



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

Number of scholarship offered	4
Department	DIPARTIMENTO DI INGEGNERIA CIVILE E AMBIENTALE

Description of the PhD Programme
<p><b>General description</b></p> <p>Structural, Seismic and Geotechnical Engineering - SSGE - encompasses the disciplines and techniques to understand, model and control the behavior of: (a) structural materials (concrete, steel, masonry, composites, bio-materials and materials for micro-systems), (b) structural systems (from constructions to bio-mechanical systems and micro-systems), (c) soils and (d) environment-construction interaction. Being deeply-rooted in the civil engineering which is, by its very nature, highly inter-disciplinary, SSGE also focuses on environmental actions, either external (such as earthquakes, vibrations, irradiation, wind and fire) or ensuing from soil-structure interaction (such as those caused by retained-earth thrust, landslides and water-table fluctuations). Because of their generality in materials and structural modeling, the methods developed within the domain of SSGE are also very useful in other technical-scientific fields, whenever understanding and controlling mechanical aspects is necessary to guarantee design reliability and structural safety, serviceability and durability. Many are the examples of typical SSGE issues: from tall buildings and bridges to industrial bio-mechanical and micro-electromechanical systems, from off-shore structures and dams to the rehabilitation of monumental buildings, from seismic design and structural dynamics to slope stability, tunnel behavior and foundations, not to mention many issues in common with several branches of industrial engineering.</p> <p><b>List of topics and research areas</b></p> <p>Advanced computational methods for coupled problems in porous media - Advanced computational methods for the simulation of complex flows with moving boundaries - Cementitious materials and concrete structure under extreme and exceptional loading - Computational and experimental mechanics - Computational mechanics of materials and structures - D-zones and anchorages under severe conditions - Earthquake engineering and structural dynamics - Fire safety of concrete structures - Geotechnical earthquake engineering - Life-cycle performance of bridges and structures - Micro Electro-Mechanical Systems and</p>



Life-cycle performance of bridges and structures - Micro Electro-Mechanical Systems and micromechanics - Microseismic monitoring of unstable rock slopes - Smart materials and structures - Structural analysis of built heritage - Theoretical modelling and mechanical characterisation of biomaterials - Topology optimization for structural design.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: ADVANCED COMPUTATIONAL METHODS FOR COUPLED  
PROBLEMS IN POROUS MEDIA**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<p><b>Motivation and objectives of the research in this field</b></p>	<p>Coupling is an inherent feature of the engineering behaviour of porous materials, and it requires multi-phase and multi-scale approach for its analysis. The interplaying role of different physical fields, e.g. electrical, chemical, thermal, hydraulic, mechanical, highly non-linear effects, moving interfaces, and large scale heterogeneities, definitely require numerical methods for their analysis. In the past the bottleneck was given by the hardware limitations, while nowadays the most relevant difficulties are related on the one side to the determination of coupled mechanical properties and, on the other side, to the setup of robust numerical procedures able to cope with multithread and parallel treatment.</p> <p>Specifically, this proposal focuses on the development of innovative numerical tools to analyse problems related to the durability of porous materials, undergoing slow cyclic and fast dynamic or thermal excitation, chemical aggression and material degradation.</p> <p>The final aim of the investigation is life-cycle assessment of engineering and biological structures made of, or interacting with, porous materials. The proposal is inserted into a wider numerical and experimental activity, supported by different Italian and foreigner private companies and public agencies.</p>
<p><b>Methods and techniques that will be</b></p>	<p>Numerical modelling requires moving on with new</p>



<b>developed and used to carry out the research</b>	techniques, stemming from standard finite element approaches, based on approximation methods more flexible in view of parallel implementation. A balanced combination of field and laboratory tests will also support accurate material characterisation.
<b>Educational objectives</b>	The proposed work can contribute to shape an all-round scientific personality. Three main abilities will be developed: theoretical modelling, numerical developments and experimental testing.
<b>Job opportunities</b>	The proposed research project will allow the Ph.D. student to come in contact with a broad family of geotechnical/structural/biomechanical problems and to get an in-depth knowledge of different theoretical subjects. Working in this project will be stimulating and will favour high-level career profile in advanced fields of engineering.
<b>Composition of the research group</b>	2 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students
<b>Name of the research directors</b>	G. Della Vecchia, C. Jommi, A. Pandolfi, D. Sterpi

<b>Contacts</b>	
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Anna Pandolfi: anna.pandolfi@polimi.it - tel. +39 02 2399 4217	
Donatella Sterpi: donatella.sterpi@polimi.it - tel. +39 02 2399 4311	
www.dica.polimi.it	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6



**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of Universities, Companies, Agencies and National or International Institutions that are cooperating in the research**

TU, Delft, Netherlands  
UPC, Barcelona, Spain  
Caltech, Pasadena, USA  
EPFL, Lausanne, CH  
University of Siegen, Siegen, Germany  
MIUR, Roma, Italy  
E.N.I., San Donato, Italy  
Technital S.p.A., Milano, Italy

**Educational activities**

The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.

**Teaching assistanship**

Ph.D. students are encouraged to apply upon prior authorization to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, and they are paid for that. The teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.

**Computer availability**

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**Desk availability**

Each Ph.D. student has his/her own desk, cabinet and locker.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: CEMENTITIOUS MATERIALS AND CONCRETE  
STRUCTURES UNDER EXTREME AND EXCEPTIONAL LOADING**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1300.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

<p><b>Motivation and objectives of the research in this field</b></p>	<p>Concrete, reinforced/prestressed concrete and advanced cementitious composites are so extensively used today that many are the structures exposed to either extreme environmental conditions (high corrosion, high/low temperature) or exceptional loads (fire, explosions, vehicle impact, bombing, natural disasters). Hence, improving structural durability, also through the use of tailored <math>\zeta</math>engineered self-healing techniques<math>\zeta</math> and preventing progressive structural failures, is becoming one of the imperatives for structural engineering and code-writing bodies. The quantitative assessment of damage in any structure exposed to extreme and exceptional loads is a basic step for risk-mitigation design. To this purpose, non-standard experimental techniques, accurate material models and advanced computational approaches should be developed.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>Both experimental techniques and numerical methods are needed to solve the still-open problems in severely-corroded or fire/blast-damaged structures. For instance, assessing the decay of bar-concrete bond under chloride attack, or quantifying the healing capacity of cementitious composites, requires special techniques and equipments to simulate different exposure conditions, accelerate their effects, e.g. in terms of corrosion rate, recovery of performance, and to quantify the related effects. Testing</p>



	<p>concrete at high temperature needs split-tube furnaces to be designed and constructed. Investigating materials and structural behaviors under blast requires special devices like shock tubes or scaled experimental models. Evaluating fracture energy and size effect in concrete structures requires special specimens. Assessing concrete damage via non-destructive test methods based on concrete colorimetry, ultrasounds and x-rays, as well as linking concrete fresh-state properties to those after hardening are bringing in advanced techniques. At the same time, adequate theoretical and numerical models at the meso-structural and structural level are being developed, to be implemented into available FE codes.</p>
<p><b>Educational objectives</b></p>	<p>Designing concrete structures for durability, fire proofing and blast resistance requires a multi-disciplinary approach, since many and different topics are involved (materials, structures, human and structural safety, heat transfer, diffusion of chemical products, chemistry of combustion, chemistry of concrete, fluid-structure interaction). Consequently, the candidate will not only have the opportunity to contribute to the broadening of the knowledge in one or more directions, but will have also an insight into a variety of problems, with high technical and socio-economic impact.</p>
<p><b>Job opportunities</b></p>	<p>In-depth research activities concerning the mechanical environment-induced decay of structural materials and constructions is a sound basis for understanding and mastering not only corrosion, fire, and blast-related events, but any incident that can regard other scenarios related to the safety of large and socially-relevant structures.</p> <p>Job opportunities are basically the same as for structural engineers (universities, public and private research centers, large engineering firms, consulting and insurance companies), but with a plus granted by a large-spectrum formation.</p>
<p><b>Composition of the research group</b></p>	<p>3 Full Professors          3 Associated Professors          4 Assistant Professors          2 PhD Students</p>



<b>Name of the research directors</b>	Marco di Prisco
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<b>Contacts</b>	
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www.dica.polimi.it	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of the Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research**

SUPSI, Canobbio-Lugano, Switzerland - <http://www.supsi.ch/>  
 Ben Gurion University of the Negev, Israel - <http://www.cs.bgu.ac.il/>  
 University of Stuttgart, Germany - <http://www.uni-stuttgart.de>  
 Arizona State University, USA - <http://www.asu.edu/>  
 ETH, Zurich, Switzerland  
 EPFL, Lausanne, Switzerland  
 Northwestern University, Evanston, Illinois, USA  
 INSA - Mech. et Durabilité des Constr., Toulouse, France  
 CTG - Italcementi, Bergamo, Italy  
 CSTB - Centre Scientifique et Technique du Bâtiment, Marne-La-Vallée, France  
 RELUIS - <http://www.reluis.it>  
 Universidade Federal do Rio de Janeiro, Brasil  
 University of Leuven, Belgium  
 University of British Columbia, Vancouver, Canada  
 Universitat Politècnica de Catalunya, Barcelona, Spain  
 DTU, Delft, The Netherlands

**Educational activities**

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**Teaching assistanship**

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**Computer availability**

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**Desk availability**

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# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: COMPUTATIONAL AND EXPERIMENTAL MECHANICS**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1300.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

### Motivation and objectives of the research in this field

The proposed subject represents an advanced topic for multi-disciplinary research activities, involving expertise in engineering, physics, and medicine. A two-year project (5 *per mille Politecnico*, Euro 80,000) a grant for equipment (*Fondazione Banca del Monte*) already concluded, and a new ongoing project by Fondazione Cariplo and Regione Lombardia (Euro 100,000) have all been awarded to Dr. R. Fedele and are now concluded. An ERC Consolidator Proposal by the same PI was selected for the interview and received "B" as final score. In addition, the CARIPOLO project coordinated by Prof. Mariani has been granted for two years, and it includes X-ray micro CT investigations on polymeric foam samples.

The main innovative content is represented by characterization and modelling of heterogeneous materials and constructs at different scales (polymeric foams, advanced ceramics, restored human teeth) on the basis of the information provided through X-rays micro CT and inverse analyses.

### Methods and techniques that will be developed and used to carry out the research

The subject will combine non-conventional experiments, mathematical modeling in a framework artlessy multi-scale and inverse analyses in a sequence (3D Digital Image Correlation, parameter identification).

In particular, X-ray computed microtomography allows to reconstruct the inner (bulk) microstructure of heterogeneous samples, possibly evolving under complex



	loading. Moreover, conventional experimental techniques at the macroscale, so far applied in engineering and to be possibly improved, will be considered for a cross validation. Possible experiments with a testing machine placed in the department laboratory at the small scale will also be considered to get insight into the material properties.
<b>Educational objectives</b>	The main objective from an educational standpoint is represented by a full-immersion training into the world of experiments, computer simulations and multidisciplinary applications, rooted into the knowledge of computational mechanics, advanced technologies and matter physics. A doctoral course on this subject was activated last year.
<b>Job opportunities</b>	From the standpoint of an academic career, working on this multidisciplinary topic will allow Ph.D. students to achieve a wide preparation, both experimental and numerical, oriented to a variety of engineering and biomedical applications, which is expected to be greatly appreciated by many research groups in Europe and in the USA. For example, a post-doc co-worker has just found an interesting research position abroad. Also private enterprises will appreciate this expertise, as across several disciplines and suitable for R&D activities.
<b>Composition of the research group</b>	0 Full Professors 2 Associated Professors 1 Assistant Professors 0 PhD Students
<b>Name of the research directors</b>	Roberto Fedele, Stefano Mariani, Aldo Ghisi

<b>Contacts</b>	
<p>Roberto Fedele: roberto.fedele@polimi.it - tel. +39 02 2399 4275                      Stefano Mariani: stefano.mariani@polimi.it - tel. +39 02 2399 4279                      Aldo Ghisi: aldo.ghisi@polimi.it - tel. +39 02 2399 2399</p> <p>www.dica.polimi.it</p> <p>The research will involve other groups from the Dept. of Mechanical Engineering, Aerospace Engineering, Chemical Engineering, working in the MicroCT lab facility AMALA of Politecnico di Milano.</p>	



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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	650.0 €
By number of months	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of the Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research**

EMPA, Zurich

McGill University, Montreal

Università degli Studi di Milano - Faculty of Medicine and Surgery, Milan

**Educational activities**

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**Teaching assistantship**

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# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: COMPUTATIONAL MECHANICS OF MATERIALS AND STRUCTURES**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1300.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

<p><b>Motivation and objectives of the research in this field</b></p>	<p>New modeling capabilities at both material and structural levels, and innovative computational procedures are favoring considerable advances in various fields of structural engineering, with important fallouts in industrial applications.</p> <p>Further research efforts are needed to develop more accurate and efficient procedures in the following contexts among others: (a) metamaterials design; (b) multi-physics problems; (c) nonlinear analyses of structures and industrial components; (d) inverse analyses aimed at calibrating material models; (e) safety assessment of existing ageing structures.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>Advances in computational methodologies (by means of FEM, X-FEM, particle-FEM, and BEM) applied to various challenging and present-day engineering problems, also in multi-scale contexts; inverse analysis based on physical measurements for damage identification and for material characterization (at various scales).</p>
<p><b>Educational objectives</b></p>	<p>The Ph.D. student engaged in this rather interdisciplinary project is expected to acquire the ability to tackle complex problems and to develop effective problem-tailored solution procedures.</p>



<b>Job opportunities</b>	There is a growing need for post-docs with specific expertise in computational mechanics and in integrity-assessment methodologies applicable both to civil engineering structures/infrastructures and to industrial components.
<b>Composition of the research group</b>	3 Full Professors 2 Associated Professors 2 Assistant Professors 3 PhD Students
<b>Name of the research directors</b>	C. Comi, G. Novati, U. Perego

<b>Contacts</b>	
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Umberto Perego: umberto.perego@polimi.it - tel. +39 02 2399 4214	
www.dica.polimi.it	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research**

LMT-Cachan, Laboratoire de Mécanique et Technologie, Cachan, France  
 École Polytechnique, Paris, France  
 École Centrale de Nantes, France  
 Poznan University, Poland  
 University of Newcastle, UK  
 E.N.I. - Ente Nazionale Idrocarburi, Italy  
 Dalmine S.p.A., Italy  
 Tetra Pak Packaging Solution, Modena, Italy  
 Rtm Breda, Cormano (Milan), Italy



A2A, Milan, Italy

R.S.E. - Ricerca Sistema Elettrico, Italy

CNRS, France

**Educational activities**

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**Teaching assistanship**

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# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: D-ZONES AND ANCHORAGES UNDER SEVERE  
CONDITIONS**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1300.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

**Motivation and objectives of the research  
in this field**

Several aspects of reinforced-concrete structures are still open to investigation. Among them the strengthening of existing members and the coupling of different members are considered in this research project. Structural strengthening via external bonding of fiber-reinforced polymer (FRP) composites has become a popular technique all over the world. The performance of the interface between FRP and concrete is one of the key factors affecting the behavior of the strengthened structure.

Many experimental and theoretical results are available nowadays on the behavior of bonded interfaces, but there is still a number of open questions regarding (a) how the bonded length and the FRC plate stiffness affect the behavior of the interface and (b) to what an extent the local phenomena at the ends of the interface affects the structural response. Nonetheless, very few data exists regarding the variation of bond properties after exposure to fire. The coupling of different R/C members and the steel to concrete connection are often performed by means of post- installed rebar or anchors, respectively. In both cases they aim to transfer externally-applied loads to the concrete member. Anchors fail in different ways, but anchor's pull-out from the concrete is the best known, as it represents the biggest concern for structural-engineering applications.



	<p>In the mid 1980s, unconservative and incorrect formulas for the prediction of the pull-out capacity were proposed, on the basis of the theory of plasticity. Later, progressive crack propagation along a single fractured surface was recognized as the driving force behind headed-anchor's pull-out, and linear-elastic fracture mechanics (LEFM) allowed to work out the so-called CCD method (Concrete Capacity Design formula, by Fuchs et al., 1995). However, several aspects are not considered yet, like the behavior of anchors and post-installed rebar under seismic action or the modifications of strut-and-tie mechanism in D-regions or R/C elements induced by an anchor.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>Both the FRP layers bonded to the concrete and the anchors embedded in the concrete need suitable numerical models to be developed, in order to investigate the shear-stress distribution at the interface in the former case and the load-displacement response in the latter case, under both static and dynamic loads. In the former case, appropriate bi-linear bond laws will be implemented.</p> <p>From an experimental point of view, post-installed anchors and rebars will be tested under seismic-type loads, with two components (a shear component and an axial component) or in real scale beam-to-column and column-to-foundation nodes. Anchors behavior will be also modeled by means of 3-D FE codes.</p>
<p><b>Educational objectives</b></p>	<p>Concrete and Reinforced-Concrete mechanics are rather multi-disciplinary, since many and different topics are involved (materials, structures, technological aspects, structural design, testing, modeling, etc.). Consequently, the candidate will not only have the opportunity to contribute to the broadening of the knowledge in one or more directions, but he/she will also have an insight into a variety of problems with high technical and socio-economic impact.</p>
<p><b>Job opportunities</b></p>	<p>An in-depth research activity in the field of concrete and R/C mechanics is a sound basis for understanding and mastering not only concrete-related phenomena, but also</p>



	<p>the structural behavior in a broader sense.                  Job opportunities are basically the same as for any structural engineer, but with a plus granted by a large-spectrum training.                  In addition, the specific knowledge in the field of post-installed connection can guarantee a career in the R&amp;D department of anchor manufacturing companies.</p>
<b>Composition of the research group</b>	1 Full Professors 1 Associated Professors 3 Assistant Professors 0 PhD Students
<b>Name of the research directors</b>	Gianpaolo Rosati, Giovanni Muciaccia

<b>Contacts</b>	
Gianpaolo Rosati: gianpaolo.rosati@polimi.it - tel. +39 02 2399 4377 Giovanni Muciaccia: giovanni.muciaccia@polimi.it - tel. +39 02 2399 4365  www.dica.polimi.it	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<p><b>List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research</b></p> University of British Columbia, Vancouver, Canada University of Stuttgart, Stuttgart, Germany Nottingham Trent University, Nottingham, UK UPC, Barcelona, Spain CSTB, Paris, France MAPEI, Italy CTG-Italcementi, Bergamo, Italy ECAP - European Consortium of Anchor Producers



**Educational activities**

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**Teaching assistanship**

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**Computer availability**

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# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<p><b>Motivation and objectives of the research in this field</b></p>	<p><u>Topics</u>                      Modeling of r.c. and steel structures under seismic actions                      Safety assessment of isolated industrial buildings                      Dynamics of systems with geometrical and mechanical nonlinearities                      Dynamics and control of bridges under wind and earthquake forces                      Dynamic response of tall buildings under wind excitation                      Dynamic response of offshore structures (e.g. Submerged Floating Tunnels, Offshore Wind Turbines)                      Experimental and numerical techniques in dynamic analysis                      Dynamic fluid-structure interaction                      Vehicle-structure interaction                      Human-structure interaction on flexible footbridges</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>a) Numerical procedures for the non-linear dynamic analysis of structural systems under dynamic environmental excitation;                      b) Analytical/numerical methods for the estimation of the response of uncertain structural systems under random dynamic excitation;                      c) Experimental vibration serviceability survey of civil structures;                      d) Development of a mechanical model of a walking pedestrian and identification of the model parameters.</p>



<b>Educational objectives</b>	The Ph.D. student will carry out a multidisciplinary research that will expose him/her to advanced experimental, analytical and numerical techniques that are beyond traditional structural engineering. The student will improve both written and oral presentation skills.
<b>Job opportunities</b>	Job opportunities in the following fields: - further academic positions in universities worldwide - research centers and institutes - construction industry as structural designers and consultants
<b>Composition of the research group</b>	1 Full Professors 5 Associated Professors 0 Assistant Professors 0 PhD Students
<b>Name of the research directors</b>	Ardito, Martinelli, Mulas, Perotti, Petrini, Racic

<b>Contacts</b>	
Raffaele Ardito: raffaele.ardito@polimi.it - tel. +39 02 2399 4272	
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Maria Gabriella Mulas: mariagabriella.mulas@polimi.it - tel. +39 02 2399 4231	
Federico Perotti: federico.perotti@polimi.it - tel. +39 02 2399 4229	
Lorenza Petrini: lorenza.petrini@polimi.it - tel. +39 02 2399 4307	
Vitomir Racic: vitomir.racic@polimi.it - tel. +39 02 2399 4233	
www.dica.polimi.it	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<b>List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research</b>



ANIMP, Milano, Italy  
Statens Vegvesen, Norway  
Tokyo Institute of Technology, Japan  
Universitat Politecnica de Catalunya, Spain  
Politecnico di Torino, Italy  
University of Warwick, UK  
University of Exeter, UK  
The Hong Kong University of Science and Technology, China  
Tongji University, Shanghai, China

**Educational activities**

The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.

**Teaching assistanship**

Ph.D. students are encouraged to apply upon prior authorization to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, and they are paid for that. The teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.

**Computer availability**

Each Ph.D. student has his/her own computer for individual use.

**Desk availability**

Each Ph.D. student has his/her own desk, cabinet and locker.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: EXPERIMENTAL ASSESSMENT AND COMPUTATIONAL MODELING OF LONG-TERM AND DEGRADATION OF IMPROVED-DURABILITY CONCRETE AND REINFORCED CONCRETE STRUCTURES**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1300.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## **Context of the research activity**

**Motivation and objectives of the research in this field**

The research is part of the project ReSHEALience (Horizon 2020) which has the aim to develop an Ultra High Durability Concrete (UHDC) and a Durability Assessment-based Design (DAD) methodology for structures, to improve durability and predict their long-term performance under Extremely Aggressive Exposures (EAE), namely chloride-induced corrosion and chemical attack. The improvement will be supported upgrading Ultra-High Performance Fiber Reinforced Concrete with new functionalities for marine structures and infrastructures and for geothermal/biomass energy plants. This goal will be achieved through (1) a comprehensive experimental campaign addressing the optimization of the mix design and the characterization of the overall behaviour at both the small and large-scale and (2) the development of a theoretical model to evaluate ageing and degradation of UHDC structures in EAE extending the modelling to predict the lifespan. The main target is to develop a new durability-based design approach for the use of UHDC, aimed at assessing the structures durability and Life Cycle Analysis, to achieve an increase service life of 30%, and a long-term reduction of maintenance costs. The overall approach will be validated through long-term monitoring in six full-scale proofs of concept that UHDC in real conditions has the expected enhancement



	in durability.
<b>Methods and techniques that will be developed and used to carry out the research</b>	The PhD candidate will work on both the experimental and modelling parts of the project ReSHEALience, with the aim of validating the numerical model against the experimental results concerning the mechanical characterization and the durability-performance assessment, so to possibly formulate a simplified analytical approach to be integrated in Standards. The general framework is represented by aging and degradation assessment in UHDC and prediction of its service-life under EAE conditions. The experimental part is mainly focused on direct and indirect tensile tests in ordinary and aggressive environment, with following monitoring of durability evolution. On the other hand, the numerical model is based on a multi-physics approach which links the effects of chemical reactions, transport of ions, diffusion of moisture and heat, in cracked and un-cracked concrete conditions, with corrosion and damage initiation and propagation. The developed numerical tool will be employed also to simulate the behaviour of real structures in service conditions.
<b>Educational objectives</b>	The doctor of philosophy at the end of his studies will have the necessary intellectual tools and technical skills to take on careers of leadership in the development of new technologies, construction of innovative and sustainable infrastructure, the design of engineered systems, and to contribute to society through participation in policy making and governance.
<b>Job opportunities</b>	A graduate from this PhD degree track can easily go on to top jobs as engineer, faculty member at top universities, engineer consultant, leader for non-governmental organizations, and even start his own company.
<b>Composition of the research group</b>	0 Full Professors 3 Associated Professors 2 Assistant Professors 1 PhD Students
<b>Name of the research directors</b>	Liberato Ferrara



Contacts	
liberato.ferrara@polimi.it	

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	650.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.</p> <p>Teaching assistanship (availability of funding in recognition of support to teaching activities by the PhD student): Ph.D. students are encouraged to apply, upon prior authorization, to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, being paid for that. The teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.</p> <p>Computer availability and desk availability: Each Ph.D. student has his/her own computer for individual use. Each Ph.D. student has his/her own desk, cabinet and locker.</p>



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: FIRE SAFETY OF CONCRETE STRUCTURE**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>In the last years, fire safety has become a major concern for a variety of civil structures. Within this framework, concrete structures stand out for a number of peculiarities, ranging from the very complex thermo-mechanical phenomena taking place in the material upon heating, to the highly non-linear structural behaviour in fire conditions. As a matter of fact, the severe conditions that characterize real fires caused a number of unexpected failures of concrete structures, and thus fostered the need for further research.</p> <p>The main research topics in this field are the following:</p> <ul style="list-style-type: none"> <li>a) investigation on actual fires, in order to highlight the advantages and shortcomings of the current approaches available for modelling fire scenarios;</li> <li>b) advanced experimental techniques to accurately characterize the thermo-hydro-mechanical behaviour of concrete upon heating and subsequent cooling;</li> <li>c) experimental investigations on small structural specimens exposed to heating, in order to set-up innovative testing techniques that are less demanding than full-scale tests;</li> <li>d) numerical simulations on the behaviour of concrete structures subjected to heating and subsequent cooling.</li> </ul>
<b>Methods and techniques that will be developed and used to carry out the research</b>	<ul style="list-style-type: none"> <li>a) Numerical codes for the simulation of the fire scenario;</li> <li>b) Experimental techniques to characterize material</li> </ul>



	properties, and to investigate the structural behaviour of small structural specimens; c) 2D and 3D numerical codes for the simulation of the structural behaviour in fire conditions.
<b>Educational objectives</b>	The Ph.D. student is expected to develop multi-disciplinary skills, that will allow him/her to communicate with researchers from different related fields.
<b>Job opportunities</b>	The most direct career opportunities offered by this research field are within large engineering firms and consulting companies, where specific task groups are devoted to fire engineering; however, employment in research institutions (universities, public or private research centres) is also possible.
<b>Composition of the research group</b>	0 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students
<b>Name of the research directors</b>	Roberto Felicetti, Patrick Bamonte

<b>Contacts</b>	
Roberto Felicetti: roberto.felicetti@polimi.it - tel. +39 02 2399 4388 Patrick Bamonte: patrick.bamonte@polimi.it - tel. +39 02 2399 4288	
www.dica.polimi.it	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<b>List of Universities, Companies, Agencies and National or International Institutions that are cooperating in the research</b> CSTB - Centre Scientifique et Technique du Batiment, Marne-La-Vallée, France



BRE - Centre for Fire Safety Engineering - University of Edinburgh, United Kingdom  
CTG-Italcementi, Bergamo, Italy  
Civil and Environmental Engineering, Michigan State University, USA  
EMPA, Zurich, Switzerland

**Educational activities**

The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.

**Teaching assistanship**

Ph.D. students are encouraged to apply upon prior authorization to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, and they are paid for that. The teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.

**Computer availability**

Each Ph.D. student has his/her own computer for individual use.

**Desk availability**

Each Ph.D. student has his/her own desk, cabinet and locker.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**THEMATIC Research Field: INNOVATIVE NUMERICAL SIMULATION OF MEMS**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1400.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

**Motivation and objectives of the research in this field**

Micro- and Nano- Electro Mechanical Systems (MEMS, NEMS) studying, designing, testing and numerical modelling is quite demanding, since MEMS and NEMS are highly sophisticated devices, where electronics is coupled with mechanical parts, to create micro- and nano-sensors, micro- and nano-actuators, as well as micro-fluidic devices. MEMS are commonly used in automotive, aerospace and consumer-oriented engineering and are the key ingredient for the Internet of Things and Industry 4.0. Other fields are now taking advantage of these devices, like structural engineering, where MEMS start being used for monitoring and self-actuation and biomedical engineering. Strictly related to the field of MEMS are issues linked to micromechanics of materials and structures.  
[www.mems.polimi.it](http://www.mems.polimi.it)

**Methods and techniques that will be developed and used to carry out the research**

MEMS-oriented research needs a highly multi-disciplinary approach and a deep knowledge of the fundamentals of physics, mechanics and electronics, as well as a certain familiarity with today's sophisticated techniques for numerical modelling and simulations.

**Educational objectives**

Since the proposed research project is highly multi-disciplinary, the candidate will have the opportunity to collaborate with a number of laboratories and research groups either in the Department of Civil and



	groups either in the Department of Civil and Environmental Engineering or in other Departments of the Politecnico di Milano, in industries and in international research centers. He/she will acquire specialized knowledge on MEMS and their related research fields, like micromechanics and microfabrication.
<b>Job opportunities</b>	Direct employment in MEMS- and NEMS-research centers and industries in Europe and all-over the world. Job opportunities in other fields, where experts in multi-physics problems, micro-mechanics, testing and computational methods, advanced structural monitoring are requested.
<b>Composition of the research group</b>	3 Full Professors 3 Associated Professors 2 Assistant Professors 4 PhD Students
<b>Name of the research directors</b>	Frangi Attilio

<b>Contacts</b>	
attilio.frangi@polimi.it – tel. +390223994213 www.dica.polimi.it www.mems.polimi.it	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	700.0 €
<b>By number of months</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>	
<p><b>Educational activities</b> (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.</p> <p><b>Teaching assistanship</b> (availability of funding in recognition of support to teaching activities by</p>	



the PhD student): Ph.D. students are encouraged to apply, upon prior authorization, to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, being paid for that. The teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.

**Computer availability and desk availability:** Each Ph.D. student has his/her own computer for individual use. Each Ph.D. student has his/her own desk, cabinet and locker.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: LIFE-CYCLE PERFORMANCE OF BRIDGES AND STRUCTURES**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>The aim of this research project is extending/optimizing the lifetime of bridges and structures experiencing damage due to material degradation (caused e.g. by corrosion), extreme events (e.g. earthquakes) or heavy sustained and repeated loads (e.g. high stress and fatigue).</p> <p>The following topics may be selected by the candidate:</p> <ul style="list-style-type: none"> <li>a) residual lifetime of concrete structures under corrosion;</li> <li>b) methodologies and procedures for life-cycle analysis, design, and optimization of bridges and civil structures, including maintenance planning and decommissioning;</li> <li>c) assessment of lifetime seismic performance of structures and infrastructure systems;</li> <li>d) behavior and modeling of damaged cables;</li> <li>e) assessment of residual load bearing capacity of bridges suspended by damaged cables.</li> </ul>
<b>Methods and techniques that will be developed and used to carry out the research</b>	<p>Topics (a, b, c) will include criteria and methods for the modeling of damage effects in corroded structures and numerical implementation, using both in-house specialized programs and commercial finite element codes. These topics will focus on performance-based techniques for lifetime assessment and optimization of bridges and structures.</p> <p>The attainment of the objectives (d, e) will require both</p>



	theoretical modeling of corroded wires/ropes/cables and numerical non-linear analysis of systems suspended by corroded cables.
<b>Educational objectives</b>	The proposed research activities are multi-disciplinary and involves several research fields, such as mechanics of materials and structures, material degradation processes, structural safety and reliability, risk analysis, structural robustness and seismic resilience, among others. A solid knowledge and expertise in the fields of nonlinear mechanics of materials, structural analysis methods, applied chemistry, statistics and probability are requested.
<b>Job opportunities</b>	Job opportunities are available in companies involved in the design and retrofitting of bridges and buildings and in public authorities involved in life-cycle assessment and optimization of structures and infrastructure networks.
<b>Composition of the research group</b>	2 Full Professors 1 Associated Professors 2 Assistant Professors 4 PhD Students
<b>Name of the research directors</b>	Fabio Biondini, Pier Giorgio Malerba

<b>Contacts</b>	
Fabio Biondini: fabio.biondini@polimi.it - tel. +39 02 2399 4394	
Pier Giorgio Malerba: piergiorgio.malerba@polimi.it - tel. +39 02 2399 4397	
<a href="http://www.dica.polimi.it">http://www.dica.polimi.it</a>	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of Universities, Companies, Agencies and/or National or International Institutions that**



**are cooperating in the research**

Lehigh University, Bethlehem, USA

Technical University of Catalunya, Barcelona, Spain

Waseda University, Tokyo, Japan

University of Canterbury, Christchurch, New Zealand

Czech Technical University, Prague, Czech Republic

**Educational activities**

The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.

**Teaching assistanship**

Ph.D. students are encouraged to apply upon prior authorization to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, and they are paid for that.

Teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.

**Computer availability**

Each Ph.D. student has his/her own computer for individual use.

**Desk availability**

Each Ph.D. student has his/her own desk, cabinet and locker.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: MICRO ELECTRO-MECHANICAL SYSTEMS AND  
MICROMECHANICS**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1300.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

<p><b>Motivation and objectives of the research in this field</b></p>	<p>Micro- and Nano- Electro Mechanical Systems (MEMS, NEMS) studying, designing, testing and numerical modelling is quite demanding, since MEMS and NEMS are highly sophisticated devices, where electronics is coupled with mechanical parts, in order to create micro- and nano-sensors, micro- and nano-actuators, as well as micro-fluidic devices. MEMS are commonly used in automotive, aerospace and consumer-oriented engineering. Other fields are now taking advantage of these devices, like structural engineering, where MEMS start being used for monitoring and self-actuation and biomedical engineering. Strictly related to the field of MEMS are issues linked to micromechanics of materials and structures.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>MEMS-oriented research needs a highly multi-disciplinary approach and a deep knowledge of the fundamentals of physics, mechanics and electronics, as well as a certain familiarity with today's sophisticated techniques for numerical modelling and simulations.</p>
<p><b>Educational objectives</b></p>	<p>Since the proposed research project is highly multi-disciplinary, the candidate will have the opportunity to collaborate with a number of laboratories and research groups either in the Department of Civil and</p>



	Environmental Engineering or in other Departments of the Politecnico di Milano, in industries and in international research centers. He/she will acquire specialized knowledge on MEMS and their related research fields, like micromechanics and microfabrication.
<b>Job opportunities</b>	Direct employment in MEMS- and NEMS-research centers and industries in Europe and all-over the world. Job opportunities in other fields, where experts in multi-physics problems, micro-mechanics, testing and computational methods, advanced structural monitoring are requested.
<b>Composition of the research group</b>	3 Full Professors 2 Associated Professors 1 Assistant Professors 4 PhD Students
<b>Name of the research directors</b>	Alberto Corigliano, Attilio Frangi

<b>Contacts</b>	
Alberto Corigliano: alberto.corigliano@polimi.it - tel. +39 02 2399 4244 Attilio Frangi: attilio.frangi@polimi.it - tel. +39 02 2399 4213	
www.dica.polimi.it www.mems.polimi.it www.mems3d.polimi.it www.lab4mems.upb.ro www.lab4mems2.ite.waw.pl	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<b>List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research</b>



STMicroelectronics - [www.st.com](http://www.st.com)

Eniac funded project Lab4MEMS - <http://www.lab4mems.upb.ro/>

Eniac funded project Lab4MEMS II - <http://www.lab4mems2.ite.waw.pl/>

IMEC - [www.imec.be](http://www.imec.be)

Massachusetts Institute of Technology - [web.mit.edu/](http://web.mit.edu/)

BSAC - Berkeley Sensor & Actuator Center - <http://www-bsac.eecs.berkeley.edu/>

### **Educational activities**

The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.

### **Teaching assistanship**

Ph.D. students are encouraged to apply upon prior authorization to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, and they are paid for that. The teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.

### **Computer availability**

Each Ph.D. student has his/her own computer for individual use.

### **Desk availability**

Each Ph.D. student has his/her own desk, cabinet and locker.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**THEMATIC Research Field: SIMULATION OF MULTI-PHYSICS MECHANICAL SYSTEMS  
FROM THE MICROSCALE TO THE MACROSCALE BY DEEP LEARNING & REDUCED  
ORDER MODELS**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1300.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## **Context of the research activity**

**Motivation and objectives of the research  
in this field**

HAVING REGARD to the D.D. 104 of 02/02/2022 (call PRIN 2022), within the framework of the National Recovery and Resilience Plan, Mission 4 Education and research – Component 2 From research to business – Investment 1.1, funded by the European Union – NextGenerationEU.

Partial financing through project funds PRIN 2022 will take place in the first months of activation of the doctoral scholarship, until the expected PRIN 2022 amount is disbursed.

PRIN 2022 Project: Digital twins of nonlinear Microstructures with iNnovative model-order-reduction strategies (DIMIN) Project code: 2022XATLT2 - CUP: D53D23004270006.

Relying on reduced order models (ROMs) is nowadays essential to perform repeated numerical simulations required, e.g., in optimal design or uncertainty quantification problems, as well as real-time simulations in multiple virtual scenarios.



	<p><b>Applications</b></p> <p><b>Design of Micro-Electro-Mechanical Systems</b> High-fidelity models of Micro-Electro-Mechanical Systems (MEMS) are extremely expensive. Because of several uncertainties hampering such systems, relying on reduced order modeling also including the effect of uncertainty is therefore essential.</p> <p><b>Bio-Inspired Flying and Swimming Devices</b> A second, relevant context in which the developed DL-ROMs will be employed is the efficient simulation of complex multi-physics problems related to archetypal types of flyers and swimmers found in nature, ranging from the microscale (bacteria) to the macroscale level (birds and fishes), together with deep reinforcement learning for use in robotic applications.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>Current strategies to build ROMs require a huge amount of data from high-fidelity, full-order solvers to train (offline) the ROMs and enable their deployment during the testing (online) stage.</p> <p>However, data from sensors as well as high-dimensional noisy images acquired over time are very often available, thus providing an alternative, cheaper source of data to train a ROM for a low-dimensional representation of the current asset.</p> <p>DL-ROMs will be first designed to perform the learning task using also experimentally acquired data, rather than only from numerically generated data, and then combined with strategies for fusion of multi-fidelity data.</p>
<p><b>Educational objectives</b></p>	<p>Since the proposed research project is highly multi-disciplinary, the candidate will have the opportunity to collaborate with a number of laboratories and research groups either in the Department of Civil and Environmental Engineering or in other Departments of the Politecnico di Milano, in industries and in international research centers. He/she will acquire specialized knowledge on fluid structure interaction and on coupled numerical techniques.</p>
<p><b>Job opportunities</b></p>	<p>Direct employment in MEMS industries or research centers.</p>



<b>Composition of the research group</b>	1 Full Professors 0 Associated Professors 1 Assistant Professors 1 PhD Students
<b>Name of the research directors</b>	Attilio FRANGI

<b>Contacts</b>	
attilio.frangi@polimi.it <a href="http://frangi.faculty.polimi.it/">http://frangi.faculty.polimi.it/</a>	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<p><u>Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:</u></p> <ul style="list-style-type: none"> <li>•Universitat Politecnica de Catalunya - CIMNE</li> <li>•Université Paris-Saclay - LMT</li> <li>•University Washington, Seattle</li> </ul> <p><u>Educational activities</u> (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.</p> <p><u>Teaching assistanship</u> (availability of funding in recognition of support to teaching activities by the PhD student): Ph.D. students are encouraged to apply, upon prior authorization, to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, being paid for that. The teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.</p>



Computer availability and desk availability: Each Ph.D. student has his/her own computer for individual use. Each Ph.D. student has his/her own desk, cabinet and locker.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: SMART MATERIALS AND STRUCTURES**

Monthly net income of PhDscholarship (max 36 months)
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
<b>Motivation and objectives of the research in this field</b>	Sensors and actuators can be conveniently embedded into composites to design smart structures, able to self-detect possible local failures or to react in real time to changing environmental conditions. Smart materials are instead optimized in their microstructure to tailor their stiffness, strength, toughness, and then better withstand the external loadings. Functionally graded and ionic polymer-metal composites will be adopted in the foreseen experimental activities.
<b>Methods and techniques that will be developed and used to carry out the research</b>	Computational mechanics: multi-physics approach to model the sensing and actuation processes and the coupled materials behaviour. Experimental mechanics: embedding sensors into composite plates to build self-sensing, smart structures.
<b>Educational objectives</b>	The research field is across materials and structural engineering. Hence, Ph.D. students are expected to develop a multidisciplinary approach to the problem.
<b>Job opportunities</b>	Due to the very research-oriented goal of the project, direct employment in research centers or agencies and in companies all-over the world.
<b>Composition of the research group</b>	1 Full Professors 1 Associated Professors 3 Assistant Professors 2 PhD Students



	2 PhD Students
<b>Name of the research directors</b>	Stefano Mariani

<b>Contacts</b>	
Stefano Mariani: stefano.mariani@polimi.it - tel. +39 02 2399 4279	
www.dica.polimi.it	
www.mems.polimi.it	
www.saferhelmets.eu	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of Universities, Companies, Agencies and National or International Institutions that are cooperating in the research**

Institute of New York University, Tandon School of Engineering, USA  
 EADS Innovation Works, Leiden  
 McGill University, Montreal  
 ISIS Sensorial Material Scientific Centre, University of Bremen, Bremen  
 Università La Sapienza, Rome

**Educational activities**

The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.

**Teaching assistanship**

Ph.D. students are encouraged to apply upon prior authorization to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, and they are paid for that. Teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.

**Computer availability**

Each Ph.D. student has his/her own computer for individual use.



**Desk availability**

Each Ph.D. student has his/her own desk, cabinet and locker.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: SOIL MECHANICS, GEOTECHNICAL STRUCTURES AND  
GEOTECHNICAL EARTHQUAKE ENGINEERING**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>This research field encompasses a wide variety of topics related to the response of soils, foundations and geotechnical structures, with special emphasis to:</p> <ul style="list-style-type: none"> <li>- advanced constitutive modelling of soil materials;</li> <li>- underground structures;</li> <li>- slope stability and landslide risk assessment;</li> <li>- investigation of the role of nonlinear dynamic soil-structure interaction on the seismic response of structures;</li> <li>- numerical approaches to study seismic wave propagation from the seismic source to the structure, with special regard to shallow soil layers;</li> <li>- seismic actions for design.</li> </ul>
<b>Methods and techniques that will be developed and used to carry out the research</b>	<ul style="list-style-type: none"> <li>- Macroelement constitutive approaches for shallow/deep foundations</li> <li>- Small scale experimental testing</li> <li>- 2D and 3D numerical codes for seismic wave propagation in the linear and nonlinear range</li> <li>- Analytical and numerical methods for nonlinear soil-structure interaction analyses</li> <li>- Advanced processing of strong motion records</li> </ul>
<b>Educational objectives</b>	<p>The Ph.D. student is expected to develop multi-disciplinary skills, that will allow him/her to communicate</p>



	with researchers and professionals from different related fields, such as civil engineers, geologists, seismologists.
<b>Job opportunities</b>	The most direct career opportunities offered by this research field are within research institutions (universities, public or private research centers), large engineering firms and consulting companies.
<b>Composition of the research group</b>	2 Full Professors 2 Associated Professors 1 Assistant Professors 4 PhD Students
<b>Name of the research directors</b>	C. di Prisco, R. Paolucci

<b>Contacts</b>	
Claudio di Prisco: <a href="mailto:claudio.diprisco@polimi.it">claudio.diprisco@polimi.it</a> - tel. +39 02 2399 4298	
Roberto Paolucci: <a href="mailto:roberto.paolucci@polimi.it">roberto.paolucci@polimi.it</a> - tel. +39 02 2399 4353	
<a href="http://www.dica.polimi.it">www.dica.polimi.it</a>	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<p><b>List of Universities, Companies, Agencies and National or International Institutions that are cooperating in the research</b></p> <p>Delft University of Technology, The Netherlands - <a href="http://www.tudelft.nl">www.tudelft.nl</a>            Eucentre, Pavia, Italy - <a href="http://www.eucentre.it">http://www.eucentre.it</a>            Istituto Nazionale di Geofisica e Vulcanologia, Italy - <a href="http://www.ingv.it">http://www.ingv.it</a>            RELUIS - <a href="http://www.reluis.it">http://www.reluis.it</a>            Aristotle University of Thessaloniky, Greece (prof. K. Pitilakis) - <a href="http://www.auth.gr">http://www.auth.gr</a></p> <p><b>Educational activities</b></p> <p>The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.</p>



**Teaching assistanship**

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**Computer availability**

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**Desk availability**

Each Ph.D. student has his/her own desk, cabinet and locker.



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: STRUCTURAL ANALYSIS OF BUILT HERITAGE**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>The research program deals with the engineering of conservation of existing structures with a focus on the structural analysis of architectural heritage. In detail, the study of built heritage is a multi-disciplinary approach, which considers surveying, monitoring, diagnostic investigation, structural analysis, experimental tests, non-linear computer modelling, repairing and strengthening techniques, etc.</p> <p>The research project will take into account the estimation of residual life and assessment of concrete, masonry and iron or steel existing structures affected by damage due to aging, degradation of the material (for example caused by aggressive environment) and hazard events (such as earthquakes and landslides), with the aim of developing a methodology in terms of safety, reliability and cost to evaluate and compare different scenarios of maintenance and/or rehabilitation and their applicability on civil or industrial existing constructions. The focus will be on buildings of cultural value, included constructions of the 50's, which are already suffering from different levels of damage.</p>
<b>Methods and techniques that will be developed and used to carry out the research</b>	<p>The following topics can be chosen by the candidate for her/his thesis:</p> <p>a) laboratory experimental research on material characteristics and constitutive laws;</p>



	<p>b) experimental research and calibration of different Non Destructive Techniques (NDT);</p> <p>c) modeling of the material deterioration;</p> <p>d) modeling of material and structural behavior during hazardous events;</p> <p>e) assessment of residual lifetime of deteriorated structures;</p> <p>f) assessment of vulnerability of existing buildings in seismic area (e.g. historical centers).</p>
<b>Educational objectives</b>	The candidate will increase her/his expertise in the fields of nonlinear mechanics of materials, structural analysis, applied chemistry, statistics and probability, NDT methods, etc.
<b>Job opportunities</b>	The programme will open up job opportunities both as researcher within research institutions (universities, research centers) and as field engineer or architect in private companies involved in design and rehabilitation.
<b>Composition of the research group</b>	<p>1 Full Professors</p> <p>3 Associated Professors</p> <p>1 Assistant Professors</p> <p>0 PhD Students</p>
<b>Name of the research directors</b>	Cardani, Coronelli, Garavaglia, Petrini, Zanzi

<b>Contacts</b>	
Giuliana Cardani: giuliana.cardani@polimi.it - tel. +39 02 2399 4204	
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Elsa Garavaglia: elsa.garavaglia@polimi.it - tel. +39 02 2399 4284	
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www.dica.polimi.it	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6



**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of Universities, Companies, Agencies and National or International Institutions that are cooperating in the research**

Waseda University, Tokyo, Japan  
Technical University of Catalonia, Barcelona, Spain  
The Pennsylvania State University, USA  
University of Minho, Portugal  
Université Catholique de Louvain, Belgium  
University of Padua, Italy  
RELUIS (<http://ww.reluis.it>), Italy

**Educational activities**

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**Teaching assistanship**

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**Desk availability**

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# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**THEMATIC Research Field: THE VIRTUAL ELEMENT METHOD FOR ENGINEERING  
APPLICATIONS TO IMPROVE DISASTER RISK FORECAST AND MANAGEMENT**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>HAVING REGARD to the D.D. 1409 of 14/09/2022 (call PRIN PNRR 2022), within the framework of the National Recovery and Resilience Plan, Mission 4 Education and research - Component 2 From research to business - Investment 1.1, funded by the European Union - NextGenerationEU.</p> <p>Partial financing through project funds PRIN PNRR 2022 will take place in the first months of activation of the doctoral scholarship, until the expected PRIN PNRR 2022 amount is disbursed.</p> <p>PRIN PNRR 2022 Project: Polyhedral Galerkin methods for engineering applications to improve disaster risk forecast and management: stabilization-free operator-preserving methods and optimal stabilization methods - Project code: P2022BH5CB - CUP: D53D23018840001.</p> <p>The proposal concerns the development of numerical methods suitable for simulations for safety assessments in several fields of civil and environmental engineering and it is framed within a PRIN-PNRR national research project, involving also research units from the Politecnico di Torino, the Bicocca University of Milan and from Pavia University.</p> <p>Civil structures are subject to aging and the evolution of</p>



	<p>the surrounding environment increases the possibility of dramatic events. This project aims to develop Virtual Element Methods (VEM) capable to overcome usual modelling difficulties such as, for example, mesh generation problems, mesh adaptation problems, mesh quality problems, and incompressibility conditions. Unlike the traditional FEM, which relies on polynomial basis functions defined over a fixed mesh of elements, the VEM offers a more flexible and adaptive framework based on non-polynomial functions. It allows for the incorporation of irregular, non-conforming and non-convex elements, making it exceptionally well-suited for modeling complex geometries and dealing with problems involving singularities or evolving discontinuities.</p> <p>Although its great success in managing many of the overmentioned problems, some issues still affect its applicability in fields like non-linear elasticity, elastoplasticity, viscoplasticity and in strongly non-linear engineering problems, One of the main issues is related to the non-consistent stabilization term needed by these methods to get well-posed discrete problems for the simulation.</p> <p>This project will focus on stabilization-free VEMs with the aim of retaining the key features of VEM but without the side-effect of the pollution introduced by the stabilizing terms. Stabilization-free VEMs will be derived and applied to elasticity, elastoplasticity and fluid-structure interaction problems.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>Starting from an approach proposed by the research group, an innovative self-stabilized Virtual Element Method will be proposed. The research work, will be divided into two phases:</p> <p>Phase 1. Formulation development, code prototyping and testing of self-stabilized Virtual Elements in 2D for elasticity and elastoplasticity problems in both small and large strains context.</p> <p>Phase 2. Formulation development, code prototyping and testing to extend the formulations in Phases to 3D Virtual Elements.</p> <p>In all the developments, particular attention will be</p>



	devoted to efficiency and to the integration within existing finite element codes. All the progress will be shared and discussed with the company involved in the project.
<b>Educational objectives</b>	<p>Given the groundbreaking nature of the proposed research project, the selected candidate will have the opportunity to collaborate with various laboratories and research groups both within Italy and internationally. Specifically, a research internship within one of the most active groups specializing in Virtual Elements will be arranged. Furthermore, the candidate will gain valuable insights into the industrial environment through a research stage within the company.</p> <p>This experience will equip the candidate with specialized knowledge in computational mechanics, with a particular focus on Virtual Element methods and their applications in solid mechanics. The candidate is expected to develop the proficiency needed to address complex problems and devise innovative and effective solution strategies.</p>
<b>Job opportunities</b>	In R&D departments of large companies and research centers, there is a growing need for individuals with specific expertise in computational mechanics and high-performance computing. In addition, engineering companies are increasingly seeking expertise in modelling complex, multiphysics engineering problems using new and unconventional approaches.
<b>Composition of the research group</b>	<p>3 Full Professors                  1 Associated Professors                  0 Assistant Professors                  1 PhD Students</p>
<b>Name of the research directors</b>	Massimiliano Cremonesi, Umberto Perego

<b>Contacts</b>	
umberto.perego@polimi.it +39 02 2399 4214	
massimiliano.cremonesi@polimi.it +39 02 2399 6230 <a href="http://cremonesi.faculty.polimi.it/">http://cremonesi.faculty.polimi.it/</a>	



Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	650.0 €
By number of months	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research**

**Universities:**

- Politecnico di Torino
- University of Milano -Bicocca
- University of Milano
- University of Pavia
- Leibniz University Hannover

**Company:**

- Dassault Systemes Simulia Corp

**Educational activities**

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**Teaching assistanship**

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**Desk availability**

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# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: THEORETICAL MODELLING AND MECHANICAL  
CHARACTERISATION OF BIOMATERIALS**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>Several surgical procedures devoted to the solution of health issues require a personalized treatment: it is for instance the case of small-scale interventions concerning sensorial organs (eye and ear), replacement of heart valves, or insertion of arterial stents. As experimental testing is impossible, the customization of surgical treatments can only be achieved through numerical modelling, that requires the knowledge of the individual geometry and the characterization of the individual physical properties through inverse analysis procedures. Whilst modern imaging systems (MRI, PET scan, CAT scan, SGH, OCT) have reached a high level of accuracy and can provide fully tridimensional geometry of the organ, the customization of the material model still needs to be developed and requires further deep and intense investigations. Strongly coupled to other physical processes in biology and medicine mechanics, hydro-chemo-electric coupling is often fundamental to explain the behaviour of the tissue.</p> <p>The creation of a numerical model for biotissues and organs requires the definition of a suitable material model, able to account for the underlying micro- and nano-structure, and the personalized characterization of its mechanical and physical properties, to be achieved by means of in-vivo non-destructive testing. At the same time, the optimization of mini-invasive treatments requires</p>



	<p>an accurate study of the interaction between device and tissue as well as a deep knowledge of the device material properties.</p> <p>The objective of this research project is to improve the knowledge on the relationships between the micro-structure of biomaterials and tissues and their physical behaviour, with the aim of providing a support to personalized surgery.</p>
<b>Methods and techniques that will be developed and used to carry out the research</b>	<p>Experimental as well as numerical methods will be used. Collaborations with the Department of Chemistry, Materials and Chemical Engineering "Giulio Natta" of Politecnico di Milano (Proff. Boschetti, Migliavacca and Rodriguez) have already been established to support the research with the necessary laboratory equipment.</p>
<b>Educational objectives</b>	<p>The proposed research field has a large potential for educational objectives thanks to the multidisciplinary nature of its topics. Furthermore, the educational opportunities offered by Politecnico di Milano in the fields of biomechanics and material engineering will widen the basic knowledge of the Ph.D. students.</p>
<b>Job opportunities</b>	<p>A large number of the most recent Ph.D.s with a research experience on the above-mentioned topics are now holding R&amp;D positions in a few companies well known in the field of bio-engineering and bio-materials.</p>
<b>Composition of the research group</b>	<p>0 Full Professors 3 Associated Professors 0 Assistant Professors 0 PhD Students</p>
<b>Name of the research directors</b>	<p>Gabriella Bolzon, Anna Pandolfi, Lorenza Petrini</p>

<b>Contacts</b>
<p>Gabriella Bolzon: <a href="mailto:gabriella.bolzon@polimi.it">gabriella.bolzon@polimi.it</a>, tel. +39 02 2399 4319                      Anna Pandolfi: <a href="mailto:anna.pandolfi@polimi.it">anna.pandolfi@polimi.it</a>, tel. +39 02 2399 4217                      Lorenza Petrini: <a href="mailto:lorenza.petrini@polimi.it">lorenza.petrini@polimi.it</a>, tel. +39 02 2399 4307</p> <p><a href="http://www.dica.polimi.it">www.dica.polimi.it</a></p>



Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	650.0 €
By number of months	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research**

Stanford University, CA - USA  
 University College Dublin, Ireland  
 University of Zaragoza, Spain  
 University of Salerno, Italy  
 University of Liverpool, UK  
 University of Oxford, UK  
 Università di Genova, Italy  
 California Institute of Technology, CA - USA

**Educational activities**  
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**Teaching assistanship**  
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**Computer availability**  
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**Desk availability**  
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# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**OPEN SUBJECT Research Field: TOPOLOGY OPTIMIZATION FOR STRUCTURAL DESIGN**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>Topology optimization is a powerful design tool with a broad range of applications in many branches of engineering. Given a design domain, prescribed loads and boundary conditions, topology optimization searches for the distribution of material that minimizes an objective function (maximizes a target performance), subject to a prescribed set of constraints.</p> <p>Most of the conventional formulations of topology optimization deal with the minimization of the structural compliance (maximization of the structural stiffness), without enforcing any additional requirement concerning e.g. strength and fatigue of the material, buckling modes, structural behaviour under dynamic loads.</p> <p>Aim of this research is the formulation of comprehensive approaches of topology optimization to cope with design problems arising in the field of structural engineering. Examples are the conceptual design of bracing systems for high-rise buildings and the achievement of the optimal distribution and orientation of fiber-reinforcement layers to strengthen existing structures.</p>
<b>Methods and techniques that will be developed and used to carry out the research</b>	<p>Structural mechanics and computational mechanics provide theoretical methods and numerical tools to investigate optimal solutions for structural problems. In particular, anisotropic bodies and linear elastic no-tension/no-compression materials will be dealt with. The arising multi-constrained minimization problems will be</p>



	solved through ad hoc methods of mathematical programming.
<b>Educational objectives</b>	Ph.D. students are expected to develop new approaches and tools to address the conceptual design of structures and structural components.
<b>Job opportunities</b>	Increasing attention is being directed to the adoption of topology optimization in civil engineering and architecture. International firms involved in these fields, as well as research centers and R&D departments in companies, are expected to be interested in the skills developed during this research.
<b>Composition of the research group</b>	1 Full Professors 1 Associated Professors 0 Assistant Professors 0 PhD Students
<b>Name of the research directors</b>	Matteo Bruggi, Alberto Taliercio

#### Contacts

Matteo Bruggi: matteo.bruggi@polimi.it - tel. +39 02 2399 4232  
 Alberto Taliercio: alberto.taliercio@polimi.it - tel. +39 02 2399 4241  
 www.dica.polimi.it

#### Additional support - Financial aid per PhD student per year (gross amount)

<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

#### Scholarship Increase for a period abroad

<b>Amount monthly</b>	650.0 €
<b>By number of months</b>	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

#### **List of Universities, Companies, Agencies and National or International Institutions that are cooperating in the research**

University of Liège, Belgium  
 Budapest University of Technology and Economics, Hungary



**Educational activities**

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**Teaching assistanship**

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