



PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 39th cycle

Number of scholarship offered	3
Department	DIPARTIMENTO DI INGEGNERIA CIVILE E AMBIENTALE

Description of the PhD Programme

General description

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.

List of topics and research areas

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



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 - 39th cycle

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

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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>Motivation and objectives of the research in this field</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>Methods and techniques that will be</p>	<p>Numerical modelling requires moving on with new</p>



developed and used to carry out the research	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.
Educational objectives	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.
Job opportunities	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.
Composition of the research group	2 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students
Name of the research directors	G. Della Vecchia, C. Jommi, A. Pandolfi, D. Sterpi

Contacts	
Gabriele Della Vecchia: gabriele.dellavecchia@polimi.it - tel. +39 02 2399 4264 Cristina Jommi: cristina.jommi@polimi.it - tel. +39 02 2399 4281 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	

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	597.76 €
By number of months	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

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 - 39th cycle

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

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	<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 ζengineered self-healing techniquesζ 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>
Methods and techniques that will be developed and used to carry out the research	<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>Educational objectives</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>Job opportunities</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>Composition of the research group</p>	<p>3 Full Professors 3 Associated Professors 4 Assistant Professors 2 PhD Students</p>



Name of the research directors	Marco di Prisco
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Contacts	
Marco di Prisco: marco.diprisco@polimi.it ; tel. +39 02 2399 4400	
www.dica.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	597.76 €
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

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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PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 39th cycle

OPEN SUBJECT Research Field: COMPUTATIONAL AND EXPERIMENTAL MECHANICS

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	<p>The proposed subject represents an advanced topic for multi-disciplinary research activities, involving expertise in engineering, physics, and medicine. A two-year project (5 <i>per mille Politecnico</i>, Euro 80,000) a grant for equipment (<i>Fondazione Banca del Monte</i>) 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 CARIPLO project coordinated by Prof. Mariani has been granted for two years, and it includes X-ray micro CT investigations on polymeric foam samples.</p> <p>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.</p>
Methods and techniques that will be developed and used to carry out the research	<p>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).</p> <p>In particular, X-ray computed microtomography allows to reconstruct the inner (bulk) microstructure of heterogeneous samples, possibly evolving under complex</p>



	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.
Educational objectives	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.
Job opportunities	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.
Composition of the research group	0 Full Professors 2 Associated Professors 1 Assistant Professors 0 PhD Students
Name of the research directors	Roberto Fedele, Stefano Mariani, Aldo Ghisi

Contacts	
<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	597.76 €
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

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OPEN SUBJECT Research Field: COMPUTATIONAL MECHANICS OF MATERIALS AND STRUCTURES

Monthly net income of PhDscholarship (max 36 months)

€ 1195.5

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>Motivation and objectives of the research in this field</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>Methods and techniques that will be developed and used to carry out the research</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>Educational objectives</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>



Job opportunities	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.
Composition of the research group	3 Full Professors 2 Associated Professors 2 Assistant Professors 3 PhD Students
Name of the research directors	C. Comi, G. Novati, U. Perego

Contacts	
Claudia Comi: claudia.comi@polimi.it - tel. +39 02 2399 4215	
Giorgio Novati: giorgio.novati@polimi.it - tel. +39 02 2399 4257	
Umberto Perego: umberto.perego@polimi.it - tel. +39 02 2399 4214	
www.dica.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	597.76 €
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

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

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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>Motivation and objectives of the research in this field</p>	<p>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.</p> <p>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>



	<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>Methods and techniques that will be developed and used to carry out the research</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>Educational objectives</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>Job opportunities</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&D department of anchor manufacturing companies.</p>
Composition of the research group	1 Full Professors 1 Associated Professors 3 Assistant Professors 0 PhD Students
Name of the research directors	Gianpaolo Rosati, Giovanni Muciaccia

Contacts	
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	

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	597.76 €
By number of months	6

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

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PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: DEVELOPMENT OF HIGH-PERFORMANCE COMPUTING
METHODS FOR THE SIMULATION OF FREE-SURFACE FLUID-STRUCTURE INTERACTION
PROBLEMS**

Monthly net income of PhDscholarship (max 36 months)

€ 1195.5

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**

Borsa parzialmente finanziata da (scholarship partially supported by):

**CN-HPC: CENTRO NAZIONALE PER HPC, BIG DATA
E QUANTUM COMPUTING**

CUP D43C22001240001 - Decreto di concessione D.D.
1031 del 17/06/2022

Bando D. D. 3138 del 12/16/2021 rettificato con D.D.
3175 del 18/12/2021

Avviso pubblico per presentazione Proposte di intervento per il Potenziamento di strutture di ricerca e creazione di "campioni nazionali" di R&S su alcune Key Enabling Technologies da finanziare nell'ambito del Piano Nazionale di Ripresa e Resilienza, Missione 4 Componente 2 Investimento 1.4 "Potenziamento strutture di ricerca e creazione di "campioni nazionali di R&S" su alcune Key Enabling Technologies - finanziato dall'Unione europea - NextGenerationEU".

The objective of this project is to develop highly efficient numerical approaches for solving interaction problems between free-surface non-Newtonian fluids and



	<p>structures. These phenomena are critical in various industrial applications, such as cartoon packaging production and 3D printing, as well as in environmental problems, including e.g. landslide-structure interactions. Exploiting state-of-the-art high-performance computing techniques, an effective numerical simulation tool will be developed, enabling the solution of real-scale engineering problems with a level of detail never experienced before. The project will be developed in the framework of the "Italian Research Center on High-Performance Computing, Big Data and Quantum Computing".</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>This research primarily focuses on the theoretical development and implementation of innovative numerical simulation approaches, involving advancements in existing computational methodologies, such as the Finite Element Method (FEM), Virtual Element Method (VEM), and Particle Finite Element Method (PFEM). Particular attention will be given to optimizing the efficiency of the numerical tools to facilitate the simulation of very large-scale problems. To this purpose, high-performance computing techniques (e.g., MPI) and accelerating tools (e.g., graphics processing units (GPUs)) will be tested, and the most effective solution will be adopted.</p>
<p>Educational objectives</p>	<p>Since the proposed research project will be developed in the framework of the "Italian Research Center on High-Performance Computing, Big Data and Quantum Computing", the candidate will have the opportunity to collaborate with a large number of laboratories and research groups in Italy. Moreover, industries and international research centers will be involved in the project. The candidate will acquire specialized knowledge of innovative numerical techniques. He/She is expected to become prepared to tackle complex problems and to develop effective innovative solution procedures.</p>
<p>Job opportunities</p>	<p>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</p>



	complex, multiphysics engineering problems using new and unconventional approaches.
Composition of the research group	1 Full Professors 1 Associated Professors 0 Assistant Professors 5 PhD Students
Name of the research directors	Massimiliano Cremonesi

Contacts	
massimiliano.cremonesi@polimi.it phone +39 02 2399 6230 http://cremonesi.faculty.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	597.76 €
By number of months	0

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p><u>List of Universities, Companies, Agencies and National or International Institutions that are cooperating in the research</u></p> <ul style="list-style-type: none"> • Universitat Politecnica de Catalunya – Barcelona • Université Paris-Saclay - Paris • Tetra Pak Packaging Solution - Modena <p><u>Educational activities</u></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> <p><u>Teaching assistanship</u></p> <p>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.</p>



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 - 39th cycle

OPEN SUBJECT Research Field: EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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>Motivation and objectives of the research in this field</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>Methods and techniques that will be developed and used to carry out the research</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>



Educational objectives	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.
Job opportunities	Job opportunities in the following fields: - further academic positions in universities worldwide - research centers and institutes - construction industry as structural designers and consultants
Composition of the research group	1 Full Professors 5 Associated Professors 0 Assistant Professors 0 PhD Students
Name of the research directors	Ardito, Martinelli, Mulas, Perotti, Petrini, Racic

Contacts	
Raffaele Ardito: raffaele.ardito@polimi.it ; tel. +39 02 2399 4272	
Luca Martinelli: luca.martinelli@polimi.it ; tel. +39 02 2399 4247	
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	

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	597.76 €
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



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 - 39th 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)

€ 1195.5

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.
Methods and techniques that will be developed and used to carry out the research	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.
Educational objectives	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.
Job opportunities	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.
Composition of the research group	0 Full Professors 3 Associated Professors 2 Assistant Professors 1 PhD Students
Name of the research directors	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	597.76 €
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 - 39th cycle

OPEN SUBJECT Research Field: FIRE SAFETY OF CONCRETE STRUCTURE

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	<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"> a) investigation on actual fires, in order to highlight the advantages and shortcomings of the current approaches available for modelling fire scenarios; b) advanced experimental techniques to accurately characterize the thermo-hydro-mechanical behaviour of concrete upon heating and subsequent cooling; 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; d) numerical simulations on the behaviour of concrete structures subjected to heating and subsequent cooling.
Methods and techniques that will be developed and used to carry out the research	<ul style="list-style-type: none"> a) Numerical codes for the simulation of the fire scenario; b) Experimental techniques to characterize material



	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.
Educational objectives	The Ph.D. student is expected to develop multi-disciplinary skills, that will allow him/her to communicate with researchers from different related fields.
Job opportunities	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.
Composition of the research group	0 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students
Name of the research directors	Roberto Felicetti, Patrick Bamonte

Contacts

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

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	597.76 €
By number of months	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

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 - 39th cycle

**THEMATIC Research Field: HYBRID (DATA-DRIVEN AND PHYSICALLY INFORMED)
METHODS FOR STRUCTURAL HEALTH MONITORING WITH HIGH PERFORMANCE
COMPUTING**

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	<p>Structural mechanics and mechanics of materials often involve large computational burdens. To tackle these problems, High Performance Computing (HPC) can now exploit hardware and software solutions that combine execution on graphics cards and on standard CPUs, and other heterogeneous systems. A related challenge is that artificial intelligence models can augment expert analysis of data sets to produce results faster at the same level of accuracy.</p> <p>As exemplary application, the treatment of large data sets, such as those obtained from sensors distributed in dense networks, in the context of the monitoring of structures and infrastructures, requires deep learning techniques during the computational phase necessary to produce real-time data processing solutions involves high computational demands, using, which should adopt state-of-the-art hardware and software.</p>
Methods and techniques that will be developed and used to carry out the research	<p>Development of benchmarks for HPC systems in the context of structural engineering. Possible development of computer codes for HPC either in Fortran or C or Python language.</p>



Educational objectives	To build up a large pool of talents with strong expertise on state-of-the-art hardware and software technologies and tools for advanced computing, specifically for structural engineering applied also in multi-scale and multi-physics contexts. The goal is to contribute to the reduction of the severe skill gap in this area and to increase the number of highly-trained professionals who are essential for Italy's industrial growth and competitiveness in the digital economy.
Job opportunities	During the PhD period the student is encouraged to enter into contact with supercomputing centres and with companies with HPC facilities.
Composition of the research group	0 Full Professors 3 Associated Professors 1 Assistant Professors 3 PhD Students
Name of the research directors	Aldo Francesco Ghisi

Contacts

aldo.ghisi@polimi.it
+39 02 2399 4310

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	597.76 €
By number of months	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:

the following universities are collaborating in the framework of the National Center "Future HPC", flagship 5:

Università di Catania, Università di Bologna, Università di Torino, Politecnico di Milano,



Politecnico di Torino, Università di Pisa, Università di Padova, Università di Roma Tor Vergata, Università di Napoli, Università della Calabria, Università di Ferrara. The following public agencies are also collaborating: ENEA, INAF, CINEC, IIT.

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

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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 - 39th cycle

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

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	<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"> a) residual lifetime of concrete structures under corrosion; b) methodologies and procedures for life-cycle analysis, design, and optimization of bridges and civil structures, including maintenance planning and decommissioning; c) assessment of lifetime seismic performance of structures and infrastructure systems; d) behavior and modeling of damaged cables; e) assessment of residual load bearing capacity of bridges suspended by damaged cables.
Methods and techniques that will be developed and used to carry out the research	<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.
Educational objectives	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.
Job opportunities	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.
Composition of the research group	2 Full Professors 1 Associated Professors 2 Assistant Professors 4 PhD Students
Name of the research directors	Fabio Biondini, Pier Giorgio Malerba

Contacts	
Fabio Biondini: fabio.biondini@polimi.it ; tel. +39 02 2399 4394	
Pier Giorgio Malerba: piergiorgio.malerba@polimi.it ; tel. +39 02 2399 4397	
http://www.dica.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	597.76 €
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

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

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Teaching assistanship

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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 - 39th cycle

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

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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, 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.
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



	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.
Job opportunities	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.
Composition of the research group	3 Full Professors 2 Associated Professors 1 Assistant Professors 4 PhD Students
Name of the research directors	Alberto Corigliano, Attilio Frangi

Contacts

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

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	597.76 €
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



STMicroelectronics - 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

Massachusetts Institute of Technology - 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

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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 - 39th cycle

OPEN SUBJECT Research Field: SMART MATERIALS AND STRUCTURES

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	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.
Methods and techniques that will be developed and used to carry out the research	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.
Educational objectives	The research field is across materials and structural engineering. Hence, Ph.D. students are expected to develop a multidisciplinary approach to the problem.
Job opportunities	Due to the very research-oriented goal of the project, direct employment in research centers or agencies and in companies all-over the world.
Composition of the research group	1 Full Professors 1 Associated Professors 3 Assistant Professors 2 PhD Students



	2 PhD Students
Name of the research directors	Stefano Mariani

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

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	597.76 €
By number of months	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 - 39th cycle

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

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	<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"> - advanced constitutive modelling of soil materials; - underground structures; - slope stability and landslide risk assessment; - investigation of the role of nonlinear dynamic soil-structure interaction on the seismic response of structures; - numerical approaches to study seismic wave propagation from the seismic source to the structure, with special regard to shallow soil layers; - seismic actions for design.
Methods and techniques that will be developed and used to carry out the research	<ul style="list-style-type: none"> - Macroelement constitutive approaches for shallow/deep foundations - Small scale experimental testing - 2D and 3D numerical codes for seismic wave propagation in the linear and nonlinear range - Analytical and numerical methods for nonlinear soil-structure interaction analyses - Advanced processing of strong motion records
Educational objectives	<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.
Job opportunities	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.
Composition of the research group	2 Full Professors 2 Associated Professors 1 Assistant Professors 4 PhD Students
Name of the research directors	C. di Prisco, R. Paolucci

Contacts	
Claudio di Prisco: claudio.diprisco@polimi.it ; tel. +39 02 2399 4298	
Roberto Paolucci: roberto.paolucci@polimi.it ; tel. +39 02 2399 4353	
www.dica.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	597.76 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>List of Universities, Companies, Agencies and National or International Institutions that are cooperating in the research</p> <p>Delft University of Technology, The Netherlands - www.tudelft.nl Eucentre, Pavia, Italy - http://www.eucentre.it Istituto Nazionale di Geofisica e Vulcanologia, Italy - http://www.ingv.it RELUIS - http://www.reluis.it Aristotle University of Thessaloniky, Greece (prof. K. Pitilakis) - http://www.auth.gr</p> <p>Educational activities</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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PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 39th cycle

OPEN SUBJECT Research Field: STRUCTURAL ANALYSIS OF BUILT HERITAGE

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	<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>
Methods and techniques that will be developed and used to carry out the research	<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>
Educational objectives	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.
Job opportunities	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.
Composition of the research group	<p>1 Full Professors</p> <p>3 Associated Professors</p> <p>1 Assistant Professors</p> <p>0 PhD Students</p>
Name of the research directors	Cardani, Coronelli, Garavaglia, Petrini, Zanzi

Contacts	
<p>Giuliana Cardani: giuliana.cardani@polimi.it - tel. +39 02 2399 4204</p> <p>Dario Coronelli: dario.coronelli@polimi.it - tel. +39 02 2399 4395</p> <p>Elsa Garavaglia: elsa.garavaglia@polimi.it ; tel. +39 02 2399 4284</p> <p>Lorenza Petrini: lorenza.petrini@polimi.it ; tel. +39 02 2399 4307</p> <p>www.dica.polimi.it</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	597.76 €
By number of months	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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PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 39th cycle

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

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	<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>
Methods and techniques that will be developed and used to carry out the research	<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>
Educational objectives	<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>
Job opportunities	<p>A large number of the most recent Ph.D.s with a research experience on the above-mentioned topics are now holding R&D positions in a few companies well known in the field of bio-engineering and bio-materials.</p>
Composition of the research group	<p>0 Full Professors 3 Associated Professors 0 Assistant Professors 0 PhD Students</p>
Name of the research directors	<p>Gabriella Bolzon, Anna Pandolfi, Lorenza Petrini</p>

Contacts	
<p>Gabriella Bolzon: gabriella.bolzon@polimi.it, tel. +39 02 2399 4319 Anna Pandolfi: anna.pandolfi@polimi.it, tel. +39 02 2399 4217 Lorenza Petrini: lorenza.petrini@polimi.it, tel. +39 02 2399 4307</p> <p>www.dica.polimi.it</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	
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By number of months	6

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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

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PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 39th cycle

OPEN SUBJECT Research Field: TOPOLOGY OPTIMIZATION FOR STRUCTURAL DESIGN

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	<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>
Methods and techniques that will be developed and used to carry out the research	<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.
Educational objectives	Ph.D. students are expected to develop new approaches and tools to address the conceptual design of structures and structural components.
Job opportunities	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.
Composition of the research group	1 Full Professors 1 Associated Professors 0 Assistant Professors 0 PhD Students
Name of the research directors	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)

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

Scholarship Increase for a period abroad

Amount monthly	597.76 €
By number of months	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



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