POLITECNICO DI MILANO

PhD School of the Politecnico di Milano

Regulations of the PhD Programme in:

Environmental and Infrastructure Engineering
Cycle XXXI

Location: Milano Leonardo

1. General Information

PhD School of the 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 of the PhD Programme

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. *Hydraulic and 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, disposal and reuse of wastewater, advanced biological and physical-chemical water and wastewater treatment; sludge management and disposal; anaerobic digestion processes.
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. Phenomenology of atmospheric environment and treatment of gaseous emissions: statistical models of air quality data, sampling and speciation of fine particulate in the atmosphere, emission models from mobile sources, emissions of micro-pollutants from waste incineration processes, organic volatile control by biofiltration techniques.
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 credits, 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 needed as a basis for the general framework presented 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 exploit 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 should provide 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 at the PhD Programme

5.1 Admission requirements

Italian and foreign citizens can apply. They are required 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 according to D.M. 3.11.1999 n. 509 or a master of science according to D.M. 22.10.2004 n. 270 or an equivalent academic title obtained abroad (equivalent for duration and content to the Italian title and for an overall duration of university studies of at least five years).
The certified knowledge of the English language is a requirement for admission. Applicants should refer to the Ph.D. School web site 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 the curricula of the studies, a motivation letter and the assessment of a paper 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 31° cycle of PhD Programmes, as published on the official website of the Politecnico di Milano - PhD School: http://www.polimi.it/phd.
Scholarships, both on general and on specific themes/topics, are available, according to the call for admission.

6. Contents of the PhD Programme

6.1 Requirements for the attainment of the title

Completion of the PhD curriculum in Environmental and Infrastructure Engineering requires a full time equivalent of at least three years, including development of study and research activities associated with the PhD thesis. The PhD in Environmental and Infrastructure Engineering foresees 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 Development of the research and of the PhD thesis

The aim of PhD programmes at the Politecnico di Milano is the development of a research-oriented mind-set in candidates, with expertise and skills in specific research topics.

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 of development in their research both in the academic field and in public and private organizations.

The main objective is the development of an original research contribution. The PhD thesis must contribute to increasing knowledge in the research field of the candidate. In addition, it must be coherent with the research topics developed in the department within which the PhD Programme selected by the candidate is hosted. Results of research activities must be submitted via the PhD thesis which contains and discusses the original contribution.

The PhD research will be developed under the guidance of a supervisor, who supports the candidate in the setting-out and in the everyday activities regarding the 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 Politecnico di Milano. The supervisor can be supported by one or more co-supervisors.

The PhD student is required to attend courses according to the PhD programme requirements. Credits are acquired after positive evaluation following formal examination associated with the course.

A member of the Academic Board is appointed as tutor to each candidate admitted to the program. The tutor supervises and supports the candidate during the overall training path and informs the Academic Board on the progresses of the candidate, including the assignment of credits for his/her activity. A supervisor belonging to the PhD Academic Board can also act as tutor. The selection of courses will be overseen by the tutor and will be formalized in a study plan and approved by the Coordinator of the PhD Programme.

Other activities for the development of personal skills and research expertise are encouraged during the PhD programme. The candidate must acquire the capability to present and discuss his/her work in his/her research community. Participation to international conferences and exposure of research results in international peer-reviewed journals are required.

Candidates are also encouraged to perform part of their research activities in the context of collaborations with international research groups in their field of interest. Research visits of at least three months at internationally recognized research groups are strongly encouraged. The duration of

the programme is typically three years.

6.3 Objectives and general framework of the teaching activities

The PhD Programme and the PhD School may activate diverse types of training activities (courses, seminars, project workshops, laboratories). These activities 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 setting;
- providing improved knowledge on key research issues connected with the problems developed in the thesis.

Classes are provided in English. The PhD programme foresees at least one path which is completely offered in English. Some teaching activities allow acquiring ECTS credits (structured teaching activities). A set of activities (typically specialized seminars and participation to Conferences and Workshops) are directly evaluated by the PhD School Board and the resulting grade is not quantified in terms of ECTS.

The PhD programme offers students a number of PhD level courses on methodological subjects which are shared by all five areas. Additional credits are obtained from courses offered by the PhD School, following the guidance of the tutor. Each area offers a series of specific courses. All institutional courses are associated with an evaluation (grade A-B-C-D) of each student by the course instructor.

The following tables illustrate the educational training activities which are typically foreseen for PhD candidates. 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*

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*** organises every 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).

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

A detailed list of courses which will be active during the 2014-15 and 2015-16 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 CHARACTERIZING 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		5
ICAR/02	Modelling Extremes and Dependence in Multivariate Problems	C De Michele R. Rosso G. Salvadori F. Durante		5
ICAR/06	Numerical methods	L. Mussio		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	D. Berzi; F. Calvetti 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	M. Mancini C. Corbari		2
ICAR/02	Hydrology of Alpine areas	D. Bocchiola		5
ICAR/02	Sea Waves and Hydropower	A. Bianchi G. Passoni		4
ICAR/02	Dam and Reservoir Engineering	R. Rosso		2
ICAR/02	Climate Change Hydrology	R. Rosso		2
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	E. Ficara R. Canziani	Alternate years	4
ICAR/03	Statistics applied to Environmental Engineering	A. Azzellino	Alternate years	5
ICAR/04	Methods of laboratory experimental analysis	M. Crispino		6
ICAR/04	Road material performances characterization	E. Toraldo		6
ICAR/04	Pavement Management System	F. Fiori		6
ICAR/06	Positioning	B. Betti		5
ICAR/06	Advanced Geographycal Information Systems	D. Carrion		5
ICAR/06	Photogrammetry and Image Analysis	L. Pinto V. Casella		5
ICAR/06	Data Processing meets Human Sciences	L. Mussio		5
ICAR/06	WebGIS and Geoservices	M.A. Brovelli		4
ICAR/06	Satellite geodesy	F. Migliaccio		4
ICAR/06	DTM generation	R. Barzaghi		4

Table B - SUGGESTED CROSS –SECTORAL COURSES OR WITH A FOREIGN PROFESSOR

SSD (optional, also more than one)	***Course***	***Professor*** (optional)	***A.Y./Semester***	***Language***	***Credits***
	All courses offered by the PhD School of the Politecnico di Milano can be selected				

Table C - OTHER PhD COURSES

SSD (optional, also more than one)	***Course***	***Professor*** (optional)	***A.Y./Semester***	***Language***	***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 Instructions for the yearly exam

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 Other foreseen reviews

N/A

6.7 Instruction for the preparation of the PhD thesis

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 mentoring 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).

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 × 1.0m × 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 Sanitary and Environmental Engineering (LISA – Laboratorio di Ingegneria Sanitaria-Ambientale)

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 and a microcalorimeter. 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. Internationalization and other activities

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

Attachment A1 – PhD Board of Professors – Collegio dei Docenti

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 Stefano	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

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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
Colomina Ismael	Instituto de Geomatica de Catalunya (SP)
Dermanis Athanasios	Aristotle University of Thessaloniki (GR)
Radicioni Fabio	Università di Perugia

The Advisory Board has not been formally convened during the year 2014. 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 is on sabbatical at the Department of Civil and Environmental Engineering for the year 2015 and will be actively involved in the PhD Programme meetings and activities.
Prof. Sansalone will give a course (see Table A) on June 2015, as he did in 2014 and will do in 2016.
Prof. Dermanis was at DICA as visiting professor at the end of 2014 and was involved in a segment of a PhD course ("Positioning"); he participated as examiner in several defense boards in the last years.

Attachment A3.1 (Only for courses of new activation or with substantial changes)

Summary Form

Year	2015/2016		
Assignment type	Doctoral		
Course	Modelling Extremes and Dependence in Multivariate Problems		
Professor	C. De Michele/R. Rosso/G. Salvadori/F.Durante		
Cfu	5.00	Course type	Monodisciplinary

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Modelling Extremes and Dependence in Multivariate Problems

Detailed Programme and foreseen learning results:

MODELING EXTREMES AND DEPENDENCE IN MULTIVARIATE PROBLEMS

1) UNIVARIATE EXTREME VALUE THEORY (1.1 Order Statistics 1.2 Extreme value theory and asymptotic extreme value distribution 1.3 Return period, Hazard and Risk) with examples from hydrology, geosciences, finance and economics.

2) MULTIVARIATE EXTREME VALUE THEORY (Multivariate Extreme Value Distributions 2.2 Characterizations of the domain of attraction 2.3 Multivariate dependence 2.4 Multivariate return periods).

3) COPULAS (3.1 Copulas and Sklar theorem; 3.2 Archimedean copulas; 3.3 Return periods via copulas, and the concept of dynamic return period; 3.4 Tail dependence; 3.5 Extreme value copulas; 3.6 Simulations of multivariate random samples). Examples selected from hydrology, geosciences, finance and economics will be illustrated.

4) DEPENDENCE (4.1 concepts of dependence in bivariate and multivariate framework; 4.2 Measures of association in bivariate and multivariate framework). Examples from hydrology, geosciences, finance and economics.

5) HAZARD, RISK and DESIGN IN MULTIVARIATE PROBLEMS (5.1 multivariate design quantile; 5.2 design of engineering works in multivariate framework; 5.3 verification of engineering works in multivariate framework; 5.4 Hazard trajectories and Hazard Fan; 5.5 evaluation of the risk and structural risk in multivariate framework). Examples selected from hydrology, geosciences, finance and economics will be illustrated.

Bibliography

Extremes in nature: an approach using copulas - 2007, by G. Salvadori, C. De Michele, N.T. Kottegoda and R. Rosso, edited by Springer.

Teaching Mix

Didactical issue type	Didactical hours
Lesson	25
Training	0.0
IT laboratory	0.0
Test laboratory	0.0
project	20
Project laboratory	0.0

Information in English to support internationalisation

Course completely offered in English
Study material/slides available in English
Textbook/Bibliography available in English
It is possible to take the examination in English
Support available in English

Notes about the evaluation modalities

Oral presentation and discussion of an individual project based one or more topics addressed in the course.