UNIVERSITY OF NAPLES FEDERICO II

DEPARTMENT OF STRUCTURES FOR ENGINEERING AND ARCHITECTURE
PHD PROGRAM IN
STRUCTURAL, GEOTECHNICAL ENGINEERING AND SEISMIC RISK

CYCLE XXXIX

The undersigned prof. Raffaele Barretta

(Full X Associate □ Researcher □) and

The undersigned prof. Francesco Marotti de Sciarra

(Full X Associate □ Researcher □)

Department of Structure for Engineering and Architecture, S.S.D. ICAR/08 – Structural Mechanics

ASK

to be included in the list of tutors for cycle XXXIX.

1. Curriculum vitae (max 500 words)
Raffaele Barretta Full Professor of Structural Mechanics at the Department of Structures for Engineering and Architecture, University of Naples Federico II. Associate Professor (2015–2021). Assistant Professor (2010–2015). Ph.D. in Structural Mechanics, University of Naples Federico II (2007). Master Degree in Civil Engineering (magna cum laude), University of Naples Federico II (2003). Coordinator of AIMETA Group Multiscale and Nanostructure Mechanics (2022); http://bit.ly/3FcUSDw. Local Coordinator of MIUR PRIN 2017 Multiscale Innovative Materials and Structures. Principal Investigator of MIUR PRIN 2022 Nonlocal Mechanics of Innovative Soft Nanostructures. Editorial Board of scientific journals Acta Mechanica and Archive of Applied Mechanics.

Research interests: multiscale structures; nano-engineered materials and structures; generalized continua; homogenization; nonlinear constitutive relations; geometric methods in nonlinear continuum mechanics; variational methods; variable mass dynamic systems; solid-fluid interaction with applications to turbines, jets, rockets and sprinklers; thermoelasticity; waves, phase transitions, nonlinear shells.
Top Italian Scientist in the Engineering Area from Single Year Career 2017.
Awarded in the top list of 90 scholars of University of Naples Federico II, database of PloS Biology 100,000 top world scientists (http://bit.ly/37ox6Uk).
Ranked #714 in the world and #12 in Italy among Top Scientists 2023 (http://bit.ly/3M5nhPl).

Francesco Marotti de Sciarra

Full Professor of Solid and Structural Mechanics at the Department of Structures for Engineering and Architecture (DiSt) of the University of Naples Federico II, Italy.
- Webpages: Univ. Naples Federico II (https://www.docenti.unina.it), Scopus (https://bit.ly/2LH9UYQ), Orcid (https://orcid.org/0000-0001-7241-370X), Google Scholar (https://scholar.google.com/citations?user=mxiKiFwAAAAJ&hl=it).
- Top Italian Scientist in the Engineering Area from Single Year Career 2017 and - Top Italian Scientist in the Engineering Area 2019-2020.
Local Coordinator of MIUR PRIN 2015: Advanced mechanical modeling of new materials and structures for the solution of 2020 Horizon challenges. - Project code 2015JW9NJT.
Component of MIUR PRIN 2020: Sustainable modelling of materials, structures and urban spaces including economic-legal implications - Project code 20209F3A37.
Local Coordinator of MIUR PRIN 2022: Preparation and Performance of Pervious Concretes (PCs) with Nanostructures for Civil Engineering Projects - Project code 2022X5L45T.
RESEARCH FIELDS and INTERESTS
Nano-engineered materials and structures; generalized continua; nonlinear constitutive relations; variational methods; plasticity and damage; thermoelasticity, convex analysis.

2. PhD students of whom the undersigned has been a tutor in the last three years

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CYCLE XXXIX

n. 1	*1. Marzia Sara Vaccaro (university funds)*

3. Title of the proposed research
Nonlinear Mechanics of Soft Structures

4. Field of study
Geotechnical Engineering □ Structural Engineering X Seismic Risk □

5. Type of grant for which the project is proposed
Ateneo X DM 117 (Investimento 3.3) □ *(in questo caso indicare l'azienda co-finanziatrice)* DM 118 (Investimento 4.1 P.A.) □ DM 118 (Investimento 4.1 generici) □ DM 118 (Investimento 4.1 Patrimonio culturale) □

6. Summary of the research project (max 500 words. State of the art, short program planned for the activities, etc.)

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CYCLE XXXIX

The research program aims at addressing the structural analysis of continua undergoing large displacements and deformations. This kind of structural problems is nowadays of an ever increasing importance in innovative engineering applications regarding a wide spectrum of disciplines, spanning from nano-mechanics, electro-mechanics, biomechanics. Practical applications are of utmost interest for industrial design and production of sensors, actuators, composites, soft tissues, compliant electronic devices and mechanisms at different scales. A consistent analysis of such problems requires a revision and a reformulation of basic notions and methodologies of current usage in structural mechanics both from the theoretical and computational standpoint.

Specifically, the present proposal will deal with the investigation of soft structures by a geometric approach. In this context, constitutive relations ought to be reformulated as instantaneous incremental responses to a finite set of tensorial state variables and to their time convective rates along the motion. A careful answer to the mathematical question of conservativeness of the elastic response is of basic importance for the whole analysis.

Integrability criteria for the tangent elastic compliance ensures existence of an elastic stress potential and a zero-work property in closed cycles of the stress field. To fulfil these criteria, the stress descriptor must be formulated per unit mass since conservation of mass plays a basic role in the proof. Thus, a natural stress which is a contravariant tensor field per unit mass ought to be taken as leading field in constitutive relations. This brief consideration imposes a brand-new treatment even for standard and basic elastic constitutive models and a fortiori also for an elastic one.

The leading ideas are summarized below.

- New physico-geometric notions of material and spatial fields, both defined on the trajectory manifold, will be introduced. Constitutive properties will be described in terms of material fields and in incremental form pertaining to current configuration. Comparison of material tensors at different times will be performed by push along the motion. Spatial fields will be compared by a parallel transport along the motion.
- The geometric stretching is one-half the convective derivative of the material metric tensor.
- The stress is a material contravariant tensor dual to geometric stretching and its rate is measured by a convective derivative. Duality interaction between stress and stretching provides the mechanical power per unit mass.
- The rate elastic response is linear in the stress rate and nonlinear in the stress.
- The geometric stretching is the (commutative) contribution of physical phenomena of various kind: elastic, thermal, visco-plastic, phase-changing, electromagnetic, growth, each described by a specific model. Neither elasto-visco-plastic finite deformations nor chain (multiplicative) decompositions of the deformation gradient will be involved in the

proposed geometrically nonlinear formulation. A referential formulation will be resorted to as an effective tool in performing linear operations. Recent finite element formulations will be exploited for computing cables, beams, membranes, shells and 3D continua.

7. Research publications on the research topic (max 10)

1. Romano G., Barretta R., Diaco M., Spacetime evolutive equilibrium in Nonlinear Continuum Mechanics. Continuum Mechanics and Thermodynamics 1-22 (2023). 10.1007/s00161-023-01213-z.
2. Barretta R., Čanađija M., Marotti de Sciarra F., On thermomechanics of multi-layered beams. International Journal of Engineering Science 155, 103364 (2020).
3. Barretta R., Marotti de Sciarra F., Constitutive boundary conditions for nonlocal strain gradient elastic nano-beams. International Journal of Engineering Science 130, 187-198 (2018).
4. Romano G., Barretta R., Diaco M., Marotti de Sciarra F., Constitutive boundary conditions and paradoxes in nonlocal elastic nanobeams. International Journal of Mechanical Sciences 121, 151-156 (2017).
5. Romano G., Barretta R., Diaco M., Rate formulations in nonlinear continuum mechanics. Acta Mechanica 225(6), 1625-1648 (2014).
6. Romano G., Barretta R., Diaco M., The geometry of nonlinear elasticity. Acta Mechanica 225(11), 3199-3235 (2014).
7. Romano G., Barretta R., Diaco M., Geometric continuum mechanics. Meccanica 49, 111-133 (2014).
8. Marotti de Sciarra F., Hardening plasticity with nonlocal strain damage. International Journal of Plasticity 34, 114-138 (2012).
9. Romano G., Marotti de Sciarra F., Diaco M., Well-posedness and numerical performances of the strain gap method. International Journal for Numerical Methods in Engineering 51(1), 103-126 (2001).
10. Marotti de Sciarra F., General theory of damage elastoplastic models. Journal of Engineering Mechanics 123(10), 1003-1010 (1997).

8. Funded research projects in which the proposed research fits

PRIN 2022: Preparation and Performance of Pervious Concretes (PCs) with Nanostructures for Civil Engineering Projects - project code 2022X5L45T

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CYCLE XXXIX

PRIN 2022: Nonlocal Mechanics of Innovative Soft Nanostructures (NoMISN) - project code 2022ZW2NMJ ReLUIS 2022-2024

9. Funds available for research grants, equipment, missions, etc.

10. Information related to the research period abroad (min. 3 months) provided for the PhD student (please indicate University/research institution and professor/researcher of reference) (max 300 words)
1. University of Rijeka, Faculty of Engineering, Department of Engineering Mechanics, Vukovarska 58, 51000 Rijeka, Croatia - Prof. Marko Čanađija 2. Texas A&M University, College of Engineering, J. Mike Walker '66 Department of Mechanical Engineering, 3127 TAMU, College Station, TX 77843-3123, USA - Prof. Junuthula N. Reddy 3. Bialystok University of Technology, Faculty of Mechanical Engineering, Wiejska 45C, 15-351 Bialystok, Poland - Prof. Krzysztof Kamil Żur

11. Collaborations with companies on the research topic (if available) (max 300 words)

Naples, 20/6/2023 SIGNATURE

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Il presente modulo va compilato in ogni sua parte ed inviato all'indirizzo di posta elettronica phd.dist@unina.it entro e non oltre **il 30/06/2023.**