POLITECNICO DI MILANO

PhD School of Politecnico di Milano

Regulations of the
PhD Programme in Environmental and Infrastructure Engineering
XXX Cycle

Campus: 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 Hydraulic Engineering** - SSD ICAR/01 (Hydraulics)
02 Hydrology, hydraulic constructions, water resources and coastal engineering - SSD ICAR/02 (Hydraulic and maritime constructions and Hydrology)
03 Environmental technologies - SSD ICAR/03 (Sanitary Environmental Engineering)
04 Transport infrastructures and geosciences - SSD ICAR/04 (Roads, railroads and airports)- SSD GEO/05 (Applied Geology)
05 Geomatics - SSD ICAR/06 Topography and Cartography

2. General presentation of the PhD Programme:

Area 01- "Hydraulic Engineering"

Major research topic of Hydraulic Engineering include: fluid mechanics; fluid-structure interactions; hydraulic measurements; river hydraulics; hydraulic risk assessment 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 analysis.

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; flow and multicomponent reactive transport process in heterogeneous media under uncertainty; multiphase flows; 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 in the subsurface to provide the building blocks for reliable technologies to mitigate environmental risk and restore polluted aquifer systems.

Area 02 - "Hydrology, hydraulic constructions, water resources and coastal engineering"

The main research activities of "Area 02" 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 03 - "Environmental technologies"

The full range of research topics offered in this area covers the following:

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).
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 soils and their remediation, groundwater protection and treatment: risk assessment related to contamination levels of soil and its use, sampling methodologies, statistical analysis and mapping of contamination data, in-situ and on site bio-remediation.

Area 04 – "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: modeling 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 05 – "Geomatics"

This wide-ranging area 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 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 Ph.D. is awarded upon completion of at least three years of advanced study and research for a total of 180 credits. Out of these 180 credits, a minimum of 30 credits (Section 6) must be acquired through *PhD level courses*. A key objective of this PhD Curriculum is the development of autonomous research abilities of the PhD student in the context of inter- and multi-sectoral subjects. The PhD Programme is structured according to the five areas illustrated in Section 2, i.e., *Hydraulic Engineering*, *Hydrology, hydraulic structures, water resources and coastal engineering*, *Environmental technologies*, *Transport infrastructures and Geosciences*, and *Geomatics*.

Introductory courses provide the preparatory knowledge needed as a basis for the general framework presented in the PhD Programme and provide the common knowledge background to Ph.D. students that may be derived from various branches of Engineering and related fields. Research training is provided through mentoring by highly qualified Faculty members. Key elements of the programme include: (a) an improved fundamental preparation of candidates, 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.

To fulfil the education needs required by any researcher operating in the field of environmental and civil engineering, a proper balance of educational activities is very delicate, mainly due to the wide cultural base required.

PhD courses will exploit the long experience and know-how in laboratory activities of the academic board members and will offer training activities on essential research tools such as the Environmental, Hydraulics and Engineering and Geomatics Laboratory, Environmental Monitoring, Environmental Reactors.

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 Ph.D. students at highly qualified companies.
The most qualifying activity of the entire Ph.D. Programme is the development of the thesis. This 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 autonomous research centre.
A research experience at International Research Centers and/or Universities is considered essential for Ph.D. 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 centers, 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 requested to have graduated in accordance with the pre-existing laws D.M. 3.11.1999 n. 509 or they 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 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. Please refer to the Ph.D. School web site for details. Admission to the programmes will be granted according to the evaluation of the curricula of the studies, the motivation letter and a proposal describing the tentative development plan of a PhD-level research topics. These documents are submitted by prospective candidates together with their application to the admission call.

5.2 Admission deadlines and number of vacancies

The number of vacancies is indicated in the Call for admission to the 30° cycle of PhD Programmes:
http://www.polimi.it/phd
Scholarships both on general and on specific themes are available, in accordance with what is specified in 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. Credits allowed by the PhD programme and associated with research activities may also 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 in candidates of a research-oriented mind-set, 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 the Politecnico di Milano. The supervisor can be supported by one or multiple 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 PhDAcademic 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 various types of training activities with diverse valences (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 in 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	*Possible details or reference to following tables*	*Number of credits (min)*	*Note*
Courses characterizing the PhD Programme	*See Table A*	*15*	
PhD School Courses	*See Table B*	*5*	
Other PhD Level Courses	*See Table C*	*0*	
Other activities	*Participation to conferences, national and international summer schools*		

PhD PROGRAMMES

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

B) The PhD School organises every year general and Interdoctoral courses and courses with foreign professors. The acquisition of **at least 5 credits is mandatory** among the courses of B type. The list of Ph.D. courses organized by the PhD School is available at the following page 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 other courses are subsequently activated at 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**	**Language**	**Credits**
ICAR/06	Monte Carlo-Markov chains statistical methods (2 integrated modules)	G. Venuti M. Reguzzoni		English	5
ICAR/06	Numerical methods	L. Mussio		English	5
ICAR/01	Fluid mechanics	V. Armenio	Alternate years	English	5
ICAR/01	Groundwater	A. Guadagnini	Alternate years	English	5
ICAR/01	Granular Matter: from packing to flow	D. Berzi; F. Calvetti C. di Prisco;		English	5
ICAR/02	Sustainable Urban Water Systems	G. Becciu J. Sansalone		English	2
ICAR/02	Water and Food Security	M.C. Rulli		English	3
ICAR/02	Remote Sensing in Hydrology	M. Mancini C. Corbari		English	2
ICAR/02	Hydrology of Alpine areas	D. Bocchiola		English	5
ICAR/02	Sea Waves and Hydropower	A. Bianchi G. Passoni		English	4
ICAR/02	Dam and Reservoir Engineering	R. Rosso		English	2
ICAR/02	Climate Change Hydrology	R. Rosso		English	2
ICAR/03, BIO/07, BIO/19	Environmental Chemistry and Applied Microbiology	M. Antonelli	Alternate years	English	6
ICAR/03	Environmental reactors and biological processes applied to environmental-sanitary engineering	E. Ficara R. Canziani	Alternate years	English	4
ICAR/03	Statistics applied to Environmental Engineering	A. Azzellino	Alternate years	English	5
ICAR/04	Performance characterization of materials	M. Crispino		English	6
ICAR/04	Methods of laboratory experimental analysis	M. Crispino		English	6
ICAR/06	Positioning	B. Betti		English	5
ICAR/06	Advanced Geographycal Information Systems	D. Carrion		English	5
ICAR/06	Photogrammetry and Image Analysis	L. Pinto V. Casella		English	5
ICAR/06	Data Processing meets Human Sciences	L. Mussio		English	5
ICAR/06	WebGIS and Geoservices	M.A. Brovelli		English	4
ICAR/06	Satellite geodesy	F. Migliaccio		English	4
ICAR/06	DTM generation	R. Barzaghi		English	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 must submit his/her study plan. Candidates will have the opportunity to review it periodically (typically every three months) in order to adequate it to possible change of the training offer or to needs motivated by the development of his/her study plan. The plan is approved by the Coordinator of the PhD Programme, following the advice of the tutor, according to the procedures established by the Academic Board 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 annual 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 who need more time to 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 byat least three members (at least two of the Committee members are external to the PhD Programme).

7. Laboratories, PhD Secretary Services

Area 01 - "Hydraulic Engineering" and Area 02 - "Hydrology, hydraulic constructions, water resources and coastal engineering"

The *Laboratory Gaudenzio Fantoli* 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.

Area 03 - "Environmental technologies"

Laboratory for environmental monitoring and control (LANCI)

The Laboratory currently extends over 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 5 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 reactors 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.Since many years the Laboratory takes part in ring comparison tests (both national and international) and participates in working groups promoted by UNICHIM and IRSA for the development of analytical methods.

Area 04 - "Transport infrastructures and Geosciences"

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.

Area 05 - "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 Geoid Service, 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.

<u>Surveying and monitoring</u>:
- 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

<u>Data management and interpretation</u>:
- 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

Composition of the Board of Professors

Name	Affiliation	SSD / Title of SSD
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
Canziani Roberto	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
Giugliano Michele	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering
Guadagnini Alberto	Politecnico di Milano - DICA	ICAR/01 Hydraulics
Malavasi Stefano	Politecnico di Milano - DICA	ICAR/01 Hydraulics
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
Vismara Renato	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering

Attachment A2 – PhD Advisory Board

Composition of the Advisory Board

Name	Affiliation
Sanchez-VilaXavier	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 2013. 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.

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

Summary Form

Year	2014		
Assignment type	Doctoral		
Course	Monte Carlo – Markov chains statistical methods – Mod. A		
Professor	Venuti Giovanna		
Cfu	2.00	Course type	Integrated

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Monte Carlo statistical methods – Mod. A

Detailed Programme and foreseen learning results:

The integrated course (Mod.A + Mod. B) aims at giving an overview of the statistical methods for data simulations to be used for solving optimization problems.

- The first part of the course (Mod. A) will be devoted to a quick review of the basics, followed by a description of sampling techniques. An introduction to Markov Chains theory will conclude this modulus
- The second part of the course (Mod. B) will deal withMetropolis algorithms, Gibbs Sampler,stochastic optimization and numerical examples.

Bibliography

- F. Sansò, M. Reguzzoni, D. Triglione (2011), Metodi Monte Carlo e delleCatene di Markov: unaintroduzione.Maggiolieditore.
- C.P. Robert, G. Casella (2004), Monte Carlo Statistical Methods. Springer text in Statistics.
- A. Papoulis, S.U. Pillai (2001), Probability, Random Variables and Stochastic Processes. McGraw-Hill

Teaching Mix

Lectures

Lectures and computeslaboratoryactivities

Didactical issue type	Didactical hours
lesson	10.0
training	0.0

IT laboratory	0.0
Test laboratory	0.0
project	0.0
Project laboratory	0.0

Information in English to support internationalisation

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

Notes about the evaluation modalities

Evaluation will be based upon a final written report (or, alternatively, oral exam with evaluation).

Professor's notes

Attachment A3.2 (Only for courses of new activation or with substantial changes)

Summary Form

Year	2014		
Assignment type	Doctoral		
Course	Monte Carlo – Markov chains statistical methods – Mod.B		
Professor	ReguzzoniMirko		
Cfu	3.00	Course type	Integrated

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Monte Carlo statistical methods – Mod. B

Detailed Programme and foreseen learning results:

The integrated course (Mod.A + Mod. B) aims at providing an overview of the statistical methods for data simulations to be used for solving optimization problems.

- The first part of the course (Mod.A) will be devoted to a quick review of the basics, followed by a description of sampling techniques. An introduction to Markov Chains theory will conclude this modulus
- The second part of the course (Mod. B) will deal withMetropolis algorithms, Gibbs Sampler,stochastic optimization and numerical examples.

Bibliography

- F. Sansò, M. Reguzzoni, D. Triglione (2011), Metodi Monte Carlo e delleCatene di Markov: unaintroduzione.Maggiolieditore.
- C.P. Robert, G. Casella (2004), Monte Carlo Statistical Methods. Springer text in Statistics.
- A. Papoulis, S.U. Pillai (2001), Probability, Random Variables and Stochastic Processes. McGraw-Hill

Teaching Mix

Lectures

Lectures and computeslaboratoryactivities

Didactical issue type	Didactical hours

lesson	12.0
training	0.0
IT laboratory	8.0
Test laboratory	0.0
project	0.0
Project laboratory	0.0

Information in English to support internationalisation

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

Notes about the evaluation modalities

Evaluation will be based upon a final written report (or, alternatively, oral exam with evaluation).

Professor's notes