PhD School - Politecnico di Milano

Regulations of the PhD Programme in:

Environmental and Infrastructure Engineering

Cycle XXXII

Location: Milano Leonardo

1. General Information

PhD School - Politecnico di Milano

PhD Programme: Environmental and Infrastructure Engineering

Location of the PhD Programme: Milano Leonardo

Subjects (SSD):
- ICAR/01 Hydraulics
- ICAR/02 Hydraulic and maritime constructions and Hydrology
- ICAR/03 Sanitary Environmental Engineering
- ICAR/04 Roads, railroads and airports
- ICAR/06 Topography and Cartography
- GEO/05 Applied Geology

PhD School Website: **http://www.polimi.it/phd**

PhD Programme Website: : http://www.dica.polimi.it (http://www.dica.polimi.it/dottorato/dot-amb)

Areas:
01 Water Science and Engineering - SSD ICAR/02 (Hydraulic and maritime constructions and Hydrology)
02 Transport infrastructures and geosciences - SSD ICAR/04 (Roads, railroads and airports) - SSD GEO/05 (Applied Geology)
03 Environmental and Hydraulic Engineering and Geomatics - SSD ICAR/03 (Sanitary Environmental Engineering) - SSD ICAR/01 (Hydraulics) - SSD ICAR/06 (Topography and Cartography)

2. General presentation

Area 01 - "Water Science and Engineering"
The main research activities of "Area 01" are centred on the field of water resources spanning from hydrology to coastal engineering. The research activity constituting the core of the profile is fully recognised by the national and international research community. Research activities place PhD students in the network of international research and allow them to improve the state of knowledge with outstanding work in the fields of hydrological sciences, hydrological extremes, network hydraulic infrastructure as well as maritime hydraulics. The research topics and methodological approach render the student curriculum fully acknowledged by major academic institutions, private enterprises and national and international organisations as demonstrated by career opportunities of former PhD students. A short description of the main research branches is given in the following.

1. *Hydrology and water resources*: addresses in-depth understanding of the main physical processes of the hydrological cycle which determine flood as well as drought phenomena and

pollution migration. Measurement and modeling of variables active in water and energy budgets (radiation, evapotranspiration, snow mantle dynamics, hydrological losses) are carried out. In situ data as well satellite data of the earth's surface are used to understand the processes and their representative scales. Continuous distributed water balance models are developed for simulating and monitoring flood as well drought processes.

2. *Hydrogeological hazard and mitigation strategies* focuses on the analysis of hydrological extremes, frequency of floods, droughts and precipitation. Probabilistic, stochastic and physically based models are used together with field observation to study and reproduce rainfall fields, floods and droughts. Early warning operative systems are developed for shallow land sliding, snow avalanching and flood risk.
3. *Hydraulic networks engineering* addresses the evaluation of design variables for urban sewage and aqueducts. In particular, water quality and quantity in drainage networks and effects of local and diffused structures for flood and pollution controls are investigated. Aqueduct efficiency and monitoring of water losses and pollution in a pressurized network are investigated.
4. *Coastal engineering* addresses the hydrodynamics of wave motion, marine currents, littoral dynamics, wave-structure interactions, Lagrangian and Eulerian numerical models.

Area 02 - "Transport infrastructures and geosciences"

The main research topics considered as fundamental for the development of research activities concerning transport infrastructures could be summed up in four main topics, reciprocally connected to the topics related to other PhD research profiles.

1. *Transport networks*. Complex transport network modelling (both homogeneous and non-homogeneous modal networks), also considering the functional interactions with regional, national and international territory.
2. *Sustainable development*. Analysis of the complex phenomenology characterizing the dynamics of development and its relations with the infrastructure system. Interaction between tunnels and underground hydraulic systems.
3. *Technological innovation*. Analysis of methods, criteria and indicators for the performance characterization of infrastructure construction and maintenance techniques.
4. *Risk management*. Analysis and development of improvement measures concerning both the construction and management of road infrastructures, aimed at reducing risk for both workers and users. Geological risk deriving from the construction of transportation infrastructures.
5. *Applied geology*. a) analysis of the hydrogeological risk linked to the underground excavation in rocks (e.g., water inflow, piezometric drawdown); b) landslide hazard (assessment of the influence of key hydrogeological parameters, such as permeability and heterogeneity coefficient, on slope instability); c) water resources identification and management, pollution problems, also in coastal aquifers.
6. *Methods*: modelling and decision process analysis, at both a strategic, tactical and operative level, characterizing road infrastructure design, construction and management (including Project Management, Pavement Management Systems, Bridge Management Systems).

Area 03 – "Environmental and Hydraulic Engineering and Geomatics"

Research in **Environmental Engineering** covers the following topics:

1. Water supply technology and treatment, wastewater treatment and reuse, liquid waste treatment,

recovery of energy and products from wastewater, liquid waste and sludges, advanced biological and physical-chemical water and wastewater treatment; sludge management and disposal; anaerobic biotechnologies.

2. Management and planning of environmental resources: source apportionment of pollutant loads and assessment of their effects on the receiving water bodies/environmental components; water quality modelling, scenario analysis and knowledge-based decision support systems of management alternatives.
3. Solid wastes and sludge minimization and management (composting the organic fraction of solid wastes, waste-to-energy plants, sanitary landfill, leachate treatment, hazardous waste solidification). Bioenergy from agricultural wastes and by-products.
4. Air quality assessment and control (statistical models of air quality data, source apportionment techniques, sampling and monitoring of fine and ultrafine atmospheric particles, emissions modelling for impact assessment), gaseous emissions treatment technologies (measurement/analysis of conventional and trace pollutant emissions at lab and field scale plants, evaluation of process techniques for pollutants removal).
5. Contaminated soil, sediment and groundwater: characterization, risk assessment, in-situ and on site remediation technologies.

Research topics of **Hydraulic Engineering** include: fluid mechanics; fluid-structure interactions; hydraulic measurements; river hydraulics; hydraulic risk quantification and management; flow and transport processes in porous systems; hydraulic networks. Experimental, modeling and methodological aspects are considered. Key research areas include:

1. *Fluid mechanics*. Emphasis is devoted to the analysis of physical processes observed at various scales and their depiction in the context of appropriate interpretive models. Research and educational activities comprise analysis of advanced methodologies of computational and experimental fluid dynamics (e.g., image analysis techniques for hydraulic processes on multiple observational scales) and modeling of processes of fluid-structure interactions for environmental, civil and industrial engineering applications.
2. *River hydraulics and sediment mechanics*. The key research topics are associated with optimization of approaches and technologies for land protection. Research and educational activities include modeling of free surface flows, local and general scour processes, hyper-concentrated flows, flooding and hydraulic risk quantification and management.
3. *Flow and transport processes in porous systems*. Key research topics include: characterization of hydraulic properties from pore-scale to aquifer systems; well testing; inverse modeling / history matching / data assimilation; flow and multicomponent reactive transport process in heterogeneous media under uncertainty; multiphase flows, including oil and gas reservoir engineering; scaling of hydrogeological quantities; mixing processes in coastal aquifers; geothermal fluxes at the reservoir and basin scales. A major focus is the study of theoretical and operational bases for the assessment of hydro-geo-chemical processes governing the distribution and residence time of solutes and fluids in the subsurface. Critical applications include quantification of environmental risk associated with polluted aquifer systems and the improvement of enhanced oil recovery approaches.

Geomatics includes all disciplines dealing with positioning, global and local reference system establishment, surface surveying and reconstruction from a global scale down to the scale of the

individual architectural manufact, representing data by graphical or virtual tools, archiving and cross-referencing spatial information in terms of geographic information systems. Summarizing, we can identify the following education and research topics:

1. *Physical geodesy and satellite geodesy*, including estimation and representation of the gravity field at all scales and its geophysical interpretation.
2. *Positioning, deformation estimation and navigation*, with the use of both classical and satellite techniques, such as GPS.
3. *Surface surveying with optical or other sensors*, such as SAR, LIDAR, etc., at different scales from regional down to the manufact scale.
4. *Digital photogrammetry and image analysis*, including the development of photogrammetric software for the geometrical reconstruction of surfaces and feature extraction.
5. *Remote sensing*, namely the problem of identifying, by suitable spectral analysis, specific geographic information.
6. *Geographic information systems*, with application of the most modern technology for internet GIS and mobile GIS.
7. *Cultural heritage reconstruction and archiving*, with the solution of complex problems of combination of different data into a unique data base, providing three-dimensional virtual models that preserve full geometrical and metrical information.

3. Objectives

The PhD degree is awarded upon completion of at least three years of advanced study and research. Within the context of these years, a minimum of 30 credits (Section 6) must be acquired through *PhD level courses*. The PhD Programme is structured according to the three areas illustrated in Section 2, i.e., 01 *Water Sciences and Engineering,* 02 *Transport infrastructures and Geosciences,* and 03 *Environmental and Hydraulic Engineering and Geomatics*.

Introductory courses provide the knowledge required as a basis for the general framework illustrated in the PhD Programme and provide the common knowledge background to PhD students. Research training is provided through mentoring by the highly qualified Faculty members. Main elements of the programme include: (*a*) an improved preparation of candidates at the fundamental level, as required by the PhD School, with the introduction of new opportunities for student evaluation through written exercises or oral examinations, and (*b*) development of a close connection with industry to foster the emergence of outstanding professional abilities attractive to industry.

PhD courses will leverage on the long-standing experience and know-how in laboratory activities of the academic board members. Of key relevance are the training and research activities associated with the Laboratories (Section 7).

Contacts with bodies other than Universities have been established through participation to specialized seminars and refresher courses provided by experts from industry, together with short training internships for PhD students at highly qualified companies.

The most qualifying activity of the entire PhD Programme is the development of the thesis/dissertation. This phase should reflect the leading and unconditioned role of research and is fully in line with the requirements and needs of authorities, public bodies and private companies.

The long-desired innovation in ecosystem services and industry should be a long-lasting product of sound research activity which only a University can provide, especially for the benefit of small and

medium-size enterprises which cannot afford the burden of an in-house research centre.
A research experience at International Research Centres and/or Universities is considered to be highly relevant for PhD students to complete their education and to exchange research experience and expertise.

4. Professional opportunities and job market

A PhD in Environmental and Infrastructure Engineering provides highly qualified personnel to cover key positions and roles in research centres, top level management in Public Bodies and Authorities involved in environmental policies, as well as senior consultants for engineering companies.

5. Enrolment

5.1 Admission requirements

Italian and International citizens can apply. They are requested to have graduated in accordance with the pre-existing laws D.M. 3.11.1999 n. 509, or to have a Master of Science degree in accordance with D.M. 3.11.1999 n. 509, or a Master of Science in accordance with D.M. 22.10.2004 n. 270, or similar academic title obtained abroad, equivalent for duration and content to the Italian title, with an overall duration of university studies of at least five years.
The certified knowledge of the English language is a requirement for admission. Please refer to the PhD. School website for details.
According to the guidelines for applications published on the website of the PhD School at the Politecnico di Milano, admission to the program will be based upon the evaluation of candidates curricula, motivation letters and the assessment of a report describing the development of a possible PhD research project. All these documents will be submitted by candidates together with their application to the admission announcement. Applicants are requested to follow the specific rules advertised on the official website of the Politecnico di Milano PhD School.

5.2 Admission deadlines and number of vacancies

The number of vacancies is indicated in the Call for admission to the 32° PhD cycle Programmes: http://www.polimi.it/phd
Scholarships on general and on specific themes are available, in accordance with the contents of the call for admission.

6. Contents

6.1 Requirements for the PhD title achievement

The achievement of the PhD title in Environmental and Infrastructure Engineering requires a study and research activity of at least three years equivalent of full time study, research and development of PhD thesis. The PhD in Environmental and Infrastructure Engineering requires a minimum of 30 credits from PhD level courses to be acquired as illustrated in Section 6.3. Additional credits may be attained by participation to national and international seminars and summer schools; these are subject to *a posteriori* assessment by the tutor.

6.2 Research development

The main aim of all Politecnico di Milano PhD programmes is the development in the candidates of a research-oriented mind-set, with expertise and skills in a specific research topic. To this end, candidates develop a problem-solving capability in complex contexts, including the capacity of performing deep problem analysis, identifying original solutions, and evaluating their applicability in practical contexts.

These skills provide the PhD candidates with major opportunities of development in their research both in the academic field, and in public and private organizations.

PhD candidates are requested to develop an original research contribution. The PhD thesis must thus contribute to increase the knowledge in the candidate's research field. Besides, it has to be coherent with the research topics developed in the Department where the PhD Programme is carried out.

The original research results are collected in the PhD thesis, where the candidate's contribution is put in perspective with respect to the research state of the art in the specific research field.

The PhD research is developed under the guidance of a supervisor, who supports the candidate in the setting-out and in the everyday activities related to the thesis development. The supervisor is not necessarily a member of the Board of Professors, and may also belong to an institution different from the Politecnico di Milano. The supervisor can be supported by one or more co-supervisors.

To develop the capability of carrying out research activities, candidates must earn a minimum of 30 credits from (PhD level) courses coherent with their PhD programme. To each candidate admitted to the programme, a tutor, belonging to the Board of Professors, is appointed. The supervisor and the tutor may coincide.

The tutors supervise and support the candidates for the whole duration of their training path. They assist the candidates in the selection of courses to be included in their study plan. The latter must be approved by the Coordinator of the PhD Programme.

Further activities intended to develop the candidate's personal skills and research expertise are encouraged during the PhD path.

Candidates must acquire the capability to present and discuss their work in their research community. Participation to international conferences and publication of research results in peer-reviewed journals are encouraged.

The PhD programme favors the candidates' research interactions with other groups in their research field, preferably abroad. Research visits of at least three months are strongly encouraged, as through them the candidates may acquire further skills to develop their research work and thesis.

The duration of the programme is typically three years.

6.3 Objectives and general framework of the teaching activities

The PhD Programmes and the PhD School activate teaching forms of different kind and credit value, including courses, seminars, project workshops, and laboratories. Teaching activities cover the basic research challenges (problem setting, theoretical framework, methods), which represent the founding element of the PhD Programme and identify clearly its cultural position. Classes are usually held in English, except when otherwise announced. The PhD programme includes at least one complete path delivered in English language.

Structured teaching activities enable a candidate to earn ECTS credits. Other activities, typically specialized and for which it is difficult to quantify learning, fall within the scientific activities which the PhD Board of Professors considers in the overall evaluation. Note that these do not allow earning

ECTS.

First and second year

The following tables illustrate the educational training activities which are typically foreseen for PhD candidates during the first and second years of the programme. The programme requires that each candidate focuses on research activities in a continuous manner, in collaboration with his/her supervisor and the PhD Board of Professors.

Courses and other activities	*Details*	*Number of credits (min)*
Courses characterizing the PhD Programme	*See Table A*	*15*
PhD School Courses	*See Table B*	*5*
Other PhD Courses	*See Table C*	*0*
Other activities	*Participation to conferences, national and international summer schools*	*0*

PhD Course List

A) The PhD Programme in Environmental and Infrastructure Engineering offers a series of **Characterizing Courses** (see Table A). Acquisition of a minimum of 15 credits associated with such courses is **mandatory** for the admission to the final exam.

B) The **PhD School** organizes each year general and **Interdoctoral courses** and courses with foreign professors. Acquisition of **at least 5 credits** among courses of the B type **is mandatory**. The list of PhD courses organized by the PhD School is available at http://www.dottorato.polimi.it/en/during-your-phd/phd-school-courses/

C) Other PhD courses. Example: 5 of the 30 mandatory credits can be obtained from type A or B PhD courses or from other courses offered by other PhD programmes of the Politecnico di Milano and/or external entities (in this case prior approval of the supervisor, of the tutor and of the coordinator is required).

Third year

The third year is typically devoted to research and development of the PhD thesis.

PREPARATORY COURSES

The supervisor and the tutor might require that the candidate attends preparatory courses (typically selected among the courses which are active at the Politecnico di Milano). The Academic Board of the PhD programme can then assign a number of extra-credits to be acquired for completion of the training programme. There is only one course delivered by the PhD which can be considered of this kind. This is a short, 3 credits introductory course illustrating the general research activities carried on in the different areas defining the programme. These credits will be considered as additional to the

mandatory credits to be acquired with PhD courses.

SPECIALISTIC COURSES, LONG-TRAINING SEMINARS

The attendance of Specialist Courses, Workshops, Schools, Seminars cycles is strongly encouraged and (if these seminars, workshops are certified and evaluated) may permit to acquire credits according to the rules established by the Board of Professors and prior approval of the study plan submitted by the candidate. These courses and workshops can be inserted in the study plan as optional "additional teaching", even as they are not subject to formal evaluation (and therefore not qualified as credits).

A detailed list of courses which will be active during the 2016-17 and 2017-18 academic years is provided in Table A. It is possible that additional courses be activated by the PhD School. In this case candidates will be promptly informed to enable them to insert these new courses in their study plan.

Table A: PHD COURSES CHARACTERISING THE PHD PROGRAMME

SSD (optional, also more than one)	**Course**	**Professor** (optional)	**A.Y./Semester**	**Credits**
ICAR/06	Monte Carlo-Markov chains statistical methods (2 integrated modules)	G. Venuti M. Reguzzoni	Alternate years	5
ICAR/02	Modelling Extremes and Dependence in Multivariate Problems	C De Michele G. Salvadori F. Durante		5
ICAR/06	Statistical and numerical methods (2 integrated modules)	R. Barzaghi G. Venuti		5
ICAR/01	Fluid mechanics	V. Armenio	Alternate years	5
ICAR/01	Groundwater	A. Guadagnini	Alternate years	5
ICAR/01	Granular Matter: from packing to flow (2 integrated modules)	D. Berzi C. di Prisco		5
ICAR/02	Sustainable Urban Water Systems	G. Becciu J. Sansalone		2

ICAR/02	Water and Food Security	M.C. Rulli		3
ICAR/02	Remote Sensing in Hydrology (2 integrated modules)	M. Mancini C. Corbari		2
ICAR/02	Hydrology of Alpine areas	D. Bocchiola		5
ICAR/02	Sea Waves and Hydropower (2 integrated modules)	A. Bianchi G. Passoni		4
ICAR/03, BIO/07, BIO/19	Environmental Chemistry and Applied Microbiology	M. Antonelli	Alternate years	6
ICAR/03	Environmental reactors and biological processes applied to environmental-sanitary engineering (2 integrated modules)	E. Ficara R. Canziani	Alternate years	4
ICAR/03	Statistics applied to Environmental Engineering	A. Azzellino	Alternate years	5
ICAR/04	Road material performances characterization	E. Toraldo	Alternate years	6
ICAR/04	Pavement Management System	F. Fiori	Alternate years	6
ICAR/06	Positioning	B. Betti		5
ICAR/06	Advanced Geographycal Information Systems	D. Carrion	Alternate years	5
ICAR/06	Photogrammetry and Image Analysis	L. Pinto V. Casella	Alternate years	5
ICAR/06	Data Processing meets Human Sciences	L. Mussio		5
ICAR/06	Geospatial Web, Geo Big Data and Citizen-generated Geographic Information	M.A. Brovelli		6
ICAR/06	Satellite geodesy	F. Migliaccio	Alternate years	4

ICAR/06	DTM generation	R. Barzaghi	Alternate years	4

Table B SUGGESTED CROSS –SECTORAL COURSES

SSD (optional, one or more)	Name of the Course	**Professor** (optional)	Semester	Language	Credits
	All courses offered by the PhD School of the Politecnico di Milano can be selected				

Table C OTHER PhD COURSES (only if applicable)

SSD (optional, one or more)	Name of the Course	**Professor** (optional)	Semester	Credits
	All courses offered by all PhD programmes of the Politecnico di Milano and/or external organizations(*)			

(*) prior approval of the supervisor, of the tutor and of the coordinator is mandatory.

6.4 Presentation of the study plan

Each PhD candidate is required to submit his/her study plan to the PhD Programme and PhD School. The candidate will have the opportunity to review it periodically (i.e., every three months) to gear it to possible changes of the training offer or to needs motivated by the development of his/her study plan. The study plan is approved by the Coordinator of the PhD programme, according to the rules established by the Board of Professors of the PhD Programme.

6.5 Yearly evaluations

The candidate is subject to yearly evaluations for admission to the following year. Admission of the candidate to the final exam (held by the external Commission) is assessed on the basis of the third-year evaluation. Admission of first-year students to the second year of the PhD Programme is based on the examination of student activities and a written report which will be approved by the student tutor. Admission to the third (and possibly following) year is additionally associated with an oral presentation of the candidate who presents his/her work to the Academic Board. After each yearly evaluation, the candidate will receive an evaluation mark (A/B/C/D). In the case of insufficient marks the candidate will be qualified as a "Repeating candidate (Er)" or "not allowed to continue with the PhD (Ei)". After completion of the three years, candidates having achieved sufficient results but requiring additional time to complete/write their thesis may obtain an extension up to a maximum of 12 months.

6.6 PhD thesis preparation

Full time study and research activities will be performed during the three years of the PhD programme. The possibility of internships or study periods at Italian or foreign companies/research institutions/universities is foreseen. The main objective is the development of an original research contribution. The PhD thesis should contribute to increase the knowledge in the research field of the candidate. The thesis should be consistent with the research activities developed in the department within which the PhD programme is carried out. The candidate will present the original thesis to a board of examiners, discussing his/her contribution to the state of the art in the research field. The PhD research will be developed with the mentorship of a supervisor, who will provide the day-to-day support required by the PhD student and assist in defining the educational objectives and research work. Admission of the candidate to the final exam will be evaluated by the Academic Board upon termination of studies. A final exam for attainment of the PhD is then required in which the research work and the thesis will be evaluated by an examination Committee composed by at least three members (at least two of the Committee members should not belong to the PhD Programme).
Candidates who receive a positive evaluation submit their theses to two external reviewers for refereeing. If the evaluation provided by the reviewers is positive (or after the revisions required by the external reviewers), the candidates defend their thesis in a final exam, in front of a Committee composed of three members (at least two of which must be external experts).

7. Laboratories, PhD Secretary Services

Laboratory Gaudenzio Fantoli

The ***Laboratory Gaudenzio Fantoli*** hosts activities related to Hydraulic Engineering and Water Science Engineering. It was first established in 1939. It comprises areas devoted to research and educational activities. Two main floors, each covering an area of about 800 m^2, are currently devoted to laboratory activities. The Lab staff comprises 4 people. Major hydraulic facilities include:

- *Free surface flume*: a 30m $\times$ 1.0m $\times$ 0.6m flume with adjustable floor and glass sides, a fixed floor flume with glass sides. It is provided with the tools to convert the structure into a wave flume (piston wavemaker, artificial beach, wave gauges).
- *Hydraulic channel:* a 6 m × 0.5 m × 0.5 m free surface flume designed for studying fluid-structure interaction by means of direct measurement of forces, stress distributions, displacements and velocity distributions. Image analysis techniques are employed for kinematic measurements.
- Test plant for flow resistances: a water flow loop, provided with flowmeter and pressure transmitters, dedicated to measure the loss coefficient and other characteristics of regulation devices (including, *e.g.* valves, resistors, connectors). The plant is also equipped with high pressure pumps.
- *Transparent pressurized duct*: specifically built for sediment transport and scour experiments with image processing measurements. The duct length is 5.8 m with a cross section 40 cm wide and 16 cm deep. In the central part of the duct is a recess section with a length of s2 m and depth of 0.5 m. The hydraulic head in the duct is imposed by a Bazin weir located in the downstream tank; the upstream tank is provided with a streamlined inlet to avoid wakes in

the flow.

- *Dam-break flume*: used to investigate the dam-break wave (unsteady flow) of a hyperconcentrated mixture of water and cohesionless granular matter. It consists of a 6 m long, square section (0.5 x 0.5 m) flume of adjustable slope. Failure of the dam is simulated by means of a pneumatic rising sluice-gate (opening time t = 0.3 s). One of the side walls of the flume is made of glass in order to record of wave propagation by means of a digital camera.
- *Rotating drum*: this device is used to investigate the behavior of a steady dry granular flow over a loose bed. It consists of a cylinder (inner diameter D = 1 m and axial length W = 250 mm) half-filled with granular material, which is mounted on a pair of friction rollers and rotates around its axis at a constant angular velocity. One of the endplates of the cylinder is made of 10 mm thick glass to allow optical measurement of the flow fields through a progressive CCD scan camera.

Other site facilities include: a series of calibrated basins with a total capacity of 50 m^3, a computer centre, an electronics workshop for construction and repair of instrumentation; a mechanical workshop for the construction of experimental facilities, laboratory instrumentation for measuring most hydraulic parameters (including an automated system to detect and measure river-bed shapes), and field instrumentation to measure hydrodynamic processes. The Lab has been certified within the SQA (Quality Assurance Protocol of the Politecnico) within the context of hydraulic parameter measurements, determination of characteristic curves of hydraulic machinery and field and laboratory scale flow rate determination. The laboratory is a SIT certified Calibration Centre for measurement of liquid flow rates (range: 3-80 l/s). Finally, a total free area of 600 m^2 is available for set-up of hydraulic models. The area is served by an overhead traveling crane of 1500 kg_p and by a piping system allowing a maximum flow rate of about 600 l/s.

Laboratory of Environmental Engineering (LIA – Laboratorio di Ingegneria Ambientale[m1])

It hosts activities related to Environmental Technologies. It currently covers 580 m^2 and is divided into two sections: the analytical section with different working areas (wet chemistry, sample preparation, analytical instrumentation, and biology) and the pilot-plant section. The Laboratory staff comprises 3 permanent staff (2 graduates) and one temporary position (graduate). The main activities of Laboratory are: (a) sampling and determination of pollutants in different environmental matrices (water, air, soil, sludge, solid waste); (b) evaluation of remedial technologies with laboratory pilot plants; (c) planning and management of demonstrative wastewater treatment pilot plant; (d) tests of biodegradation and treatability of wastewaters by means of titration/respirometric sensors an BMP (biomethane potential); (e) tests for the characterization of sludge and digestates with CST (capillary suction time), filtration apparatus and a zetameter. Analytical instrumentation includes: electrometry, nephelometry, molecular absorption spectrophotometry, atomic absorption spectrometry, liquid chromatography (ionic and HPLC), gas-chromatography, X-ray spectrometry, polarography, voltammetry, TOC analyser, ion-coupled plasma mass Spectrometry (ICP-MS). The Laboratory is also equipped with instrumentation for sampling of liquid, solid and gaseous pollutants.

The pilot plant section is equipped with: aerobic and anaerobic instrumented bioreactors for activated sludge and fixed biomass processes, membrane bioreactors, batch reactors for contaminated soil remediation, reactors for chemical oxidation and water disinfection, biosensors for the study of microbial activity. Experimental activity through pilot-plants is frequently carried out at public institutions and private firms.

Road Research Laboratory (RRL)

The Road Research Laboratory (RRL) refers to the Road Infrastructure Section and performs experimental activities associated with road materials (soils, rocks, inerts, binders, asphalt concrete, cement bound materials and cement concrete), soil analysis (sub layers, foundations and rises), pavement analysis, preliminary and validation investigations concerning road, railway and airport works as well as dumps and embankments. The RRL has at its disposal equipment for qualification and characterization tests related to road materials, such as inerts, soils, bituminous binders, asphalt and cement concrete. The RRL also has equipment for in-situ tests, such as bearing capacity, roughness and adherence, for the quality control of materials and working phases, in accordance with current Italian and European regulations.

The RRL is also equipped with a full scale test area of approx. 50000m² in Carpiano (MI), at the Bacchi Enterprise, and also with equipment, work machines and plant for the implementation of full scale tests regarding road, railway and airport infrastructures (pavement, sub layer, etc.). This area is used for full scale tests when the limits of the laboratory scale need to be overcome, checking the critical states of construction techniques as well as validating laboratory tests. Much experimental analysis already carried out and in progress in the full test area show the remarkable potential and effectiveness of full scale testing which could be effectively use for both internal and commissioned research, under the control of the RRL. Adjacent to the full scale test area is a fully equipped laboratory for carrying out further traditional tests on road materials (soils, inerts, cement and asphalt concrete, etc.), as well as innovative tests (flexion and indirect tensile fatigue tests, complex modulus, dynamical creep, etc.). The laboratory directly cooperates with plants producing asphalt and concrete cement in order to test real mixtures and overcome the limits due manufacturing mixtures in the laboratory.

Laboratory of Geomatics

The recent development of the subject has fostered activities in new fields of advanced research such as spatial geodesy, navigation, photogrammetry, remote sensing, numerical cartography, geographic information systems (GIS), as well as a return to the field of geophysics. This research is conducted by the Department with the support of structures such as:

- the International Service for the Geoid, which can be considered as an IT laboratory for the gravity field
- the laboratory of geomatics, which is partly instrumental and partly IT.

The main instruments, software and activities conducted in the laboratory are illustrated in the following.

Surveying and monitoring: GPS instrumentation from a permanent station to low cost receivers; measurements to monitor ground, buildings and structures; photogrammetric surveying of architectural manufacts; thematic mapping; infrastructure land registry.

Data management and interpretation: Gravimetric data interpretation; geoid determination; spatial mission analysis; GPS permanent network analysis; Statistical methods in surveying and monitoring; integration of images and maps; management of GIS data bases; evaluation of uncertainty and reliability.

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8. Internationalisation and other activities

The PhD Program strongly encourages research and educational collaboration with other Universities / Research Institutions. The Politecnico di Milano 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.

Attachment A1 – PhD Board of Professors

Description of the composition of the Board of Professors

Name	**Affiliation**	**SSD / Title of SSD**
Guadagnini Alberto (coordinator)	Politecnico di Milano - DICA	ICAR/01 Hydraulics
Azzellino Arianna	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering
Ballio Francesco	Politecnico di Milano - DICA	ICAR/01 Hydraulics
Barzaghi Riccardo	Politecnico di Milano - DICA	ICAR/06 Topography and Cartography
Becciu Gianfranco	Politecnico di Milano - DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Betti Barbara	Politecnico di Milano - DICA	ICAR/06 Topography and Cartography
Bocchiola Daniele	Politecnico di Milano - DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Canziani Roberto	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering
Cernuschi Srefano	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering
Crispino Maurizio	Politecnico di Milano - DICA	ICAR/04 Roads, railroads and airports
De Michele Carlo	Politecnico di Milano - DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Malavasi Stefano	Politecnico di Milano - DICA	ICAR/01 Hydraulics
Malpei Francesca	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering
Mancini Marco	Politecnico di Milano - DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Migliaccio Federica	Politecnico di Milano - DICA	ICAR/06 Topography and Cartography
Mussio Luigi	Politecnico di Milano - DICA	ICAR/06 Topography and Cartography
Papini Monica	Politecnico di Milano - DICA	GEO/05 Applied Geology
Riva Monica	Politecnico di Milano - DICA	ICAR/01 Hydraulics
Rulli Maria Cristina	Politecnico di Milano - DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Saponaro Sabrina	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering
Scesi Laura	Politecnico di Milano - DICA	GEO/05 Applied Geology
Venuti Giovanna	Politecnico di Milano - DICA	ICAR/06 Topography and Cartography

Attachment A2 – PhD Advisory Board

Description of the composition of the Advisory Board

Name	Affiliation
Sanchez-Vila Xavier	Politechnical University of Catalonia, Barcelona (SP)
Ruffo Paolo	ENI
Sansalone John J.	Florida University
Burlando Paolo	ETH Zurigo
Marino Carlo	ARPA Lombardia
Bortone Giuseppe	Regione Emilia Romagna
Fanelli Roberto	Istituto M. Negri, Milano
Bernet Nicolas	LBE – INRA, Narbonne (F)
Losa Massimo	Università di Pisa
Marti Urs	SwissTopo, Berne (CH)
Dermanis Athanasios	Aristotle University of Thessaloniki (GR)
Radicioni Fabio	Università di Perugia

The Advisory Board has not been formally convened during the year 2015. Due to the structure of the PhD Programme, individual members of the Advisory Board have been invited to events associated with research /educational activities developed within the context of the diverse PhD Areas. This has enabled dynamic assessment of the quality of progresses and structure of the PhD programme as a whole and with reference to its key components. Prof. Sanchez-Vila was on sabbatical at the Department of Civil and Environmental Engineering (DICA) during the year 2015 and was actively involved in the PhD Programme meetings and activities.

Prof. Sansalone gave a course (see Table A, XXXI and XXX cycle) on June 2015, as he did in 2014 and will probably do in 2016.

Prof. Dermanis was at DICA as visiting professor at the end of both 2014 and 2015 and was involved in a segment of a PhD course (“Positioning”); he participated as examiner in several defense boards in the past years.