POLITECNICO DI MILANO

PhD in ARCHITETTURA, INGEGNERIA DELLE COSTRUZIONI E AMBIENTE COSTRUITO / ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING - 40th cycle

Number of scholarship offered	8
Department	DIPARTIMENTO DI ARCHITETTURA, INGEGNERIA DELLE COSTRUZIONI E AMBIENTE COSTRUITO

Description of the PhD Programme

The Doctoral Program on Architecture, Built Environment and Construction Engineering (ABC-PhD) was established in 2013, heritage of five other programs active since the first institution of Dottorato di Ricerca in Italy that progressively merged in one with the aim to realize a national Point of Reference for training researchers and experts in our fields (progressively reaching this target).
Our vision wishes our PhD holders to become self-sufficient, independent "actors", able to gain as scientist, as intellectuals, as professionals, as entrepreneurs an outstanding position at an international level. ABC-PhD is one of the most multidisciplinary PhD program in Italy (it refers to 20 different scientific sectors) and trains about one hundred PhD Candidates (1/3 new ones each year).
Our Candidates are trained to face complex questions, to develop in depth analysis and reliable models (theories) of complex (physical, economic, environmental or social) systems and to innovate.
Their natural passion and their attitude toward innovation works as an active transmission system and activate a two-way knowledge transfer between the Academy and its stakeholders.
After their training, ABC-PhD Doctors are expected to be endowed not only with a high-level scientific knowledge and a significant experience in Research and Development (R&D) activities, but also with proven communication and management skills, and to become self-sufficient, independent "actors".

For the sake of simplicity, we have organized their topics in five - interacting and reciprocally empowering Strategic Research Lines:

- Sustainability: decarbonised, resilient, adaptative and regenerative Built Environment
- Twin transition: competitive, digitalised and circular value chain for construction industry and built environment

- Well-being: safe, secure, inclusive and healthy Built Environment
- Advanced products: Advanced materials and components, clean tech, and innovative manufacturing and construction technologies/processes
- Conservation: Science and management of cultural heritage

More details about the specific research projects to be developed can be found at https://www.dabc.polimi.it/dottorato/dottorato-abc/

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THEMATIC Research Field: AI APPLIED TO CONSTRUCTION SITE HEALTH AND SAFETY

Monthly net income of PhDscholarship (max 36 months)
€ 1350.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Despite the Technology innovations and workers' safety education development in the construction sector, construction site remains one of the most dangerous workplaces. The employment increase in this sector, after the end of the pandemic, has led to a rise in the number of injuries reported on construction sites. Therefore, the advent of artificial intelligence and the development of 8D BIM (related to safety at the design and execution phase), and state-of-the-art protective devices still leave the challenge of safety on site open and critical. The research aims to develop a mock-up for the monitoring of health and safety conditions that combines environmental monitoring technologies, such as Unmanned Aerial Vehicle (UAV), surveillance cameras, Ground Monitoring Station (GMS), and artificial intelligence application as Computer Vision techniques. To achieve the goal, a previous study to identify and catalogue safety devices for a construction site will be conducted. In detail, each device will be analysed to point out a list of attributes that will allow its recognition by an AI. Currently, there are many different technicians involved in construction site accidents prevention, planning or taking

	the appropriate measures at all stages of the work, both on client side (i.e. Safety&Health Coordinator) and general contractor side (i.e. HSE Manager). The final purpose is then to improve accidents prevention providing an aiding tool to those technicians, able to increase monitoring efficiency of their activities, during both the design and execution phases of the project.
Methods and techniques that will be developed and used to carry out the research	During the research project the following methodologies and techniques will be applied: •Study and analysis of European and Italian legislation related to construction site safety devices (for this activity is recommended fluently Italian, e.g. Certificate C1). •Systemic organization of safety devices for recognition with AI. •Definition of a system of coding and standard description of geometric and appearance requirements of safety devices for AI recognition, useful for safety inspection on construction sites by digital surveying (for this activity is recommended previous experience on safety coordination). •Analysis of computer vision technique current available. •Definition of case study scenarios where to apply, in real condition, the AI recognition tool to be developed. •Use of programming languages Data analysis (3D, photographic and video surveys) collected during case study inspections.
Educational objectives	The aim is to cultivate and increase the S&H sensibility of the PhD candidate, driving his studies and research towards further progress in digital innovation of construction site, regarding the utilization of Artificial Intelligence for overseeing the accurate implementation of Health&Safety construction control methodologies.
Job opportunities	• Health&Safety construction site advisory • Health&Safety advanced construction site control • Construction site management • Health&Safety advisory for software house

	• Health&Safety advisory for software house • Researcher career
Composition of the research group	0 Full Professors 2 Associated Professors 0 Assistant Professors 1 PhD Students
Name of the research directors	Prof. Marco Lorenzo Agostino Trani

Contacts
Prof. Ing. Marco Lorenzo Agostino Trani: marco.trani@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	675.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Additional support:

Budget for the research activity (only for positions supported by scholarship):
total amount Euro 5503.35 per student
In detail:
- 1st year Euro 1834.45
- 2nd year Euro 1834.45
- 3rd year Euro 1834.45

Additional information about the organization and regultions of ABC-PhD programme can be found in the Regulations for the 40th Cycle of ABC-PhD:
download is available at link:
https://www.dottorato.polimi.it/corsi-di-dottorato/architettura/architettura-ingegneria-delle-costruzioni-e-ambiente-costruito

Additional information about ABC department and ABC-PhD programme:
available at link:
https://www.dabc.polimi.it/

Desk availability:
The ABC department provides non-permanent desks to be temporarily booked in common PhD rooms.

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THEMATIC Research Field: DESIGN FOR CIRCULARITY AND NEW SUPPLY CHAIN CONFIGURATIONS IN THE CONSTRUCTION SECTOR

Monthly net income of PhDscholarship (max 36 months)
€ 1350.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The objective of the research is to support the circular transition by developing and testing tools and procedures to sustain practices of design for circularity and new supply chain management models between the operators of the building process (clients, designers, construction firms, facility managers, manufacturers and re-manufacturers of construction products). In the last years, circular economy has become a hot topic fed by international consultations, debates and initiatives involving most of the industrial sectors. The general goal is the extension of the cycles of use and the service life of the products in order to minimize impacts and pursue environmental, economic and social sustainability objectives. The construction sector, for consumption of raw materials and production of waste is identified by the European Commission as a "priority area" in the context of circular economy. Re-manufacturing, refurbishing, re-use and repurposing are indeed virtuous circular practices, characterized by very low-impacting processes, able to minimize the generation of waste and maintain over time the value of the resources embodied in the products, once they are removed from the buildings. Despite these values and the growing interest of many

	stakeholders, the spread of these virtuous circular practices within the building industry is still an ongoing process, not without barriers, which requires a deep review of the traditional design and management practices, the experimentation of new appropriate organizational models and new supply chain configurations. The various categories of stakeholders express the need for shared references and operative tools, appropriate to various organizational models and to the various steps of the design process, to implement the circular practices with satisfying results and to measure and assess environmental benefits as well as competitive advantages. Starting from these motivations, the objective is to develop, apply to pilot cases and test: •circularity indicators useful for the comparison of solutions for various tasks (design products selection, design competitions, invitation to tender, contractual specifications, validation and quality control, etc.) in the different steps of the building process; •methods of analysis useful to support the choice, with respect to different organizational models, of the most appropriate circular strategies between re-manufacturing, refurbishing, re-use and repurposing and to assess the associated benefits/risks (economic, environmental, social); •datasets useful for the evaluation of circularity and of modalities for the tracking of information during the life cycle of the building products.
Methods and techniques that will be developed and used to carry out the research	The research will pursue the above described objectives through theoretical investigations and applications on the field. The researcher, in the first part of the work, will apply: knowledge mapping methods (analysing: literature references; research reports; EU, national and international standards and regulations) and case-based learning on selected best practices that will be critically analyzed and compared according to interpretative keys

	derived from the knowledge mapping. The results of the first investigation will be useful for the identification of a perimeter for a deeper investigation on the field where the researcher will apply methods for the analysis and representation of organizational models and for developing a stakeholder mapping; then semi-structured interviews will be organized with clustered stakeholders and multidisciplinary working groups. A period of internship in significant organizations will allow to verify on the job the interpretative findings developed in the theoretical phase of the research. On the base on the results, deriving from the first part, in the second part of the work the researcher will develop a proposal for a set of indicators and procedural tools to apply in the various steps of the building process. The proposal will be applied on pilot cases, representative of significant situations. The results emerging from the application of the field will be useful for possible revision of the proposal and for clarifying and communicate the findings.
Educational objectives	The researcher will acquire skills in the field of circular economy applied to the building sector about: international standards, regulations and certification protocols dealing with sustainability; approaches of design for circularity; indicators for measuring circularity. The investigation and application tasks will give the research the ability to map and represent processes, stakeholders, supply chain relations and support tools.
Job opportunities	The researcher can have job opportunities in various contexts in the AEC industry for topics dealing with sustainability and circular economy with the possibility of consulting or being employed in different categories of stakeholders: clients, design firms, construction companies, facility management companies, building products manufacturers, remanufacturers, etc.
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Prof. Cinzia Maria Luisa Talamo

Contacts
Prof. Cinzia Maria Luisa Talamo: cinzia.talamo@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	675.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Additional support:

Budget for the research activity (only for positions supported by scholarship):
total amount Euro 5503.35 per student
In detail:
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Desk availability:
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THEMATIC Research Field: DEVELOPMENT OF INNOVATIVE THERMAL NETWORKS FUELED BY RENEWABLE ENERGY SOURCES AND WASTE HEAT IN THE FRAMEWORK OF THE RENEWABLE ENERGY COMMUNITIES

Monthly net income of PhDscholarship (max 36 months)
€ 1350.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The heating and cooling (HC) sector is the most impacting in the European built environment and there are several energy targets to be satisfied in the next decades, as also underlined by the recent EPBD formulation. Moreover, toward the global shift towards sustainable energy practices, Renewable Energy Communities (RECs) have emerged as potential contributor for decarbonization. However, this model is consolidated in the electricity sector, while it is still to be built in the thermal sector. In the framework of the technological research and science applied to the built environment, the following topics will be treated in the proposal PhD research, also with the support of dynamic energy simulation and GIS representation: integration of renewable energy sources at building and district scale, energy efficient HVAC systems, energy saving solutions and technologies for energy-efficient buildings, development of innovative thermal networks. More in detail, the overall objective of the research is to analyse the state of the art of the district heating and cooling (DHC) sector and to propose solutions for supporting a fast implementation of low-grade renewable

	energy sources (RES) and waste heat (WH) towards the expected rapid decarbonizaiton, according to the European regulations. A deep involvement of the DHC operators is foreseen together with surveys for other key stakeholders and with the setting of effective capacity buildings tools. During the research, technical and non-technical barriers will be identified at national and EU levels, and solutions to support the decision-making processes will be provided. The evolution of DHC will be studied, with focuses on IV and V generation systems, underlining the real potentialities of such models in the Italian context. The role of consumers and prosumers will be proposed and analysed in this framework and the possibility to create thermal RECs will be also investigated, adopting quantitative approaches and indicators.
Methods and techniques that will be developed and used to carry out the research	According to the previous points, the following methods and techniques are suggested: desk research, energy simulations with different tools (demand side and supply side, including the evaluation of RES and WH potential), GIS representation. The candidate will be integrated in the research team and in the national and international activities in progress related to DHC. Therefore, due to the aims of the research, the candidate is requested to have sufficient competences and background in the energy sciences, interest and awareness on the European and Italian DHC sector. Moreover, the candidate must be aware of the features of the buildings and of the HC systems, availability of local databases, main institutions involved etc. and must be able to manage many activities involving Italian speaking only stakeholders (e.g. citizens, public administrators, white and blue collars of the sectors).
Educational objectives	The candidate will develop the capability to face scientific research with academic approach and to report the advancements by academic publications (Scopus Journals). In addition, competences in thermal sciences and in

	analysing DH systems, at demand and supply side, will be matured by research activities, PhD courses and involvement in the projects in progress. The development or use of simulation tools will be part of the research with the possibility of elaborating a toolkit or guidelines for supporting decisions in the sector.
Job opportunities	This PhD opens to several profession opportunities, mainly in three working sectors: public entities and research institutions dealing with energy planning and development of the framework for supporting DHC in Italy; companies and operators managing DHC systems and producing DHC components (hardware and software); academic research at national and international level (also promoted by IEA, EU projects etc.).
Composition of the research group	2 Full Professors 5 Associated Professors 3 Assistant Professors 10 PhD Students
Name of the research directors	Prof. Paola Caputo

Contacts
Prof.ssa Paola Caputo: *paola.caputo@polimi.it*

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	675.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Additional support: **Budget for the research activity (only for positions supported by scholarship):** total amount Euro 5503.35 per student In detail: - 1st year Euro 1834.45

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- 3rd year Euro 1834.45

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THEMATIC Research Field: ITALIAN ARCHITECTURE AND ITS INTERNATIONAL LINKAGES: HISTORICAL AND ARCHIVAL STUDY OF RELEVANT FIGURES IN MODERN AND CONTEMPORARY ARCHITECTURAL CULTURE.

Monthly net income of PhDscholarship (max 36 months)
€ 1350.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The object of the research is the Historical and Archival Study of Relevant Figures in Modern and Contemporary Architectural Culture. The aim is to study the connections between Italian and international architecture, with a specific starting focus on the archival heritage preserved in the Historical Archives of the Politecnico di Milano. The research group of Architectural History in the ABC Department deals with historical research with a special focus on the archives of Italian architects, engineers and designers. From this synergy between academic and archival contexts, the candidate will be able to work through the research methods of architectural history in a challenging and international environment. Alongside the study of a selected archival complex, the candidate will carry out wide-ranging historical research that will provide all relevant information. Specific visits and related studies in other archival contexts, in Italy and abroad, will be part of the research. Archivi Storici is part of the Library and Archives Services, through which it acquires and manages archival fonds related to the history of the university and to Milanese polytechnic culture, constituting materials of interest also

	for the teaching and research activities of the Politecnico. Its holdings include, in addition to the historical archives of the university, archives of individuals related to the activities of engineers, architects and designers, archives of institutions related to the activities of study centers and institutes of the Politecnico, and documentary collections. In the activity of producing and collecting archival descriptions Archivi Storici makes use of the open-source web application Archimista, created and developed since 2010 on the basis of an agreement between the Lombardia Region, the Piedmont Region and the General Directorate for Archives. In this environment the inventories of the fonds preserved at Archivi Storici are published periodically, starting in December 2017, and are made available for online consultation with the support of digital images of the documentation: http://www.archimistaweb.polimi.it/groups/Polimi-ArchiviStorici
Methods and techniques that will be developed and used to carry out the research	The candidate will work in a highly scientific environment, learn and develop skills in historical and archival research. He/she will be able to scientifically handle a large amount of data and sources. From a historiographical point of view he/she will learn to build a scientific and scholarly narrative from historical research. He/she will be dealing with unedited data and historical sources to be enhanced and compared with other historiographical data. In addition, the candidate will benefit from the working environment of the Historical Archives. Archivi Storici works for the description, preservation, enhancement and enrichment of archival sources of interest to the Politecnico di Milano, ensuring the inventory, reproduction and accessibility of archival collections. Organizes documentary exhibitions and promotes agreements with other Cultural Institutions and loans for exhibition purposes.
Educational objectives	Educational goals are to develop and learn historical research methodologies and understand projects from a historical perspective, developing research skills in international and multidisciplinary teams.

Job opportunities	Job and career opportunities include professional outlets in all sectors, public and private, having to do with historical research in architectural history, as well as employment in museums, archives, research foundations or architectural firms engaged in the historical preservation of their legacy.
Composition of the research group	0 Full Professors 6 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Proff. Elisa Boeri e Roberto Dulio

Contacts
Prof. Elisa Boeri: elisa.boeri@polimi.it Prof. Roberto Dulio: roberto.dulio@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	675.0 €
By number of months	6

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THEMATIC Research Field: NEW REQUIREMENTS FOR EFFICIENT HEALTHCARE SYSTEMS AND INFRASTRUCTURES

Monthly net income of PhDscholarship (max 36 months)
€ 1350.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The rapid evolution of scientific knowledge and medical technologies have determined hospital's unsuitableness few years after their construction. Several professionals and scholars, involved in hospital planning, are developing design and management strategies answering to contemporary healthcare challenges, also with a post-pandemic perspective. In addition, financial investment at National and European level in healthcare projects (i.e. Recovery Plan and PNRR Mission M6 - Health within its related Components, as well as insights from Mission 5 - Inclusion and cohesion and Mission 2 - Green Revolution and Ecological Transition) have targets of overall quality and compliance with regulations, also in terms of construction timing and costs. Furthermore, the healthcare projects must guarantee high-performances facilities and services; they should respond to the specific needs of the context and the functional requirements, within budget and specific technological requirements. For these reasons, it is necessary to define a tool useful for supporting the design phases that allows to define in spatial and functional terms the needs and requirements of the healthcare infrastructures in order to ensure the highest quality and performances.

	The aim of the research project is the definition of a multidisciplinary - evidence based - design and evaluation tool for assessing the quality of healthcare infrastructures design and support the application of Next Generation Hospital strategies.
Methods and techniques that will be developed and used to carry out the research	The aim of the research project is the definition of a multidisciplinary design and evaluation tool for assessing the healthcare infrastructures projects with a structured perspective based on established framework including all important requirements from functional design, flexibility, accessibility, sustainability, digitalization, etc. This will allow the high-performances of the spaces able to fullfill and overcome national and international market needs and requirements. Starting from an experience based approach, the Candidate will be able to visit and analyze several hospitals and he/she will meet some medical directors for understanding the processes, the healthcare needs, the dimension of the spaces, the wayfinding strategies, etc. This tool will also address the needs of several companies from the Healthcare Infrastructures supply chain and Life Science ecosystem that are seeking for validations and verifications to define strategies and investments in deeper research and applications. The research project will be supported by in-depth scoping reviews of the international literature, along with systematic analysis of relevant experiences and best practices, with the opportunity to share knowledge and discuss preliminary results with international networks. In fact, the results will be disseminated through scientific papers, conferences and meetings with experts in healthcare field, at National (AGENAS, ISS, CNETO, SIAS, SItI, JRP HI, etc.) and international (WHO, EUPHA, D&H International Academy, etc.) level. **SDGs related to this research:** Goal 3 - Ensure healthy lives and promote well-being for all at all ages Goal 9 - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation Goal 11- Make cities and human settlements inclusive,

	safe, resilient and sustainable Goal 13 - Take urgent action to combat climate change and its impacts
Educational objectives	During the research activity based on an in-depth focus on legislation, case studies, best practices and tools, the PhD candidate will be able to investigate and focus on the main Academic, Scientific and Professional connections between design &healthcare infrastructures approaches, with specific reference to experience-based design, sustainability and environmental issues.
Job opportunities	Worldwide several researchers are working on the definition of Healthcare strategies for reaching high-performances in the Next Generation Hospital field of research. Although several colleagues are focused on the topic, the innovative approach of the work is to give rise to an evidence/experience based tool for the definition of the most relevant strategies in healthcare design related to healthcare infrastructures. The added value is determined by a multidisciplinary approach that involves professionals coming from different fields of interest. For the development of the project, several disciplines will be involve, in particular the candidate will have some collaborations with: •companies in the field of healthcare design for understanding the needs of the healthcare market with the support of Joint Research Platform Healthcare Infrastructures (JRP HI); •Hospital planners for understanding the design strategies and healthcare flows with World Health Organization, Centro Nazionale per l'Edilizia e la Tecnica Ospedaliera (Italian Architects for Health association), Società Italiana dell'Architettura e Ingegneria per la Sanità (Italian Healthcare Engineering association) and International Academy of Design and Health; •Network established within the World Health Organization Collaborating Center for Design &Health: Healthcare Infrastructures Planning Design Evaluation (WHO CC)

	Managers, medical officers and medical staff for defining the healthcare processes and models with the collaboration of World Health Organization, AGENAS, Società Italiana di Igiene (Italian Public Health Association), Istituto Superiore di Sanità (Italian Health Institute) and Accademia Lombarda di Sanità Pubblica.
Composition of the research group	1 Full Professors 1 Associated Professors 3 Assistant Professors 7 PhD Students
Name of the research directors	Proff. Maddalena Buffoli e Stefano Capolongo

Contacts
email: designhealthlab-dabc@polimi.it office: +39 02 2399 5140

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	675.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Additional support:

Budget for the research activity (only for positions supported by scholarship):
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OPEN SUBJECT Research Field: PHD IN ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING

Monthly net income of PhDscholarship (max 36 months)
€ 1350.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Our mission is to train PhD Holders able to reach outstanding positions at an international level not only as scientist or intellectuals but also as professionals or entrepreneurs in one of the quoted research fields. PhD Candidates are expected to refine their skills and to reach a cutting-edge level of knowledge about their research topics and to acquire a multidisciplinary character, to enhance their proficiency in scientific communication, research management and other transferable skills and to become active part of a scientific community. Moreover, they are expected to produce a significant, original contribution to their field, to organize this contribution it in a dissertation (the PhD Thesis) and to defend it 'viva voce' (publicly) in front of a committee of experts.
Methods and techniques that will be developed and used to carry out the research	Candidates without a pre-defined research topic shall plan their research and training activities and define the specific methodologies to be used to find the answer to their research question, immediately after the official start of their PhD Programme, in accordance with their Supervisors. The plan and the methodologies will be detailed it their PhD Agreement, giving evidence of their aims and of the global amount of time to be spent in each of them.

	The PhD Agreement will be endorsed by Candidate's Supervisor and approved by the Head of the Programme (or by a delegate).
Educational objectives	ABC-PhD Candidates are expected to produce knowledge advancements in their scientific field. Moreover, they are raised to be resilient, not frightened by the uncertainty and failure risks of innovations, trained in communication, management, networking and other transferrable skills, that are fundamental for doing research in this complex world. They are taught to cooperate in a competitive environment and to exploit their creativity to reach their goal, going beyond the limits of one scientific discipline, interacting and learning from other researchers and colleagues. Eventually, they are pushed to find out (and to network with) the possible stakeholders of their work. We purport that the best value for the Candidate and for the Program itself is the reward given by the chance of a practical application of the knowledge advancements realized.With this experience, ABC-PhD Doctors are expected to acquire the capacity to shoulder the responsibilities of R&D activities, to plan and to manage control tasks, to help the development and the critical optimization of policies and projects, to innovate: in particular about the PhD thesis topic, in general about the many sectors of Architecture, Built Environment and Construction Engineering and in all the most critical subjects related to the sustainable transformation and management of the Built Environment (environmental, economic, social and cultural sustainability).
Job opportunities	The holder of an ABC-PhD will gain high-level scientific knowledge, significant experience and proven R&D management skills, transferrable to other activities. This, together with the habit of communicating and working in English, acquired interacting with colleague at a global scale, during visits and stays abroad, and a deep knowledge of the academic world qualifies the Doctorate for positions offered by the best international universities and research centres.

	ABC-PhD experience, nevertheless, will offer the best occupational opportunities also for employments in architectural and engineering design enterprises, in public bodies and wherever highly qualified personnel (at an international level), specific competencies at the highest level, the attitudes and the network of a researcher is acknowledged. The more the Candidate, during the three PhD years, has taken the opportunities to stay in touch with the stakeholders of actual (or future!) societal needs and to operate real knowledge transfer, the more this comes true. ABC-PhD holders, in fact, are problem-setters, trained to model complex environments, to understand complex questions and to apply critical thinking, and problem solvers, trained to turn uncertainty in methodology and doubts in reliable solutions.
Composition of the research group	46 Full Professors 86 Associated Professors 51 Assistant Professors 171 PhD Students
Name of the research directors	Prof. Marco Scaioni

Contacts
head-phd-dabc@polimi.it phd-abc@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	675.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Additional support: **Budget for the research activity (only for positions supported by scholarship):** total amount Euro 5503.35 per student

In detail:
- 1st year Euro 1834.45
- 2nd year Euro 1834.45
- 3rd year Euro 1834.45

PhD students admitted without scholarship will have to negotiate the budget for research activities with their Supervisors.

Additional information about the organization and regultions of ABC-PhD programme can be found in the Regulations for the 40th Cycle of ABC-PhD:
download is available at link:
https://www.dottorato.polimi.it/corsi-di-dottorato/architettura/architettura-ingegneria-delle-costruzioni-e-ambiente-costruito

Additional information about ABC department and ABC-PhD programme:
available at link:
https://www.dabc.polimi.it/

Desk availability:
The ABC department provides non-permanent desks to be temporarily booked in common PhD rooms.

POLITECNICO DI MILANO

PhD in ARCHITETTURA, INGEGNERIA DELLE COSTRUZIONI E AMBIENTE COSTRUITO / ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING - 40th cycle

THEMATIC Research Field: ROLE OF STEREOTOMY IN THE SEISMIC BEHAVIOR OF DOUBLE CURVATURE MASONRIES: ADVANCED NUMERICAL MODELLING

Monthly net income of PhDscholarship (max 36 months)
€ 1350.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Masonry is a fragile material with orthotropic behavior. Its mechanical properties strongly depend on the actual arrangement of the blocks/stones/bricks and on their shape. The seismic assessment of existing masonry structures is therefore not an easy task and the use of macroscopic smeared crack models cannot be considered satisfactory because it may be responsible for inaccurate evaluations of the seismic vulnerability. The actual arrangement and shape of the blocks should be therefore taken into consideration with a suitable approach that involves stereotomy considerations and heterogeneous seismic analyses at a structural level, or at least by means of simplified models where the geometric features of the blocks and the texture are considered. Albeit advanced finite element modelling is considered nowadays the standard to deal with such kind of problem and it proved to be quite accurate in reproducing the non-linear behavior of the constituent materials, for existing/historical structures it is required an efficient approach that starts from a detailed surveys of the structural elements, the construction of an high fidelity geometrical digital twin, its implementation at structural level in existing finite element software and the consequent analysis under seismic loads. There are still several practical issues in the in-

	series realization of such intermediate steps, such as for instance the survey data reduction, the computer assisted realization of the geometric model, its discretization into finite elements and the obtainment of the structural results in a reasonably fast and efficient way. The difficulties become even more dramatic for masonry curved structures, such as vaults and domes, multi-leaf walls, massive structures with scarcely resistant or deteriorated joints, where the so-called crumbling failure is quite frequent, etc.. The research proposed has as main objective to fill all the aforementioned lack of knowledge, proposing innovative automatized procedures for the seismic assessment of large-scale masonry structures and structural elements with complex geometry and arrangement of the blocks, where the main local features of the masonry material are considered with a sufficient level of in-depth.
Methods and techniques that will be developed and used to carry out the research	The methods and the techniques that will be developed are those considered standard by the scientific community in earthquake engineering and in structural mechanics in general, but applied to the specific case of masonries where the role played by the units' shape is paramount, a field of research still in rapid evolution. They include the development of tools for the automatic generation of the geometric digital twin and the subsequent generation of structural models where the basic features of the masonry material are considered in the most advanced and accurate way. As far as this latter aspect is concerned, both commercial and in-house developed finite element (FE) and distinct element (DE) models will be proposed and adopted. The basic features of the constituent materials will be considered as well, modelling masonry by means of original approaches that may span from heterogeneous methods to fully macroscopic models, passing through engineering homogenization. The seismic analysis of existing and historical masonry structures will require to have insight into the damaging behavior of the mortar joints and the possible presence of pre-existing states of degradation (e.g. cracks, settlements, water leakage). Accompanying the most diffused techniques used nowadays for the seismic

	assessment of masonry structures, limit analysis coupled with either finite elements or assuming the units infinitely resistant will be applied to real cases. Finally, the role played by the irregularity of the shape and thickness of the joints will be considered in selected cases studies.
Educational objectives	1) To train the PhD student in the advanced seismic assessment of historical masonry structures. 2) To transfer above the average experience and knowledge in the advanced finite element and distinct element modelling for structures subjected to seismic loads. 3) To acquire experience and knowledge in the automatization in the field of geometric generation of complex patterns. 4) To transfer knowledge in the field of limit analysis applied to the seismic assessment of complex structures made with quasi no-tension materials.
Job opportunities	R&D staff and/or junior team leader in structural engineering software houses, public administration, private and public building industry.
Composition of the research group	0 Full Professors 1 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Prof. Marco Vincenzo Valente

Contacts
Prof. Marco Vincenzo Valente: marco.valente@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
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Additional support:

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In detail:
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