Report on the education and training in geo-engineering sciences in Italy

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ABSTRACT: After the description of the engineering education system, the report summarizes the most relevant features of education and training in geo-engineering sciences in Italy. Because of the recent evolution of the education system in Italy, the information given cannot be considered either up-to-date or exhaustive. More details and updates can be found in the websites of individual Universities and through the Italian Geotechnical Society (AGI).

1 THE ENGINEERING EDUCATION SYSTEM IN ITALY

1.1 *The general framework*

At present, it is not an easy task to describe the Higher Education system in Italy, because since the Bologna Declaration (19.VI.1999) it has experienced two different reforms in the last decade: the first (Decreto_509 1999) was implemented since 2000 (Lo Presti & Tordella 2001, 2002) and the second (Decreto_270 2004) is going to be introduced next year.

Following the Decreto_509 (1999), the European Credit transfer System (ECTS) has been adopted; the same reform has introduced the first and second level degrees:

- a first-level degree, approximately corresponding to a B.Sc. title: it lasts 3 years, with 180 credits, including thesis and/or practical placement;
- a second level degree, approximately corresponding to a M.Sc. title: it lasts 2 years, with 120 credits, including thesis and/or practical placement.

At the first-level degree, two different types of curricula have been established for each course. The two curricula (the so called 'two-tier system') differ each other for a number of credits which is very variable among different Universities. One curriculum is intended for those students who want to continue studying, the other for those that want to conclude their career after the first degree. It is possible to access the second level courses even without the first-level degree, provided that at least 120 out of 180 credits have been obtained by the student.

The Decreto_270 (2004) cancels the two-tier system and specifies two different types of requirements for the access to the second level ('Laurea Magistrale'), concerning:

- the curriculum at the first level degree, especially for those students coming from different Universities or Schools;
- the individual student qualification, according to tests specified by each University.

The same reform prescribes also that a student can attend the classes of the second level degree only after graduating at the first level; the impact of this change is still not very clear. The Decreto_270 (2004) is also more restrictive about the ECTS, because the maximum number of examinations has been fixed to about 18-20 for the first level degree: this implies that it is very hard to have subjects with less than 6 credits.

It is not yet clear how the Decreto_270 (2004) will be introduced in practice. Two different scenarios can be envisaged, namely:

- the first-level curricula mainly concern basic subjects, and the requirements to enter the second level are very weak. This means that the first level degree is just a break-point, and the new system will eventually coincide with the old five year-course;
- the first-level degree consists of both basic and engineering subjects. The criteria to enter the second level degree are very strict, and only the students with a better qualification can apply to enter. This means that first and second level degrees are in series and to get the first level gives the opportunity to enter the labour market.

1.2 *Admission requirements for higher education*

1.2.1 *Criteria for admission to the first cycle*

The Decreto_509 (1999) has prescribed the possess of a Diploma from any type of Italian High School (Lyceum etc.), or an equivalent title for the students coming from foreign Countries. The Decreto_270 (2004) prescribes that the fundamental competency and ability required to enter the first cycle must be defined. The above requirements mainly concern Mathematics (Calculus, Algebra and Geometry).

In any case, the students should pass an entry test. The test is the same for most Italian Schools of Engineering and is prepared by C.I.S.I.A. ('Centro Interuniversitario per l'accesso alle Scuole di Ingegneria e Architettura').

The students that do not pass the entry test and want to enter a School of Engineering are requested to attend additional pre-classes of Mathematics with a final examination, prior or during the first teaching period. A successful result in such pre-classes is mandatory for the student career.

1.2.2 *Criteria for admission to the second cycle*

As already mentioned, requirements based on the curriculum and the qualification must be specified by each University. As an example, the following requirements are specified by Università di Pisa:

- Curricula at the first cycle: this is mainly relevant for those students coming from other Schools of Engineering, or even different Schools. The criterion is that a minimum number of credits of basic and engineering subjects (i.e. 120 over 180) should coincide with those specified by the curriculum of a given Course of the School to be accessed.
- Individual qualification of students: the criterion is that students with a rank higher than a given threshold can enter the second cycle, while those with a rank below another threshold are not admitted. The two thresholds do not necessarily coincide; in case they differ, those students with a rank falling in between are admitted only after passing an appropriate entry test.

1.2.3 *Criteria for admission to the integrated-programme courses*

The number of students that can enter the integrated-programme courses in 'Building Engineering & Architecture' is limited. Usually, a maximum number of 72 students can be accepted.

Applicant students have to stand a test (by C.I.S.I.A.) and are admitted according to the test ranking, until the fixed maximum number of students.

1.3 *Types of higher education institutions offering engineering education*

The higher education system in Italy is mainly based on State Universities. Fifteen years ago, there existed Schools of Engineering in about 55 State Universities. In the last years, the number of Universities, Schools of Engineering or Campuses has greatly increased, with the attempt to 'drain' the over-crowded Universities. The most representative examples are the following:

- 'Politecnico di Torino' has new-born Schools of Engineering or Campuses spread over cities and town of Piedmont located at a maximum distance of 100 km from Turin (Vercelli, Mondovì, Alessandria and Biella);
- 'Politecnico di Milano' has satellite Schools or Campuses in Como, Cremona, Lecco, Mantova and Piacenza;
- 'Politecnico di Bari' has two new Campuses in Taranto and Lecce;
- University of Bologna has Schools or Campuses in Ravenna, Forlì, Cesena and Rimini;
- the Universities of Rome increased from one to three (Roma La Sapienza, Roma Tor Vergata and Roma3);
- a Second University of Naples was settled in Aversa (15 km from Naples), and a third ('Parthenope') in the city center.

1.4 *Study programmes having geo-engineering subjects in the curricula.*

Teaching programmes in Geo-engineering are offered in the following Courses given in Schools of Engineering:

- Civil Engineering Course (CE);
- Building Engineering Course (BE);
- Environmental Engineering Course (EE);
- Building Engineering & Architecture Course (BE&A), implying a five-year course integrated-programme established by a Law of the European Union.

Geo-engineering is seldom taught in the Schools of Architecture and, more frequently, in those of Geological Sciences (GS). Degrees in Engineering Geology have never been established in Italy. The Courses of Mining Engineering slowly disappeared, after the crisis of the Italian Mining Industry, which started after the end of the II World War.

Table 1 gives a list of Italian Universities where Geo-engineering is taught. The list is probably neither complete nor updated, since it is mainly based on the information available on websites and that given by various colleagues answering to the Authors' inquiry.

Table 1. Italian Universities and Courses where Geo-engineering subjects are taught.

University (website)	CE	BE	EE	BE&A	GS
Politecnico di Bari (www.poliba.it)	X	X	X	X	-
Politecnico di Milano (www.polimi.it)	X	X	X	X	-
Politecnico di Torino (www.polito.it)	X		X		-
Università di Trento (www.unitn.it)	X		X	X	
Università di Trieste (www.units.it)	X	X	X		X
Università di Udine (www.uniud.it)	X		X		
Università di Genova (www.unige.it)	X		X		X
Università di Padova (www.unipd.it)	X	X	X		X
Università di Pavia (www.unipv.it)	X		X	X	X
Università di Bologna (www.unibo.it)	X	X	X	X	X
Università di Parma (www.unipr.it)	X		X		X
Università di Ferrara (www.unife.it)	X		X		
Università di Pisa (www.unipi.it)	X	X		X	X
Università di Firenze (www.unifi.it)	X	X	X		X
Università Politecnica delle Marche (www.univpm.it)	X	X	X	X	
Università di Perugia (www.unipg.it)	X		X		X
Università di Roma La Sapienza (www.uniroma1.it)	X	X	X	X	X
Università di Roma Tor Vergata (web.uniroma2.it)	X	X	X	X	X
Università di Roma 3 (www.uniroma3.it)	X				X
Università dell'Aquila (www.univaq.it)	X		X	X	
Università del Molise (www.unimol.it)		X			
Università del Sannio (www.unisannio.it)	X				X
Università di Napoli Federico II (www.unina.it)	X	X	X	X	X
Seconda Università di Napoli (www.unina2.it)	X		X		
Università Parthenope (www.uniparthenope.it)	X		X		
Università della Basilicata (www.unibas.it)	X	X	X	X	X
Università della Calabria (www.unical.it)	X	X	X	X	X
Università Mediterranea di Reggio Calabria (www.unirc.it)	X		X		
Università di Messina (www.unime.it)	X	X			
Università di Catania (www.unict.it)	X	X	X	X	X
Università di Palermo (www.unipa.it)	X	X	X	X	X
Università di Cagliari (www.unica.it)	X	X	X	X	

2 GEOTECHNICAL ENGINEERING SUBJECTS IN DIFFERENT STUDY PROGRAMMES

Teaching programmes in Geotechnical Engineering can greatly differ among the various Schools, as shown by the examples in Table 2.

In Table 2, the subject 'Geotechnics' most times corresponds to 'Basic Soil Mechanics', typically taught at the first level; in some cases, however, it can be more addressed to geotechnical design. Subjects specifically addressed to applicative problems (for instance, foundations or slopes) are seldom included in the first-level curricula, and often offered at the second level only.

Specializations (branches or even degrees) in Geotechnical Engineering exist in 2nd Level Courses in Civil Engineering, in major Universities.

Some examples of syllabuses relevant to representative subjects (taught at the University of Genoa) are reported in the Annex.

3 DOCTORATE PROGRAMMES IN GEOTECHNICAL ENGINEERING

In Italy there exist Ph.D. programmes in Geotechnical engineering since early '80s. At present, there are three different types of Doctorates:

- Consortium of different Universities with a specific curriculum in Geotechnical Engineering. This is the case of the 'Doctorate School in Geotechnical Engineering' involving all the Universities of Campania Region (Università di Napoli "Federico II", Seconda Università di Napoli, Università del Sannio, Università di Salerno, Università Parthenope).
- Doctorate School of a single University but with different curricula. Representative examples are: the 'Doctorate in Hydraulic and Territory Engineering' at Politecnico di Torino, which includes a curriculum in Geotechnical Engineering; the 'Doctorate of Structural, Seismic and Geotechnical Engineering' at Politecnico di Milano; the 'Doctorate in Sciences and Techniques of Civil Engineering' at Università di Pisa; the 'Doctorate in Constructions' at Università di Napoli Federico II.
- Doctorate School organised by different Universities and offering different curricula. The most significant example is the 'Interpolitecnica School of Doctorate', leaded by Politecnico di Torino and involving Politecnico di Milano and Politecnico di Bari.

Table 2. Examples of teaching programmes in Geotechnical Engineering.

University	Course	Level	Subjects (Credits)
Politecnico di Milano*	CE	1st	Geotechnics (10)
		2nd	Environmental Geotechnics (5), Underground Constructions (5), Foundations (10), Slope Stability (10)
Università di Genova	BE&A	-	Geotechnics (8)
	C&EE	1st	Geotechnics (6), Foundations (5)
	CE	2nd	Soil & Rock Mechanics (5), Foundations & Underground Constructions (5)
	EE	2nd	Soil & Rock Mechanics (5), Foundations & Underground Constructions (5), Environmental Geotechnics (5), Slope Stability (5)
	TE**	2nd	Geotechnics & Infrastructures (5)
Università di Padova	EE	1st	Geotechnics (7)
	BE	1st	Geotechnics (6)
	CE	1st	Geotechnics (10)
	EE	2nd	Soil Mechanics (5), Soil Improvement (5), Environmental Geotechnics (5)
	BE	2nd	Foundations (4)
	CE	2nd	Rock Mechanics (6), Slope Stability (6), Soil Stabilization (6), Retaining Structures (6), Underground Constructions (6)
Università di Ferrara	CE	1st	Geotechnics (6), Foundations (6)
		2nd	Advanced Geotechnics (6), Soil Improvement (6), Slope Stability (6)
Università di Pisa	CE	1st	Geotechnics (9)
		2nd	Slope stability (6), Foundations (9)
	BE	2nd	Geotechnics (9)
	BE&A	-	Geotechnics (6)
Università di Roma La Sapienza	CE	1st	Geotechnics (6), Foundations and Retaining Structures (6), Underground Constructions (6)
		2nd	Soil Dynamics (6), Foundations and Soil Improvement (6), Rock Mechanics (6), Soil Mechanics (6), Deep Excavations and Retaining Structures (6), Slope Stability (6), Geotechnical Design (4.5)
	EE	1st	Geotechnics (6), Rock Mechanics (3), Slope Stability (3)
		2nd	Rock Mechanics (6), Soil Improvement (6), Environmental Geotechnics (6), Rock Slope Stability (6)
	BE&A	-	Geotechnics (9)
	BE	1st	Geotechnics (6)
		2nd	Advanced Geotechnics (6), Foundations and Retaining Structures (6)
Università di Napoli Federico II	CE	1st	Geotechnics (6), Foundations and Retaining Structures (6), Soil Improvement (6), Geotechnical Constructions and Monitoring (6)
		2nd	Soil Dynamics (9), Foundations (9), Retaining Structures and Underground Constructions (9), Slope Stability (9)
	EE	1st	Geotechnics (9), Environmental Geotechnics (3)
		2nd	Environmental Geotechnics (6), Slope Stability (6), Retaining Structures (6)
	BE	1st	Foundations (9)
		2nd	Foundations II (6)
	BE&A	-	Foundations (9)
Seconda Università di Napoli	C&EE+	1st	Soil Mechanics (9), Slope Stability (6), Geotechnics (6)
	CE	2nd	Soil Modelling & Numerical Analysis (6), Foundations (6)
	EE	2nd	Soil Modelling & Numerical Analysis (6), Slope Stabilization (6)
Università di Catania	CE	1st	Geotechnics (9)
	GE++	2nd	Soil Mechanics (6), Soil Dynamics (6), Slope Stability (6), Retaining Structures (6), Foundations (9), Soil Stabilization (6), Environmental Geotechnics (6)
Università di Palermo	CE	1st	Geotechnics (9), Geotechnical Laboratory (3)
	BE	1st	Geotechnics (6)
	EE	1st	Geotechnics (6), Slope Stability (9)
	GS	1st	Geotechnics (6)
	CE	2nd	Advanced Geotechnics (9), Foundations (9), Slope Stability (9), Rock Mechanics (6)
	EE	2nd	Stabilization of soils and rocks (9)
	BE&A	-	Geotechnics (6)

* Only the Civil Engineering Course at the Campus in Milan has been reported.

** Transportation Engineering.

\+ Course in Civil and Environmental Engineering, including three curricula (Civil Eng., Env. Eng., Constructions Eng.). Only the subject of 'Soil mechanics' is compulsory for the three curricula.

++ Geotechnical Engineering.

The Doctorate programme lasts three years, with a possible fourth year extension if needed. In the first year the students are requested to obtain a number of credits (generally no more than 60) in advanced subjects. During the following years, the students are requested to develop a research topic and to produce a final thesis, to be defended in front of a National Commission.

The Doctorate students are supported by a scholarship of about 13.000 €/year, usually funded by the Ministry of Education; however, the scholarships are sometimes sponsored by research funds and seldom made available by other public or private institutions. In most cases, the number of scholarships ranges between 2 and 4 per programme per year.

4 CONTINUING EDUCATION AND TRAINING ACTIVITIES IN GEO-ENGINEERING SCIENCES

After the first and second levels, Master or Master-type programmes in Geo-engineering sciences are offered in many Italian Universities. As an example, it is worth mentioning the Master programmes on: 'Analysis and Management of Geotechnical Systems' (Università di Trento), 'Environmental Engineering and Territory Defense' (Università Mediterranea di Reggio Calabria), 'Analysis, Mitigation and Monitoring of Seismic Risk' (Università di Catania).

Continuing education activities are mostly organized by the Italian Geotechnical Society (AGI, www.associazionegeotecnica.it), usually in conjunction with the Professional Associations of Engineers and Geologists. The topics span from Basic Soil Mechanics to Foundation Engineering, Slope Stability, Environmental or Earthquake Geotechnical Engineering, and so on. In last years, particular care has been increasingly dedicated to the recent updates in geotechnical design procedures, following the introduction of the new National and European codes.

AGI also supports the professionally-oriented continuing education courses organized every two years by Politecnico di Torino, alternatively in Soil Mechanics (CGT) and Rock Mechanics (MIR).

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ANNEX

Examples of Syllabuses at Università di Genova

Course: Civil & Environmental Engineering (1st Level)
Subject: *Geotechnics*
Credits: 6
Objectives:

The main objective is to supply the fundamentals of geotechnical engineering, with particular attention to basic soil mechanics (strength and stress-strain behaviour) and to the main design issues in practice.

Program:

Introduction to geotechnical engineering. Basic aspects of geotechnical structures: retaining structures; foundations. General features of soils and geological processes. Description, identification and classification of soils. Stress states in soils. Pore pressure, effective stress and drainage. Steady and transient flow in a porous medium. One–dimensional consolidation theory. Stress-strain and strength characteristics. Laboratory testing: compression; strength; stiffness. Limit equilibrium method and applications. Settlement prediction.

Abilities:

Analysis of stress and strain. Planning and control of in situ and laboratory investigations. Knowledge of the basic methods to analyze geotechnical problems. Assessment and use of soil parameters in geotechnical analyses. Evaluation of settlement and bearing capacity of shallow foundations.

Course: Civil & Environmental Engineering (1st Level)
Subject: *Foundations*
Credits: 5
Objectives:

The main objective is to supply capabilities for designing and verifying shallow and deep foundations as well as gravity retaining walls. Simplified and practical methods of analysis are considered.

Program:

Shallow foundations: bearing capacity; settlement analysis in cohesive and non cohesive soils; soil-foundation interaction; isolated footing, foundation beams, grid foundation, slabs; structural design of foundation elements.

Deep foundations: types of piles; bearing capacity of a single pile; piled footings.

Earth retaining structures: active and passive earth pressure; other sources for lateral pressure; stability and design of gravity and reinforced concrete walls.

Abilities:

choice of the most suitable foundation type; analysis and design of foundations and retaining walls.

Course: Environmental Engineering (2nd Level)
Subject: *Environmental Geotechnics*
Credits: 5
Objectives:

The main objective is to supply the capability for the identification and analysis of some of the most important natural and anthropic hazards, in the field of geotechnical and environmental engineering. Methods of analyses are supplied as well as the related designing tools to use in practice.

Program:

Natural and anthropic hazards: general aspects and current standards.

Liquefaction: fundamentals of soil dynamics, wave propagation in soils: experimental measurements, large scale analyses, seismic tests, SASW method; dynamic liquefaction; static liquefaction; stability of geotechnical structures; methods for liquefaction assessment.

Soil improvement techniques: pre-loading, dewatering, compaction, grouting, reinforced soil.

Geosynthetics in geotechnical engineering: basic descriptions, functions, functional design.

Geotechnical practice for waste disposal: introduction and Standards (EPA, ETC); classification of landfills; siting considerations; contaminant migration through soil; geotechnical design and construction of landfills: basal lining systems, capping systems, drainage systems; mechanical properties of waste material and waste-liner system; stability of landfills.

Rehabilitation and protection of polluted lands: off-site, on-site, in-site treatments.

Abilities:

Assessment and analysis of natural and anthropic hazards. Planning and design of geotechnical works to protect from the effects of hazards (soil improvement and stabilization, lining and drainage systems in landfills, treatment of polluted soils, etc.).

Course: Civil Engineering (2nd Level), Environmental Engineering (2nd Level)
Subject: *Soil & Rock mechanics*
Credits: 5
Objectives:

The main objective is to supply a deeper knowledge in the fundamentals of soil mechanics, focusing particularly the attention to the mechanical behaviour of soils, analysing the well-established soil models based on the framework of elasto-plasticity. The fundamentals of rock mechanics are treated; the most important aspects related to rock mass analyses are considered as well.

Program:

Fundamentals of Rock Mechanics: characteristics of intact rock; deformability, strength and failure of intact rock; measurements of rock properties; rock mass: discontinuities, natural and induced stresses; rock mass classification methods; deformability, strength and failure of rock masses; established applications.

General features of soil behaviour: elasticity and plasticity in Soil Mechanics: non-linear elastic models; elasto-plastic models; Critical State Soil Mechanics; limit analysis in geotechnical problems; applications to foundation problems; fundamentals of Soil Dynamics.

Abilities:

Development of mechanical schemes for soil behaviour, in order to analyse complex geotechnical problems under generalised soil and stress conditions. Capabilities in understanding and defining analyses for geo-mechanical problems.

Course: Environmental Engineering (2nd Level)
Subject: *Slope Stability*
Credits: 5
Objectives:

The main objective is to supply the capability for the analysis of all the related problems in the field of slope stabilization (identification, stability analysis, design of stabilisation works).

Program:

General aspects related to natural and engineered slopes; Risk Analysis.

Landslides in soil and rock masses: general features, modes of failure, classifications.

Field identification and exploration: field and laboratory tests and measurements, monitoring techniques.

Slope stability concepts and analyses: strength and failure criteria in soils and rock masses; limit equilibrium analyses, numerical methods; stability analyses in partially saturated soils; analysis of landslide triggering mechanisms.

Slope stabilization methods: design, construction and maintenance.

Abilities:

Assessment and analyses of hazards for natural and engineered slopes. Planning and design of geotechnical works for protecting and stabilising from the effects of landslides.

Course: Transportation Engineering (2nd Level)
Subject: *Geotechnics & Infrastructures*
Credits: 5
Objectives:

The course aims to give information about the design of geotechnical structures in roads, railways and airports.

Program:

Natural and artificial slope stability. Seepage problems, methods for lowering the ground-water level, drainage and soil stabilization. In situ ground improvement. Geotechnical problems in embankment design. Road structures. Shaft foundations. Anchors in soil. Special retaining structures. Diaphragm walls.

Abilities:

Design of embankments in soft soils, road structures, foundations of bridges, retaining structures for big excavation of slopes in presence of water

Course: Civil Engineering (2nd Level), Environmental Engineering (2nd Level)
Subject: *Foundations and Underground Constructions*
Credits: 5
Objectives:

The course aims to give information about experimental tests on pile foundations, about foundation design in industrial plants and structures, about shallow and deep tunnels.

Program:

Experimental tests on pile foundations: loading tests, non-destructive tests, interpretation of results. Foundation design: foundations of tanks, plate foundations, floating foundations, foundations of vibrating apparatuses. Tunnelling: methods for tunnel excavation, provisional and final lining, lining design based on rock mass quality, approach by discontinuous and equivalent continuum modelling, general limit equilibrium methods, rock reinforcement and NATM, characteristic curves method.

Abilities

Planning of tests on pile foundations, special foundations design, lining for shallow and deep tunnels.