

## **DOCTORAL COURSES (IN GEOTECHNICAL ENGINEERING): WHAT HAS BEEN CHANGING IN ITALY IN THE LAST 30 YEARS**

**DIEGO C.F. LO PRESTI<sup>1,A</sup>, NUNZIANTE SQUEGLIA<sup>1,B</sup>, ALESSIA PIEROTTI<sup>1,C</sup>,  
BARBARA COSANTI<sup>1,D</sup>, STEFANO STACUL<sup>1,E</sup>, ILARIA GIUSTI<sup>1,F</sup> AND ERIKA  
BANTI<sup>1,G</sup>**

<sup>1</sup> University of Pisa, Department of Civil & Industrial Engineering  
Largo Lucio Lazzarino 1, Pisa 56122, Italy

<sup>A</sup>E-mail address [d.lopresti@ing.unipi.it](mailto:d.lopresti@ing.unipi.it)

<sup>B</sup>E-mail address [squeglia@ing.unipi.it](mailto:squeglia@ing.unipi.it)

<sup>C</sup>E-mail address [alessia.pierotti@for.unipi.it](mailto:alessia.pierotti@for.unipi.it)

<sup>D</sup>E-mail address [barbara.cosanti@for.unipi.it](mailto:barbara.cosanti@for.unipi.it)

<sup>E</sup>E-mail address [stefano.stacul@for.unipi.it](mailto:stefano.stacul@for.unipi.it)

<sup>F</sup>E-mail address [ilaria.giusti@for.unipi.it](mailto:ilaria.giusti@for.unipi.it)

<sup>G</sup>E-mail address [erika.banti@for.unipi.it](mailto:erika.banti@for.unipi.it)

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**Abstract.** Doctoral schools in Italy began on middle 80s. Since that the objectives and fundamental rules for the third level of Higher Education in Italy changed several times. The paper shows the legislative evolution and reports, in a narrative way, the experience of 5 Ph. D. in Geotechnical Engineering over a period of 30 years (from 1987 to 2017). The narration focuses on general rules, availability of grants, tutorage and evaluation board, pointing out positive and negative aspects of the many changes occurred over 30 years. Ph. D. Courses in Italy are regulated by National Laws approved by the Parliament. The main conclusions can be summarized as follows: a) the recently introduced requirement of educational credits acquisition did not change the spirit of Doctoral studies that are mainly oriented to strength the students' research skills; b) based on the Authors' experiences it is strongly advised to promote Doctoral Schools restricted to specific subject areas in which the teaching staff and the members of the Council belong from different institutions (Consortia); c) Bilateral Agreements for double or multiple degrees are really encouraged.

## 1 INTRODUCTION

The Decree 382 (November 11<sup>th</sup>, 1980) of the President of the Italian Republic established the Doctorate in Italy. The main objective was offering to “future” researchers the possibility of carrying out original and innovative researches under the supervision of an expert or a Council of experts. The candidate was asked to produce a Ph. D. Thesis. He was also asked to defend the Thesis, firstly in front of an internal Jury, and thereafter in front of an external Jury. At that time, and somewhat also today, academia was the only occupation perspective of Ph. D graduates. People, not attending the Doctoral Courses, could be admitted to defend their Ph. D. Thesis. Public employees (Law 476 of August 13<sup>th</sup>, 1984) were encouraged to enter the Doctorate. Indeed, their position in the Public Administration was guaranteed during the Doctorate period. This type of doctorate appears very similar to those available in USA Universities.

The first fundamental change of Doctorate in Italy occurred on July 3<sup>rd</sup>, 1998 (Law No. 210 and subsequent Decree No. 224 of the Italian Ministry of Education, April 30<sup>th</sup>, 1999). These modifications reflected the addresses of the so-called Bologna Process. Doctorates became university study - courses with study programs and ECTS. Therefore, the possibility of defending the own Ph. D. thesis without admission and participation to the study-course programs was canceled. The production of a Ph. D Thesis remained but the emphasis was put on the education and training process of new Researchers (innovation and originality of the Thesis was no longer explicitly mentioned). The aim was also to enlarge the graduate employability in Public and Private Research Institution and Companies. Therefore, the Ph. D. degree is no more a pure academic title and the Ministerial Decree No. 224 strongly fosters the International cooperation and that between Academia and Industry.

Several steps were done until the Decree No. 45 of the Italian Ministry of Education (February 8<sup>th</sup>, 2013) that completed the transformation of the Doctoral Schools. This process put strong emphasis on the following aspects:

- multi-disciplinary study programs
- quality of the teaching staff
- degree of internationalization
- degree of cooperation with industry and socio-economical system;
- attractiveness
- facilities and resources

A National Agency was entrusted of evaluating, according to the above-mentioned criteria, the quality of Doctoral Courses. It is worth mentioning the impressive increase of the number of doctoral students. In the period 2000-2007 the number of students increased from 21290 to 39829. In the same period the Ph. D. graduates increased from 2919 to 10099.

## 2 EVOLUTION OF DOCTORATE IN ITALY

This chapter shows, in a narrative way, the progressive changes of Doctorate in Italy. In particular, the Authors illustrate their own experience focusing on the following aspects: admission rules, requested activities, composition of the Teacher Council, available research grants, experience at international level, assessment, recognition and post-doc perspective.

## **2.1 Doctorate in Geotechnical Engineering (Consortia of Northern Universities and Southern Universities)**

Lo Presti graduated Ph. D. in Geotechnical Engineering in 1987. The Doctoral School of Geotechnical Engineering was a Consortium of four Universities: Technical University of Milan, Technical University of Turin, University of Genoa and University of Padua. The Council of the Doctoral School included the Professors of Geotechnical Engineering of the Consortium Partners. A National competition, with 5 granted positions, was announced for the admission to the Doctorate. The admission test consisted of a written and oral examination. The examination board admitted 5 students. The only requested requirements were the Italian citizenship and a M. Sc degree.

He had the honor to have Prof. M. Jamiolkowski as tutor and to be involved, since the first day, in the ongoing research activities at ENEL CRIS Milan and Ismes Bergamo [1,2]. Lo Presti was encouraged to attend various lectures, but he was not requested to obtain educational credits. The progress of his research activity, as well as of the other students, was periodically examined by the teacher board. The final written version of his Ph. D. Thesis [3] was examined by international expert before the official defense in front of an independent National Jury in Rome. Over five Ph. D. students of his cohort, three became professors of Geotechnical Engineering.

Squeglia graduated Ph. D. in Geotechnical Engineering in 1998. The Doctoral School of Geotechnical Engineering was a Consortium of two Universities: University of Rome “La Sapienza” and University of Naples “Federico II”. The Council of the Doctoral School included the Professors of Geotechnical Engineering of the Consortium Partners. A National competition, with three granted positions, was announced for the admission to the Doctorate. The admission test consisted of a written and an oral examination. The examination board admitted three students. The only requested requirements were the Italian citizenship and a M. Sc degree.

Squeglia’s tutors were Prof. Viggiani, Prof. Evangelista – from University of Naples – and Prof. Calabresi – from University of Rome. The topic of his thesis, “Electrokinetic properties of fine grained soils” [4], originated from a field experience carried out in Pisa to verify the possibility to use electroosmosis as means to stabilize the leaning tower [5,6]. During doctorate Squeglia voluntarily attended various lectures, to complete his preparation in disciplines useful for his studies such as electrochemistry, but he was not requested to obtain educational credits. The progress of his research activity, as well as of the other students, was yearly examined by the teacher board. The final written version of his Ph. D. Thesis was examined by teacher board before the official defense in front of an independent National Jury in Rome. Over three Ph. D. students of his cohort, two became professors of Geotechnical Engineering.

## **2.2 The Leonardo da Vinci Doctoral School (University of Pisa)**

The Faculty of Engineering of the University of Pisa offered until 2012 Doctoral Courses in the framework of the Leonardo da Vinci Engineering Doctoral School. In the framework of such a School, the Civil Engineering area offered four different curricula (namely: Structural, Building, Hydraulic and Infrastructures/Transportation Engineering). Unfortunately, a curriculum in Geotechnical Engineering was not considered. The admission test consisted of a

written and oral examination, focused on a specific Ph. D. project proposed by the candidate. The only requested requirement was a M. Sc degree. There were a limited number of scholarships per year.

Ph. D. students were requested to attend a minimum number of classes i.e. a minimum number of lecture-hours such as 20-30 per year. A short non-comprehensive list of subjects includes the following topics: Tensor computation, English for writing papers, FEM and Numerical Methods, Advanced Continuum Mechanics. Students were also encouraged to attend/participate various Seminars/Workshops/Conferences/Courses organized by the Doctoral School as well as by other proponents. Participation to these events was intended to exchange information, present/illustrate the results and receive suggestions about the current research activities. In any case, the progress of the research activity was periodically (twice a year) examined by the School Council (Civil Engineering Area). Final examination was done by an ad-hoc Jury composed of external experts and members of the Council of the Doctoral School (i.e. a local Jury).

In between 2011 and 2012 the Doctoral School Leonardo da Vinci changed a lot, because of the new rules established by the Law N. 240 of December 30<sup>th</sup>, 2010 [7]. Indeed, according to the so-called Gelmini Law the Faculties were canceled and Doctoral Schools were mainly established at Department Level. It is important to remark that the Ministry granted only one Doctoral Schools for each Department. Moreover, according to the new rules, Departments with less than 50 Professors could not survive. Therefore, the Departmental reorganization of Universities created culturally heterogeneous structures in many cases. As for the University of Pisa, most of the Civil Engineering staff joined the International Doctoral School of Civil and Environmental Engineering (see next chapter). The Department of Energy, System, Territory and Construction Engineering, originated after the Gelmini reform, offered a curriculum named “Sciences and Techniques for Smart European Cities and Territories”. The Council of this Curriculum was very heterogeneous (Real estate, Urban Planning, Geotechnical Engineering, Transportation Engineering) and included a limited number of professors.

Cosanti was one of the last Ph. D graduates of the Civil Engineering Curriculum of the Leonardo da Vinci Doctoral School [8]. Based on the research results obtained during the doctoral studies Cosanti published 4 research articles in the Italian Geotechnical Journal [9-12] and 3 book chapters [13-15].

Pierotti obtained a scholarship that was granted by USL1 of Massa Carrara (a public body of the Italian Sanitary System for the control of safety conditions in underground mines). Pierotti graduated Ph. D. by discussing a Thesis [16] of Geotechnical Engineering in 2016 (Doctoral School Leonardo da Vinci, Curriculum “Sciences and Techniques for Smart European Cities and Territories”). Pierotti had three tutors: a) from the University, b) from the financing institution and c) from industry. Unfortunately, the objectives of the financing Partner diverged from the scientific objectives that have been initially established. Publishing of the output of her Ph. D. Thesis is underway.

### **2.3 International Ph. D. Course in Civil and Environmental Engineering (University of Florence, University of Pisa, University of Perugia and TU Braunschweig)**

The International Ph. D. Course in Civil and Environmental Engineering is a Doctoral

Exchange Program established by a Consortium of one German University (Technical University of Braunschweig) and three Italian Universities (University of Florence, University of Pisa and University of Perugia).

This International Ph. D. Program was born in the early 2000s based on a Joint Declaration by the Hochschulrektorenkonferenz (HRK) and the Conferenza dei Rettori delle Università Italiane (CRUI) on Bi-nationally Supervised Doctoral Theses ('co-tutelle de thèse').

This Joint Declaration was developed taking into consideration the Sorbonne Declaration of May 1998 and the Bologna Declaration of June 1999, with the awareness that bi-nationally supervised doctoral theses will play an important role in the development of intra-European mobility of university researchers and in fostering the institutional co-operation between Italy and Germany.

In the first years, this Ph. D. Course was characterized by a real doctoral students' exchange. Approximately the 40% of the enrolled students came from Germany and the other 60% from Italy. In the last years practically all the students came from Italy.

During the last ten years this Ph. D. Course changed its name at least three times. At the beginning the name was '*Risk Management on the Built Environment*', then '*Mitigation of Risk due to Natural Hazards on Structures and Infrastructures*', in 2011 (XXVII Cycle) became '*Processes, Materials and Constructions in Civil and Environmental Engineering and for the Protection of the Historic-Monumental Heritage*' and finally in 2012 (XXVIII Cycle) the name assumed the current form.

In the same year (2012), the Agreement on a Joint Doctoral Program between the Technical University of Braunschweig and the University of Florence was signed. In this document the two universities stated to:

- recognize the result of the jointly supervised doctoral procedure and the validity of the doctoral degree awarded and
- jointly award the doctoral degree and issue a joint doctoral diploma.

Starting from 2012 (XXVIII Cycle) and up to now, the International Ph. D. Course in Civil and Environmental Engineering was structured in three different curricula:

- Solid, fluid and materials mechanics;
- Constructions design, verification and control;
- Environment, resources and security.

The overall teaching staff and the members of the Council of the Doctoral School are heterogeneous and composed by Italian and German Professors belonging to all the main areas of Civil and Environmental Engineering and Architecture. The number of Geotechnical Engineering Professors is substantially covered by the Italian teaching staff. In fact, from the German side there is only one Associate Professor in Geotechnical Engineering.

The admission to the Doctoral School takes place after a national/international and public competitive examination. The call for the students' selection offered scholarships every year, funded by Universities and public or private institutions.

The admission procedure consists of two steps:

- evaluation of the curriculum vitae, qualifications, publications, research activities and of a research project proposal developed independently by each candidate (with maximum length of 3 pages, written in English);
- oral examination held in the official language of the Ph. D. Course (English).

The requirement to attend the examination is the MSc degree (or an equivalent degree).

According to the Ph. D. Course regulations (XXIX Cycle), was mandatory to spend at least 9 months abroad in one or more international Universities and as minimum 4 months at the Technical University of Braunschweig. Moreover, was mandatory to obtain a total of 40 educational credits by attending several seminars and lectures organized during the Ph. D. Course (1 credit was equivalent to 4 hours). The progress of the students' research activities was examined by the Board of Teachers every 6 months during the Plenary Meeting which was held in Germany (at TU Braunschweig) in the month of May and in Italy (Florence, Pisa or Perugia) in the month of November. In the Plenary Meeting each student had to show the progress of its own research project with a presentation of 15 minutes (+5 minutes of discussion). This meeting lasted 3 days and the program offered in most of the cases enough time for individual meetings between tutors and students.

Stacul graduated Ph. D. in Civil and Environmental Engineering in November 2017, together with Banti and Giusti. They attended the Ph. D. Course enrolment examination in October 2013. The examination board totally admitted 11 students with only 10 scholarships.

Stacul spent 6 months at the Institut für Grundbau und Bodenmechanik (Braunschweig) under the supervision of his German tutor and 3 months at the Research Laboratory of Geotechnical Engineering of the Vilnius Gediminas Technical University (VGTU). The final version of his Ph. D. Thesis [17] was reviewed by two international experts in Geotechnical and Pile Foundation Engineering (according to the Italian regulations) and by his two tutors before the official defense in Florence in front of an Examination Committee composed by 3 Italian and 3 German Professors. Based on the results obtained in this Ph. D. Thesis Stacul published 4 research papers in international peer-reviewed journals [18-21].

Giusti developed her research program mainly at the University of Pisa and at MIT. Indeed, she has been hosted by the Department of Civil and Environmental Engineering of the Massachusetts Institute of Technology for 5 months joining the Prof. Whittle's research group. The experience at MIT has been developed within the MIT-UNIPI Project, an exchange program between the University of Pisa and the Massachusetts Institute of Technology that promotes and supports research collaboration between the two universities. Moreover, Giusti spent 4 months at the Institut für Grundbau und Bodenmechanik (Braunschweig). A part of the experimental activities was done at Pagani Geotechnical Equipment (Piacenza – Italy) that granted her scholarship. The defense of her Ph. D. Thesis [22] took place in Florence in November 2017. As mentioned before, to be admitted to the final defense, the thesis has been reviewed by two external professors, internationally recognized as experts on the specific topic (Piezocone test interpretation for transitional soils), in particular, Prof. M. Randolph (University of Western Australia) and Prof. G. Gottardi (University of Bologna). The reviewers were asked to judge the following aspects:

- Overall scientific merit: originality, relevance in the specific field, completeness;
- Methodology - Data Analysis: appropriate methods / suitable and exhaustive data

- analysis;
- Introduction and bibliography: the introduction contains enough information on the object of the thesis, bibliographical references are suitable and complete;
  - Research work description;
  - Results: convincing and clearly presented results / suitable number and quality of tables and figures;
  - Discussion and Conclusions: correct interpretation of the results / advance of the results in the research field.

In addition to that, as a condition for the candidate admittance to the final defense, the Italian and German tutors evaluated the thesis proposal and the overall research work, giving a grade.

Following the defense, the examination board of teachers had the possibility of asking for corrections and integration of the thesis. The research activity developed during Ph. D. studies gave her the possibility of publishing the following journal papers [10,23]. Other contributions are on the way.

Banti graduated with a Ph.D. in Civil and Environmental Engineering in November 2017. During her doctorate, Banti spent 6 months at the University of Braunschweig at the Institut für Grundbau und Bodenmechanik under the supervision of her German tutor. Moreover, Banti had the pleasure to be hosted for 3 months by Professor Dong Soo Kim at the Korea Advanced Institute of Science and Technology (KAIST) at the Geotechnical Centrifuge Testing Center, in Daejeon (South Korea). The final written version of her Ph. D. Thesis [24] was examined by both tutors and by two external reviewers. The external professors were two international experts on the specific topic of her thesis (seismic assessment of earth constructions). The final defense was debated in front of an examination board made up of 3 Italian and 3 German Professors and took place at the University of Florence.

Among the 11 students enrolled in our doctoral cycle (XXIX), 3 are now post-doc fellows in German Universities, and 4 are post-doc fellows in Italian Universities.

### **3 FINAL REMARKS**

National Decrees or Laws can produce different results when applied in different contexts. Overall, it is possible to state that the requirement of credit acquisition did not modify the spirit of Doctoral studies essentially aimed at developing specific skills in doing research as well as many related soft skills. This aspect is very important, considering that the Higher Education system in Italy is quite adverse and critical with respect to the so-called Bologna process and in particular to the so-called student-centered approach. See as an example [25] and [26]. With this respect, doctoral studies represent the first and unique occasion for students to be the main subject of the learning process.

The quality of a Doctoral School mainly depends on the strong ness of the Teacher Council. It is preferable to have very specific Doctoral Schools (i.e. Geotechnical Engineering) or restricted to a given subject area (Civil Engineering). It is also preferable to have “many” professors from different Institutions (consortia). Admission rules and assessment criteria seems to play a less important role. Therefore, it is strongly suggested to sign Bilateral Agreements for double (multiple) degrees.

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