

**Proposal of a PhD Programme (PhD)  
managed by the Politecnico di Milano**

**PhD in: STRUCTURAL, SEISMIC AND GEOTECHNICAL ENGINEERING**

**CYCLE: XXIX**

TYPE OF ACTIVATION PROPOSAL:

- A.) Re-proposal of a PhD already activated – no change to the training project
- B.) Re-proposal of a PhD already activated – no substantial changes to the training project
- C.) Re-proposal of a PhD already activated - substantial changes to the training project
- D.) Newly activated PhD (not applicable for the XXVIII cycle)

Proposing Department: DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Other proposing departments:.....

POLITECNICO DI MILANO



**PhD School of the Politecnico di Milano**

**Regulations of the PhD Programme in  
STRUCTURAL, SEISMIC AND GEOTECHNICAL ENGINEERING  
XXIX Cycle**

Campus: Milano Leonardo

# 1. General Information

PhD School of the Politecnico di Milano

PhD Programme: STRUCTURAL, SEISMIC AND GEOTECHNICAL ENGINEERING

Official Languages: English/Italian

PhD Programme campus: Milano Leonardo

PhD School Website: <http://www.ricerca.polimi.it/phd>

PhD Programme Website: [http://www.stru.polimi.it/EN/Didattica\\_Dottorato.plp](http://www.stru.polimi.it/EN/Didattica_Dottorato.plp)

## 2. General presentation of the PhD Programme

Structural, Seismic and Geotechnical Engineering - SSGE - consists of 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 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 domains, whenever understanding and controlling mechanical aspects are necessary to guarantee both 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.

## 3. Mission and Goals

Within the context outlined above, the primary objective of this PhD Programme is to improve the advancement of knowledge, with reference to: (a) innovation in materials and structures; (b) building safety under highly-variable actions; (c) soil and surface/buried structure stability and (d) biomechanics, a key aspect of industrial bio-engineering.

This objective is pursued by giving PhD candidates advanced, research-oriented training, based on the pivotal role of Structural Engineering and on the multi-disciplinary nature of Seismic and Geotechnical

Engineering. More specifically, the 3-year curriculum of the PhD Programme in Structural, Seismic and Geotechnical Engineering has the objective of providing the following professional skills that will be developed to a greater or lesser extent according to the specific interests of the candidate:

- (a) Basic and operative knowledge of the main, up-to-date methods used in computational mechanics, in order to model and analyze the elastic, inelastic and cyclic behavior of materials, structures and soil.
- (b) Critical understanding and conscious use of numerical codes, depending on the level of the analysis (micro-, meso- and macro-structural levels).
- (c) Basic and operative knowledge of experimental mechanics, including the most up-to-date experimental techniques and their instrumentation, in order to test materials, structures and soil, either in a laboratory or on site.
- (d) Knowledge of the most common procedures for test-based identification of the parameters characterizing the mechanical properties of materials, soils, and structural damage (for assessment of structural safety).
- (e) Basic and operative knowledge of the design criteria and socio-economic implications governing any major structural project.

## 4. Professional opportunities and employment market

The possible employment opportunities for a PhD in Structural, Seismic and Geotechnical Engineering include research and development in academia or in other public or private research institutions, professional activities - typically as an independent self-employed professional or high-level consultant, mainly in the field of advanced structural design and monitoring - Civil and Environmental Engineering and Industrial Engineering. Switching from one field to another is facilitated by open-mindedness and the ability to model complex systems, which are among the main educational results of the PhD Programme.

## 5. PhD Programme Enrolment

### 5.1 Admission requirements

Italian and foreign citizens can apply. They are required to have graduated in accordance with the pre-existing laws MD 3.11.1999 n. 509 or to have a Master of Science degree in accordance with MD 3.11.1999 n. 509 or a Master of Science in accordance with MD 22.10.2004 n. 270 or similar academic qualification obtained abroad, equivalent in duration and content to the Italian qualification and for an overall duration of university studies of at least five years.

Knowledge of the English language to at least B2 level is required.

Admission to the programme will be decided according to evaluation of the academic curriculum, the cover letter and to the development of possible PhD research which candidates must submit together with their application in reply to the admission call.

## **5.2 Admission deadlines and number of places available**

The number of places available is indicated in the call for admission to the 29th PhD Programme cycle:

<http://www.polimi.it/phd>

Scholarships both on general and on specific topics are available, in accordance with what specified in the admission call

## 6. PhD Programme Contents

### Qualification attainment requirements

Attainment of a PhD in STRUCTURAL, SEISMIC AND GEOTECHNICAL ENGINEERING requires study and research activity of at least three years full-time dedicated to study, research and development of the PhD thesis.

The PhD programme foresees a **minimum of 35 credits** from PhD level courses to be acquired as indicated in paragraph 6.3 below. Additionally, candidates are required to attend seminar activities organized by the Department, according to the rules defined by the Academic Board.

### 6.2 Development of research and the PhD thesis

The PhD study and research work will be carried out, full time, during the three years of the PhD course.

The aim of PhD programmes at the Politecnico di Milano is the development in candidates of a research-oriented mind-set, with expertise and skills in a specific research topic. To develop a research-oriented mind-set, candidates must acquire problem-solving capabilities in a complex context, including in-depth analysis of the problem, identification of an original solution and the capability of evaluating a solution and its applicability in given contexts. These skills provide PhD candidates with major opportunities for personal growth coupled with research and professional training, which make them suitable for leading positions in the academic field as well as in public and private organisations.

The main objective of the activity of a PhD candidate is the development of an original research contribution which must be coherent with the research topics developed in the Department in which the PhD Programme is carried out. Research must be submitted via a PhD thesis, in which the objectives of the research work should be clearly stated in the context of the state of the art of the research field and the methods and original results presented and discussed. The PhD research will be developed under the guidance of a supervisor who supports the candidate in setting-out and in the everyday activities regarding development of the thesis. The supervisor is not required to be a member of the Academic Board and can also belong to an institution other than the Politecnico di Milano. In the latter case, the thesis should be co-supervised by a member of the Academic Board.

To develop the capability of carrying out research activities, the candidate must attend courses, according to the PhD programme defined for his/her study plan, and pass them with a positive evaluation.

For each candidate admitted to the programme, a tutor, belonging to the Academic Board, is appointed. The tutor supervises and supports the candidate in the overall training path. The supervisor and the tutor can coincide. The choice of courses will be overseen by the tutor and will be formalized in a study plan to be approved by the Coordinator of the PhD Programme. Any other

activity to develop and improve personal skills and research expertise of the candidate is encouraged during the course of the PhD.

The candidate must acquire the capability to present and discuss his/her work in his/her research community. Consequently both participation in international conferences and publication of research results in international peer-reviewed journals are encouraged.

Candidates are also strongly encouraged to carry out part of their research activities in contact with other research groups, preferably abroad, in order to acquire further skills in their research field and establish strong links for their future work.

The duration of the programme is normally three years.

### 6.3 Objectives and overview of teaching activities

The PhD Programme and the PhD School may activate various types of training with different valences (courses, seminars, project workshops, laboratories). All activities will aim at:

- creating common starting knowledge for the PhD Programme;
- examining the basic research issues (problems, theories, research methods) which represent the cornerstone of the PhD Programme and which identify clearly its cultural position;
- providing improved knowledge on key research issues connected with the problems developed in the thesis.

Courses are offered in English, unless otherwise provided for individual courses. At least one path entirely in English is foreseen in the PhD Programme.

Certain teaching activities entitle to acquisition of ECTS credits (Structured teaching activities); other activities, typically specialised and for which it is difficult to make an assessment of learning and quantification of the same, fall within the scientific activities which the Academic Board will take into account in the overall assessment, but whose value is not quantified in ECTS. At the same time, the programme foresees that the candidate is devoted to research activity in a continuous manner, under the guidance of his/her supervisor and the Academic Board.

The tables below show the foreseen path for candidates and refer only to coursework activities. Details of the programmes of each course and the evaluation procedures will be available at the PhD Student Secretary Service (see section 7.3) and on the PhD Programme website.

#### First/Second Year

<b>Courses</b>	<b>Possible details or reference to following tables</b>	<b>Number of credits (min-max)</b>	<b>Notes</b>
<i>(A) Courses characterising the PhD</i>	<i>See Table A</i>	<i>Minimum 30 type A credits</i>	

<i>Programme</i>			
<i>(B) PhD School Courses</i>	<i>See Table B</i>	<i>Minimum 5 type B credits</i>	
<i>(C) Other PhD courses</i>			<i>For such credits to be recognized as type (A) or type (B), prior approval of the Academic Board is mandatory</i>
<i>(D) Graduate courses</i>	<i>From the Master curriculum at Politecnico</i>		<i>These courses are mainly intended to complete the training programme.</i>
<i>(E) Seminar activities at the Department</i>			<i>For admission to the following year, candidates must attend Seminar activities at the Department, according to the rules provided by the Academic Board</i>
<i>(F) Specialistic courses, Workshops, Long-training seminars</i>			<i>If certified and evaluated, these activities permit acquisition of additional credits, with prior approval of the study plan submitted by the candidate.</i>

### Third year

In the third year the candidate should be devoted entirely to research and development of the PhD thesis.

### PhD PROGRAMMES

#### A) Characterizing courses

The PhD Programme in STRUCTURAL, SEISMIC AND GEOTECHNICAL ENGINEERING organises the following Characterising Courses (see Table A)

For admission to the final exam acquisition of **at least 30 credits** is mandatory, to be acquired via the “characterising” PhD courses offered by the PhD Programme.

The candidate must earn **credits in at least 3 out of the 4 research areas**: (a) General; (b) Structures; (c) Earthquake Engineering; (d) Geotechnical Engineering.

At least **20** type A credits must be acquired for admission to the second year, while at least **30** credits must be acquired for admission to the third year.

#### B) General courses

The PhD School organises every year general and Interdoctoral courses and courses with foreign professors. **Acquisition of at least 5 credits is mandatory from type B courses**

#### C) Other PhD courses.

In addition to the minimum requirements from (A) and (B) courses, the candidate is encouraged to

acquire further credits from courses provided by other PhD Programmes at the Politecnico, at other Universities and/or other institutions, such as CISM in Udine and Rose School in Pavia. For such credits to be recognized as type (A) or type (B) courses, prior approval of the Academic Board is mandatory.

### PREPARATORY COURSES

If the supervisor and the tutor find it useful or necessary for the candidate to attend preparatory courses (chosen among the courses activated at the Politecnico di Milano) the Academic Board of the PhD Programme can assign a number of extra-credits to be acquired to complete the training path. The credits acquired in this way will be considered as additional, in relation to the mandatory credits to be acquired with the PhD courses.

### SPECIALISTIC COURSES, LONG-TRAINING SEMINARS

Attendance of Specialist Courses, Workshops, Schools and Seminar cycles is strongly encouraged and (if these seminars, workshops are certified and evaluated) may permit acquisition of credits with prior approval of the study plan submitted by the candidate. These courses and workshops can be inserted in the study plan, even if they are not evaluated (and therefore not qualified as credits), as optional “supplementary teaching”.

To guarantee a sufficiently broad overview of the scientific activities and results in the research areas of interest to the PhD programme, **each year the candidate is required to attend seminar activities organized within the Department**, according to the rules provided by the Academic Board.

### Schedule

In the following, the schedule for the 2013-14 and 2014-15 academic years is provided. This schedule is only tentative since other courses may be activated by the PhD School. In this case, candidates will be promptly informed in order to be able to insert the new courses in their study plan.

**Table A: PHD COURSES CHARACTERISING THE PHD PROGRAMME**

Each course in this Table is assigned 5 credits and will be taught in English.

Scientific areas	Name of Course	A.Y./ Semester	Language	Credits
<b>General (*)</b>	<b>Non-linear Solid Mechanics</b>	To be defined	English	5
	<b>Non-linear Finite Element Methods in Solid Mechanics</b>			
	<b>Experimental Methods in Solid Mechanics</b>			
<b>Structures</b>	<b>Damage Mechanics</b>			
	<b>Non-linear Fracture Mechanics</b>			
	<b>Mechanics of Composite Materials</b>			
	<b>Non-linear Analysis of RC Frames</b>			

	<b>Plates and Shells</b>		
<b>Earthquake Engineering</b>	<b>Fundamentals of Earthquake Engineering</b>		
	<b>Elastic Wave Propagation</b>		
	<b>Dynamic Soil-Structure Interaction</b>		
	<b>Structural Modelling in Civil Engineering Dynamics</b>		
<b>Geotechnical Engineering</b>	<b>Mechanics of Geomaterials</b>		
	<i>Other courses activated by the PhD School</i>		

(\*) Some of these general courses may refer to specific scientific areas, such as Experimental Methods in Structural Mechanics / Earthquake Engineering / Geotechnical Engineering.

**Table B SUGGESTED INTER-DOCTORAL COURSES**

Scientific areas	Name of Course	A.Y./ Semester	Language	Credits
Inter-doctoral courses	<b>Mechanics of Heterogeneous Media</b>	To be defined	English	5
	<b>Micro-electro Mechanical Systems</b>			
	<b>Physical Models for Cultural Heritage</b>			
	<b>Flow and Transport in Groundwater Hydrology</b>			
	<b>Smart Buildings and Structures</b>			
	<b>Multi-body Systems</b>			
	<b>Finite Element in Engineering Design</b>			
	<i>Other courses of the PhD school to be approved by the Academic Board</i>			

## 6.4 Study plan submission

Each PhD candidate must submit his/her study plan. Candidates will have the opportunity to review it periodically (every three months) in order to adapt it to possible changes in the training offer or to needs justified by the development of his/her study plan. The study plan is approved by the Coordinator of the PhD Programme, according to the procedures established by the Academic Board of the PhD Programme itself.

## 6.5 Annual exam procedures

The candidate presents his/her work to the Academic Board at least once a year to be admitted to the following year. At the end of the annual exam, the Board will evaluate the activity of the PhD candidate with grades from A (maximum) to D, based on the following criteria:

- attainment of the minimum requirements for admission to the following year;
- grades obtained in exams;

- progress of the research work.

In the case of insufficient marks the candidate will be qualified as a “Repeating candidate (Er)” or “not able to continue with the PhD (Ei)”.

## **6.6 Final exam procedures**

In the annual exam of the third year, admission of the candidate to the final exam (held by the external Commission) will be evaluated by the Academic Board according to the same procedures used for annual exams, based on the overall qualifications of the candidate throughout the PhD activities and on the quality and originality of the research contribution.

Candidates having achieved sufficient results for admission to the final exam but who need more time to write their thesis may obtain an extension up to a maximum of 12 months.

In the final exam, in order to attain the qualification, the research work carried out and the thesis will be evaluated by an Examination Committee composed of three members, of which at least two external examiners.

## **7. Laboratories, PhD Secretary Services**

### **7.1 Experimental facilities**

Experimental research activities related to the PhD programme are supported by various laboratories devoted to structures, materials and geotechnics.

These laboratories are installed in various Politecnico buildings and halls, mainly on Leonardo Campus, namely: (1) a building with a strong floor for testing entire structures under static/dynamic/fatigue loads (steel and concrete structures); (2) a building with 3 presses (a hydraulic, force-controlled press for testing ropes and cables, capacity 500 tons; a hydraulic, fully-controlled press with a capacity of 200 tons and an electromechanical, fully-controlled press with a capacity of 100 tons); (3) a wing with a variety of presses for traditional tests on concrete and with one fully-controlled, electromechanical press with a capacity of 10 tons, for testing concrete and quasi-brittle materials in tension/compression; (4) a wing containing the geotechnical laboratory; (5) a wing containing the masonry and brick-structure laboratory; (6) a hall containing a furnace for heating concrete and concrete elements up to 1000°C (the tests are performed after a thermal cycle) and a split-type furnace for simultaneous heating and loading of specimens; (7) a 600 m<sup>2</sup> hall for testing anchor bars with hydraulic actuators from 2.5 to 1000 kN, installed on frames with variable inclination. A biaxial traction device is also installed, with 15 electro-mechanical 25 kN actuators in controlled conditions.

Finally, experimental equipment is also available on the Lecco campus, mainly devoted to investigation of advanced cementitious composites. In particular the following devices are available: (a) set-up for workability measures (b) shrinkage test equipments (c) Hydraulic machines (250, 300 and 3000kN max load) and a universal electromechanical machine (max load 30kN) for mechanical characterization (d) furnace able to reach 1200°C (e) climatic chamber ranging between -40°C and 180°C for freezing and thawing. A specific lab for elements under shock loads is equipped with a

shock tube generating a wave with a maximum reflected pressure of 2.5MPa and a velocity of 3Mach. Soil structure interaction and fire-blast interaction can also be investigated with this equipment.

## **7.2 Computational resources**

All PhD students will have a personal computer for their exclusive use.

For high performance computing applications, two clusters for parallel computing are currently available in the Department. It is also worth mentioning that Politecnico di Milano is partner of the consortium CINECA ([www.cineca.it](http://www.cineca.it)), which hosts FERMI, ranked 9<sup>th</sup> among the most powerful supercomputers in the world.

## **7.3 PhD Student Secretary Service**

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## **8. Internationalisation and other activities**

All candidates are strongly recommended to carry out part of their studies and research at other institutions abroad, although no specific constraint is imposed. Such experience abroad has been part of the curriculum of most PhD candidates in the past and has proved invaluable in improving and broadening their expertise in their research field, as well as in creating and consolidating strong relationships with other researchers at an international level.

The University also offers the possibility of PhD programmes with foreign universities as well as double and joint PhD programmes. Further information can be found on the PhD School and PhD programme websites.