POLITECNICO DI MILANO

PhD in ARCHITECTURAL URBAN INTERIOR DESIGN - 40th cycle

PNRR 630 Research Field: SUSTAINABLE MODULAR CONSTRUCTION SYSTEMS FOR EMERGENCY SHELTERS USING LOCAL MATERIALS

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 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 primary motivation behind this research is to improve the quality of life for vulnerable individuals and communities. Providing safe, reliable, and quickly deployable shelters can significantly mitigate the impact on such communities, offering immediate relief and a foundation for recovery. Utilizing locally available materials reduces the environmental footprint of transporting construction materials and promotes sustainable building practices. This approach combines with global sustainability goals and supports the development of resilient communities. Developing a cost-effective construction system that can be implemented with minimal financial resources is crucial. Reducing the costs associated with emergency shelters can allocate more resources to other critical response and recovery areas. This research presents an opportunity to advance construction technology and materials science. Innovating in this space can lead to breakthroughs with broader applications beyond emergency contexts, potentially influencing mainstream construction practices. **Objectives:** Design a flexible, modular construction system that can easily assemble and disassemble. This system should be adaptable to various environmental conditions and scalable to meet different shelter needs. Identify and incorporate locally available materials into the construction system. This will involve researching and

	testing different materials for suitability in terms of durability, insulation, and structural integrity. Conduct testing to ensure the shelters meet safety standards and withstand environmental stresses such as wind, rain, and seismic activity. Design the construction system to be assembled quickly and with minimal tools and expertise. This is crucial in emergencies where time and skilled labor are often limited. Assess the environmental impact of the construction system, including the life cycle analysis of the materials used. Aim to minimize the ecological footprint and promote sustainable practices. Engage with local communities, governments, and non-governmental organizations (NGOs) to ensure that the shelters meet the needs and preferences of the end-users. This collaboration will also facilitate the adoption and implementation of the construction system in real-world scenarios.
Methods and techniques that will be developed and used to carry out the research	The candidate's research will be developed closely with Sprech, a producer of steel, aluminum, and tensile structures. This partnership presents a significant opportunity to rapidly validate design solutions by leveraging SPRECH's advanced prototyping capabilities. Working closely with their team, we can efficiently move from conceptual stages to tangible prototypes. This hands-on approach will allow us to test and refine our construction system in real-world conditions, ensuring that our solutions are practical and effective in emergencies and recovery contexts. The research will employ a multidisciplinary approach, integrating building physics, structures, and architecture. The following methods and techniques will be developed and used throughout the project: extensive review of existing literature on emergency shelters, sustainable construction practices, and using low environmental impact materials. The aim is to understand current challenges and best practices. Research and identify low-environmental impact materials. This includes natural materials (e.g., bamboo, earth) and recycled materials (e.g., plastic

	bottles, rubble). Combining local materials creates innovative composites that enhance structural integrity and insulation properties. Design modular components of the construction system. These designs will focus on ease of assembly, adaptability, and scalability. Create scale models and full-scale prototypes to test design concepts and structural components. Conduct simulations to analyze the shelters' thermal performance and ability to withstand extreme weather conditions. This includes evaluating insulation properties and ventilation efficiency. Monitor the shelters' performance over time, assessing structural integrity and thermal comfort factors. Perform an LCA to evaluate the environmental impact of the construction system from material extraction to end-of-life disposal. Aim to minimize the ecological footprint and promote sustainability. Conduct a cost-benefit analysis to compare the economic feasibility of the new construction system against traditional methods. This will consider material costs, labor, transportation, and long-term maintenance. Produce comprehensive manuals and shelter construction guidelines, including step-by-step instructions, safety protocols, and maintenance procedures. Publish research findings in academic journals and present at conferences to share knowledge with the broader scientific and engineering communities. Work closely with NGOs, governments, and international organizations to disseminate the findings and promote adopting the construction system in disaster-prone areas.
Educational objectives	The research project on developing a shelter construction system will have several educational objectives to enhance all participants' knowledge, skills, and competencies: Educate students and researchers on the latest construction technologies and methods, including modular construction, rapid prototyping, and sustainable building practices. Provide in-depth knowledge of material properties, testing methods, and innovative material applications. This includes hands-on experience with characterizing and testing locally sourced materials. Instil a strong understanding of sustainability principles in construction, focusing on the environmental impact of

	building materials and methods. Teach students how to conduct LCAs to evaluate the environmental footprint of construction projects. This includes understanding the entire lifecycle of materials from extraction to disposal. Encourage an interdisciplinary approach to problem-solving, integrating knowledge from engineering, architecture, materials science, and social sciences to develop comprehensive shelter solutions. Foster innovative thinking and creativity in developing new construction methods and materials that are both effective and sustainable. Provide opportunities for hands-on experience through field testing and pilot projects. This includes assembling prototypes, monitoring performance, and engaging with local communities. Ensure that participants understand their research?s real-world applications, emphasising their work?s practical impact on improving recovery. Teach the principles and practices of participatory design, emphasizing the importance of involving local communities in the design and implementation of shelters. Promote cultural sensitivity and awareness, ensuring the shelters meet their communities' social, cultural, and practical needs. Develop participants' ability to communicate technical information effectively to diverse audiences, including academic peers, practitioners, and community members. Encourage collaborative work and teamwork, both within the research team and with external stakeholders such as NGOs, government agencies, and local communities. Enhance research skills, including literature review, experimental design, data analysis, and academic writing. Encourage the publication of findings in peer-reviewed journals and presentations at conferences. Support the professional development of participants by providing academic training. Raise awareness of the global challenges associated with humanitarian crises. Educate participants on the role of engineering and technology in addressing these challenges. Promote advocacy for innovative disaster response and recovery solutions, encouraging participants to become leaders and advocates for sustainable and resilient construction practices.

Job opportunities	The research project on developing a construction system for emergency shelters opens various job opportunities across various sectors: Teach architecture and sustainable construction courses. Mentored students and led research projects related to emergency shelter construction. Continue research in a specialized area related to the project, potentially focusing on further innovations in emergency shelter design and materials. Design and implement architectural solutions focusing on emergency shelters, infrastructure, and resource management. Work with NGOs, international organizations, and governments to coordinate relief efforts and ensure timely shelter delivery and other essential services. Oversee the deployment and construction of emergency shelters, ensuring they meet safety and sustainability standards. Design eco-friendly buildings and structures, incorporating sustainable materials and practices learned from the research project. Manage construction projects, ensuring they adhere to safety standards, timelines, and budgets. Specialise in projects that utilize modular construction and locally sourced materials.Work in companies that develop innovative construction materials and systems. Focus on creating sustainable, cost-effective, and suitable products for emergencies. Advise organizations on sustainable practices and the environmental impact of construction projects. Conduct life cycle assessments and promote the use of sustainable materials. Implement and manage sustainability initiatives within construction firms, ensuring that projects adhere to environmental regulations and standards.
Composition of the research group	0 Full Professors 0 Associated Professors 1 Assistant Professors 1 PhD Students
Name of the research directors	Alessio Battistella

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Area Servizi

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	650.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	SPRECH S.R.L.
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	To be defined
By number of months abroad	6

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

Some of the universities that are cooperating in the research:

- Katholieke Universiteit Leuven
- Aarhus School of Architecture
- TU Delft, School of Architecture
- TU Berlin, Institute for Architecture

- University of Ljubljana

Research Budget: purchase of study books and material, funding for course participation, summer schools, workshops, and conferences).

The Candidate can count on financial aid with a total amount of **5.300,25 euros**:
1st year: max 1.766,75 euro;
2nd year: max 1.766,75 euro;
3rd year: max 1.766,75 euro.

Teaching assistantship: (availability of funding in recognition of supporting teaching activities by the PhD student).
There are various forms of financial aid supporting the teaching practice. The PhD candidate is encouraged to participate in these activities within the limits of the Polimi and AUID regulations.

Workspace: In the AUID hall, on the 4th floor of Bldg. 12 in Leonardo Campus, are available workstations for shared use. All the Ph.D. students can use their laptops with a wireless connection. Workstations and other equipment are available in the various departmental laboratories (Dastu).