engineering at Faculty of Civil and Geodetic Engineering, University of Ljubljana, Slovenia, and member of research program Earthquake Engineering. His current research is focused on the development of methods for risk-targeted force based designed and evaluation of the impact of the new type of reinforcing steel (dual-phase steel) on seismic performance of a structure. He has participated in research projects Design of structures for tolerable seismic risk using non-linear methods of analysis and Seismic stress test of the built environment, founded by Slovenian Research agency, and European projects SERIES and NEWREBAR. He published several papers in national and international journals and participated in the industry project focused on the development of risk-based seismic design rules for energy-efficient houses. Recently he has worked as part of a consultancy team from the Faculty of Civil and Geodetic Engineering, involved in the independent evaluation of project documentation for designing of a new and upgrading existing facilities of Nuclear Power Plant Krško. He is a member of the Slovenian Chamber of Engineers.</p>

<p><b>Anže Babič</b></p>	<p><b>Assistant of Civil and Environmental Civil Engineering at the Faculty of Civil and Geodetic Engineering, University of Ljubljana, Slovenia</b></p>
 <p>University of Ljubljana Faculty of Civil and Geodetic Engineering Institute of Structural Engineering, Earthquake Engineering and Construction IT</p> 	<p>Anže Babič is a teaching assistant at the Faculty of Civil and Geodetic Engineering of the University of Ljubljana and a member of research program Earthquake Engineering. His research work spans from the structural and seismic analyses of buildings to the disaster risk management of the built environment. His primary research interest is the design of earthquake-resistant structures, nonlinear dynamic analysis, the evaluation and communication of natural hazards risk, restoration analysis and lost estimation. He participated in the European STREST project aimed at developing stress tests for critical infrastructures (CIs) against natural hazards. Currently, he is involved in a basic research project entitled Seismic stress test of the built environment. In addition to the research and teaching activities, he has recently worked as part of a consultancy team from the Faculty of Civil and Geodetic Engineering, advising the Slovenian Nuclear Power Plant on designing new and upgrading existing facilities.</p>

## Registration

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## Information about the venue and accommodation

### Venue

The meeting and the workshop will be held at the **Faculty of Civil and Geodetic Engineering** (see Figure 1). It is located on **Jamova cesta 2, Ljubljana (46.0457525, 14.4949470)**, about 20 minutes walking from Grand Hotel Union. For instructions click [here](#) (see also Figures 2 and 3).



Figure 1: Faculty of Civil and Geodetic Engineering

It is recommended that you arrive from Jamova cesta as indicated in Figures 2 and 3. In this case, you will see the building of the Faculty on your right-hand side (as shown in Figure 1). The signs inside the building will show the direction to the lecture room.

### Parking

If you arrive by car, a few parking places will be available at the Faculty (ring the bell in front of the entrance to the parking and say that you are attending the short course). In case there is no place left, there is a public parking lot 100 m north from the Faculty building (Figure 2).

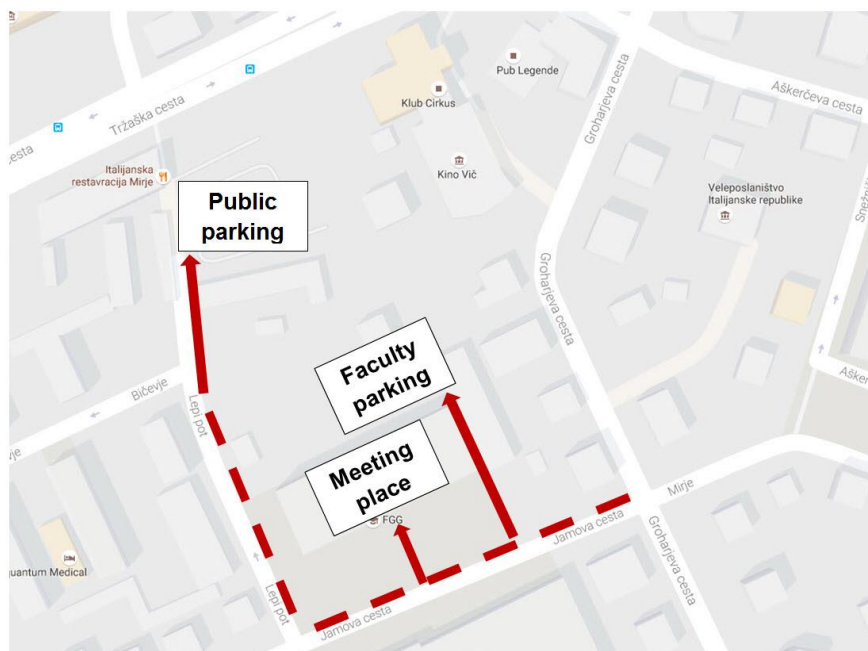


Figure 2: The Meeting place and possible parking places

## **Accommodation**

There are plenty of hotels downtown of Ljubljana, which is a walking distance to the Faculty. However, it is advised that participants book the accommodation in advance since the prices can increase if a booking is made less than two weeks before arrival. Perhaps the good option is to look on Airbnb in addition to booking.com and other providers for hotels. Please do not hesitate to contact us if you need further advice.

## **From the airport to downtown**

Upon your arrival at Ljubljana Jože Pučnik Airport, you can reach your hotel either by using a public bus service, a shuttle or by taxi. The bus has frequent itineraries every hour from 5 am to 8 pm, takes about 45 minutes to the bus station (J at Figure 2), which is a ten-minute walk from the centre of the city, and costs about 4 Euros. The shuttle ("[MARKUN shuttle](#)") takes you anywhere in the centre of Ljubljana for 9 Euros. Taxi service is available on a 24-hour base. A 30-minute drive costs approximately 40 Euros (ask for the price).

There are possibilities to fly to Trieste, Zagreb or perhaps Venice. In this case, you will need shuttle service for travelling to Ljubljana (e.g. [www.GoOpti.com](http://www.GoOpti.com)).

Other general information for the city of Ljubljana could be retrieved from:

<https://www.visitljubljana.com/en/visitors/>

<http://www.ljubljana.info/>

## **Contacts for logistic information:**

Jure Zizmond, office: +38614768611; [jizmond@fgg.uni-lj.si](mailto:jizmond@fgg.uni-lj.si)

Matjaz Dolsek, office: +38614768612; [mdolsek@fgg.uni-lj.si](mailto:mdolsek@fgg.uni-lj.si)

Please do not hesitate to contact us if you need some additional information.

## **Additional information:**

June 25<sup>th</sup> is Statehood Day, commemorating Slovenia's declaration of independence from Yugoslavia in 1991. It is a work-free day. The national ceremonial celebration will be held on 24<sup>th</sup> June at Kongresni trg (downtown Ljubljana), starts at 21:15.