XP-resilience

EXTREME LOADING ANALYSIS OF PETROCHEMICAL PLANTS AND DESIGN OF METAMATERIAL-BASED SHIELDS FOR ENHANCED RESILIENCE
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MARIE CURIE ACTIONS

Short course on

Understanding nonlinear problems in civil and industrial engineering

Rome, Italy, 6-10 May, 2019

Background

Understating nonlinear problems in civil and industrial engineering is essential to deal with the numerous challenges that the engineers will be call to tackle in the next future to design resilient structures against natural or technological threats. Accordingly, the course intents to provide the basic framework of nonlinear methods and modeling in civil and industrial engineering with applications on buildings, bridges and structures of the chemical industry.

Objectives of the course

The main objective of this course is to familiarize students with the state-of-the-art of static and dynamic analysis of structures in nonlinear regime. At the end of the course, students should be able to:

- Familiarize with the basic concepts and types of nonlinear problems in structural mechanics
- Understand the basic aspects of nonlinear modeling and their computational implementation
- Understand the solution strategies for nonlinear problems
- Understand material nonlinearity , i.e. constitutive laws for steel and concrete and masonry
- Solve specific nonlinear problems by using nonlinear static and dynamic analysis: RC frames, Masonry Structures, Industrial equipment

About the instructors

Sonia Marfia is Associate Professor in Mechanics of Solids at the University of Cassino and Southern Lazio– Department of Civil and Mechanical Engineering from 2006. From 2014 she has the National scientific qualification to function as full professor in Italian Universities.
From 2013 she is a member of the Committee of the Italian Group of Computational Mechanics (GIMC) and from 2017 she is a member of the General Assembly of IACM (International Association for Computational Mechanics).
Her main scientific interests are focused on: a) Theoretical and Applied Mechanics, b) Computational Mechanics c) Homogenization and multiscale analyses for the study of the mechanical response of structural elements made of heterogeneous material characterized by a nonlinear response, d) Material Constitutive Modeling of cohesive materials and of advanced heterogeneous materials e) Modeling of fracture or detachment process adopting interface models, f) Finite element and virtual element method. On these topics she has been involved in many national and international research projects.
She won several national and international scholarships that allows her to spend five months at Technical University of Denmark (DTU), in Lyngby, Copehagen, in 1999; three months at École polytechnique fédérale de Lausanne (EPFL) in Losanna in 2003 and one month in Czech Technical University of Praga in 2005, as visiting researcher.
She is author of more than 50 Scopus research products, publications on International Journals and Conferences.

Marialaura Malena is research associate at the Roma Tre University – Department of Engineering. Her scientific interests include: analytical and numerical models for the behaviour of composite material, rehabilitation and strengthening of structures with sustainable composites, soil-structures mutual interaction for the study of the effects of shallow tunnelling on existing structures, constitutive laws for the nonlinear behaviuor of masonry structures, seismic assessment of existing constructions including masonry bridges and cultural heritage, numerical models for the nonlinear analysis of reinforced concrete frame subject to variable actions. On these topics she is involved in international research projects and she is member of technical committees, including the RILEM TC 250-CSM, the RILEM TC 223-MSC, the COST Action TU1207. She is member of the standardization board, ACI 549-0L Committee "Design and Construction of Externally Bonded Fabric Reinforced Cementitious Matrix (FRCM) Systems for Repair and Strengthening Masonry Structures". She is author of more than 50 publications on International Journals and conferences.

Giuseppe Tomassetti is Associate Professor in Mechanics of Solids at at the Roma Tre University – Department of Engineering. His main skills are in continuum mechanics and applied mathematics. His scientific interests are in nonlinear elasticity, magnetoelastic composites, strain gradient plasticity, theories of shells and plates, piezoelectric materials, surface growth, modeling of shape-memory alloys, Cahn-Hilliard systems. He has been visiting to: Carnegie-Mellon University, Mathematics Department; Faculty of Mathematics and Physics of the Charles University in Prague; Institute of Thermomechanics of the Czech Academy of Sciences; Institute of Physics of the Czech Academy of Sciences; MIT Mechanical Engineering Department. In 2011 he was awarded the AIMETA Junior Prize from the Italian Association of Theoretical and Applied Mechanics. He is secretary of ISIMM, International Society for the Interaction of Mathematics of Mechanics. He is author of more than 40 publications on Scopus-indexed journal papers.

Fabrizio Paolacci is Assistant Professor in Structural Engineering at the Roma Tre University – Department of Engineering and Chair of the Seismic Technical Committee within the ASME PVP division. His main scientific interests are focused on: a) Performance-based design of steel-concrete composite bridges, b) Assessment and reduction of the seismic risk of reinforced concrete buildings and bridges, c) Seismic risk of major-hazard industrial plants and applicability of innovative protection systems (base isolation and energy dissipation), e) Seismic vulnerability of high-voltage electric networks and substations and applicability of innovative seismic protection systems, f) Passive and semi-active control of structures. He gained a long standing experience in the management of research projects about experimental assessment of the seismic response of

structures. He is currently PI of many European projects. From 2008 to 2013 He assumed the role of scientific coordinator of the Laboratory of Testing Materials and Structures of the Department of Structures of the University Roma Tre. He received a fellowship provided by CNR (National Research Council) for a research activity of six months at the Department of Civil and Environmental Engineering of University of California at Berkeley from September 1999 to February 2000 as visiting scholar. He is author of more than 100 publications on International Journals and conferences.

Organization and participation

The course is organized by the Doctoral School in Civil Engineering of the University Roma Tre, with the participation within the MSC ITN European Project XP-Resilience. A maximum of **30** participants will beaccepted. No fees are requested, but reservation is needed. The participation to the whole course will grant **4** ECTS. Those wishing to attend the course should contact the Department of Engineering at the following address by **May 1th 2019**.

Contacts

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COURSE SCHEDULE 6-10, May 2019

Monday 6

09:00-12:00 and 14:00-17:00 - Instructor: **Marialaura Malena**

Morning Session: **Introduction to nonlinear problems**

- Source of nonlinearities (geometric, material and boundary conditions)
- Solutions strategies for solving nonlinear problems
  - Displacement and Force control
  - Newton, Line search and Arch Length Method

Afternoon Session: **F.E. formulation of NL Frame Structures**

- Basics of F.E.M. implementation
- Analysis of frame structures under nonlinear static conditions

Tuesday 7

09:00-12:00 and 14:00-17:00 - Instructor: **Giuseppe Tomassetti**

Morning Session: **F.E. formulation for Shell Structures – Part 1**

- Static problem of shell structures

Afternoon Session: **F.E. formulation for Shell Structures – Part 2**

- Static problem of shell structures: cont'd
- Analysis of Axisymmetric Structures
  - Example: Cylindrical shell

Wednesday 8

09:00-12:00 and 14:00-17:00 - Instructors: **Fabrizio Paolacci/Giuseppe Tomassetti**

Morning Session: **F E. formulation for Shell Structures – Part 3 (Tomassetti)**

- FE modeling of plate and shell structures
  - Problems and solution strategies
  - Example: Circular Reservoir

Afternoon Session: **Fluid-Structure interaction problems in cylindrical shell str. (Paolacci)**

- FSI problems: formulation and FE modeling
- Nonlinear finite element modelling of steel storage tanks under seismic loadings
  - Modeling and response accuracy
    - Lumped mass modeling

Thursday 9

09:00-12:00 and 14:00-17:00 - Instructors: **Fabrizio Paolacci/Sonia Marfia**

Morning Session: **Fluid-Structure interaction problems (Paolacci)**

- Nonlinear finite element modelling of steel storage tanks under seismic loadings
  - Modeling and response accuracy
    - The added mass modeling
    - NL modeling with direct FSI
  - Example: Unanchored liquid storage tank

Afternoon Session: **Modeling approaches for Masonry Structures – Part 1 (Marfia)**

- Nonlinear phenomena in Masonry Structures.
- Modeling Approaches for Masonry Structures: Macro-mechanical models, Micro-mechanical, and Multiscale Models.
- Modeling of the mechanical response of Masonry Material: basic concepts of nonlocal damage mechanics and plasticity.

Friday 10

09:00-12:00 and 14:00-17:00 - Instructor: **Sonia Marfia**

Morning Session: **Modeling approaches for Masonry Structures – Part 2**

- Macro mechanical approach:
  - Nonlocal Damage and plasticity models;
  - No tension models.
- Micro-mechanical approach:
  - Interface models.

Afternoon Session: **Modeling approaches for Masonry Structures – Part 3**

- Homogenization techniques for the modeling of the Masonry Material:
  - Reduced order models;
  - Non linear finite element analyses.
- Multiscale approaches for Masonry Structures.

Closure and Acknowledgments