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Fundamental Domain: Engineering Sciences
Specialty Domain: Environmental Engineering

HABILITATION DISSERTATION

– ABSTRACT –

Sustainable solutions for reducing the environmental impact in the construction industry

CS I Dr. Eng. Andreea Cristina HEGYI
National Institute for Research-Development in Construction, Urban Planning and Sustainable Territorial Development URBAN-INCERC

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SUMMARY

In the habilitation dissertation, entitled "**Sustainable solutions for reducing the environmental impact in the construction industry**," the author presents a comprehensive overview of their professional, academic, and scientific achievements, which were obtained subsequent to obtaining the scientific title of Doctor in the field of Materials Engineering in 2011, î based on the Order of the Minister of Education, Research, Youth, and Sports no. 6468 of 07.12.2011.

The construction and construction materials sector has a significant impact on the environment. On the one hand, manufacturing and implementation technologies are characterized by their substantial resource requirements, energy consumption, and environmental impact. Conversely, throughout the lifecycle of a structure, maintenance and repair are necessary, and ultimately, demolition and disposal emerge as a novel source of pollution and energy consumption. The increased durability of constructions, achieved through the use of higher-performance materials that are also more environmentally friendly, with reduced maintenance needs, as well as the creation of a favourable framework for increasing the degree of waste recycling, represent useful and effective tools for reducing the negative environmental impact. Therefore, a multilateral approach to these aspects is proposed, on four thematic directions, as presented in Table 1, so that, in the end, the result is the reduction of the impact generated by the construction industry on the environment.

Tab. 1. Research topics and thematic areas addressed

Thematic research directions	Contributions	Functional, economic, societal, and environmental impact	Applications
REDUCING THE ENVIRONMENTAL IMPACT OF THE CONSTRUCTION INDUSTRY			
Cementitious composite materials with self-cleaning and self-sanitizing capabilities	Imparting self-cleaning and self-sanitizing properties to the surface, based on the specific behaviour of TiO_2 nanoparticles	Increasing sustainability, hygiene in use, and reducing material consumption and maintenance costs	Prefabricated elements, of the cladding panel type, intended for the finishing of building walls, and plastering mortars with increased resistance to environmental action, with self-cleaning and self-sanitizing capacity
Geopolymer materials – an environmentally friendly alternative to cementitious composite materials	Development of geopolymers through alkaline activation of local raw materials	Integration into the economic cycle of an industrial by-product currently stored as waste, reduction in cement consumption	Prefabricated elements for finishing building surfaces by cladding and prefabricated elements for paving pedestrian areas.
	Increasing the degree of protection that composite material provides to embedded steel reinforcement	Increasing sustainability and operational safety, reducing material consumption	

Unfired clay-based building systems – an environmentally friendly alternative suitable for vernacular construction	Manufacturing prefabricated wall elements	Reducing environmental impact during the extraction and processing of raw materials	Complete masonry system for the construction and finishing of vernacular buildings.
	Obtaining protective and finishing materials	Increasing sustainability, safety, and hygiene in operations, and reducing material consumption and maintenance costs	
Eco-innovative thermal insulation materials based on sheep's wool, post-industrial textile waste, plant fibres, and recycled polymer fibres	Production of thermal insulation composite materials based on recycled waste and sheep's wool	Exploitation of an insufficiently exploited renewable resource, introduction of waste into the production cycle, reduction of energy consumption for indoor climate control, improvement of indoor air quality with beneficial impact on users' health.	Prefabricated thermal insulation products designed for thermal insulation of buildings and, implicitly, for reducing energy consumption.
	Analysis of resistance to mould		
	Quantification of the impact on indoor air quality		
	Assessment of possibilities for improving sustainability	Increasing service life and operational reliability, with expanded range of applications	

In the habilitation dissertation, entitled "**Sustainable solutions for reducing the environmental impact in the construction industry**," is structured into three main parts. The initial section of the document is dedicated to the presentation of professional and academic achievements. The second section of the document presents a compendium of scientific achievements within the purview of the research topic under discussion. The final section of the document is dedicated to the presentation of career development plans and perspectives.

In the initial section of the document, the professional and academic achievements that comprise the candidate's professional trajectory are presented in a synthetic manner. From the perspective of teaching activity, it is limited to the activity carried out as an associate faculty member at the Faculty of Materials and Environmental Engineering of the Technical University of Cluj-Napoca, Department of Environmental Engineering and Sustainable Development Entrepreneurship where, starting in 2022, specific activities (lectures, seminar activities, laboratory activities) were carried out. Related activities were performed as a coordinating representative on behalf of the host institution for students who completed their internship in 2023 at INCD URBAN-INCERC, as a member of the guidance committees for doctoral students of the Faculty of Civil Engineering of the Technical University of Cluj-Napoca, and as a supervisor for the completion of bachelor's and master's theses of students of the Faculty of Materials and Environmental Engineering of the Technical University of Cluj-Napoca.

This section also presents the research activity. Thus, the research projects implemented as a project director or team member are mentioned, as well as a summary of the most important research contracts with economic agents as beneficiaries, as well as a list of the papers in which the research results were disseminated. An intense activity was carried out as a project director for project 449PED / 2020 PN-III-P2-2.1-PED-2019-0463 Ecological alternative to classic thermal insulation products, through recycling with residual energy recovery of post-industrial textile waste and the use of vegetable and sheep's wool fibres (Acronym: ALECOTERMO) or as a member of the research teams of 17 projects implemented within INCD URBAN-INCERC where, at present, the candidate works as a scientific researcher, grade I..

In regard to the dissemination of research results, following the attainment of the Doctorate in Materials Engineering in 2012, this objective was realized through the publication of 27 papers in specialized journals indexed in WOS (SCIE) and 10 papers in journals indexed in WOS (ESCI). Additionally, 13 papers were published in ISI-Proceedings indexed volumes, 29 papers were published in specialized journals indexed in BDI, 4 books were authored, and 3 chapters in specialized books were contributed. Furthermore, participation in international conferences, scientific events, and invention and innovation fairs was undertaken, resulting in the acquisition of over 70 awards and medals.

The second part of the paper takes an interdisciplinary approach to four thematic areas in the context of implementing the principles of Sustainable Development and the Circular Economy in the construction materials sector. Thus, Chapters 1-4, which present scientific achievements, are structured so that each addresses one of the four thematic areas:

1. Chapter 1 presents a summary of studies conducted on improving the performance and inducing new properties in cementitious composites by exploiting the specific properties of TiO_2 nanoparticles.
2. Chapter 2 presents a summary of studies conducted on the possibilities of recycling industrial waste and by-products through the development of geopolymer materials, which are considered a possible ecological alternative to cementitious composites.
3. Chapter 3 presents a summary of studies conducted for the development of building materials based on unfired clay, with the main focus on promoting national tradition and identity, while also identifying opportunities for increasing their sustainability.
4. Chapter 4 presents a summary of studies conducted with the aim of recycling textile and polyethylene terephthalate (PET) waste into composites for thermal insulation in buildings, while also making use of the underutilized resource of animal fibres—sheep's wool.

The third part of the paper presents career evolution and development plans.
The main directions of development are:

a) in terms of scientific and research activity – with a direct contribution to the level of knowledge in the field through the dissemination of research results:

1. Development of innovative materials for use in construction, with the aim of extending the life of the built environment and which, through their manufacturing technology and/or performance in use, enable the reduction of energy and natural resource consumption, the recycling and reuse of waste, and the reduction of maintenance and servicing requirements, all contributing to a reduced environmental impact.
2. Development of new techniques for analysing product performance, enabling accurate assessment of their behaviour and durability in operating environments, including through an interdisciplinary approach to analysis in environments contaminated with microorganisms or other aggressive environments.

b) in terms of teaching activity

1. Developing up-to-date teaching materials for undergraduate, master's, and doctoral students and coordinating their progress in course and seminar activities to achieve a high level of competence in the field of environmental engineering.
2. Coordinating students in their research activities as part of their studies for their bachelor's/master's theses or doctoral dissertations.

Through this approach, the habilitation dissertation presents the harmonious combination of the research and teaching activities existing in the candidate's professional career. This approach underscores the significance of the research in the designated field, thereby establishing a robust foundation for mutual advancement between research and teaching.

The following is a compelling argument for the inclusion of this subject in the specialized field of Environmental Engineering: The construction industry, in its present state of development, constitutes a significant source of environmental degradation, manifesting in the processes of raw material extraction, processing, and construction execution, operation, and post-operation. The linear principle of "extract-produce-consume-discard" represents an outdated concept that has proven to be detrimental to the three pillars of sustainability: environmental, economic, and social. In the contemporary context, the notion of sustainable development cannot be discussed in isolation from the imperative of attaining a stable balance between these three components. At the international level, there is a profound concern for the development of innovative materials and technologies that allow for the satisfaction of economic and social needs while also having the lowest possible impact on the environment. This concern is evidenced by a series of actions, including the reduction of raw materials and energy consumption, the reduction of pollution, the increase in product lifespan, the improvement of product performance, and the increase in the possibilities for recycling and reintegrating various wastes into the economic cycle. The notion of sustainable development, as articulated in the 1987 Brundtland Report of the World Commission on Environment and Development, entitled "Our Common Future," is delineated as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." It is therefore acknowledged that societal demands will drive continuous development of the built environment. The creation of innovative, sustainable, and highly durable construction materials with one or more enhanced characteristics and/or that facilitate the recycling and revaluation of waste, which are more environmentally friendly, is imperative. Annually, the Global Footprint Network calculates the date of "World Overshoot Day," which represents the day on which humanity has consumed the possibilities offered by the planet for one year. From that moment until the conclusion of the present year, the human species is consuming "on credit" resources that the planet is incapable of providing at the rate at which they are being consumed. In 2025, this date corresponded to July 24 (from July 25 to December 31, humanity consumes resources beyond the planet's production capacity). In the year 2024, the aforementioned date corresponded to August 1; in 2023, it was August 2, and so forth. It is evident that the temporal span during which human activity surpasses the planet's capacity is progressively diminishing on an annual basis. Concurrently, the phenomenon of "planetary debt" is escalating on a continuous basis, constituting a disconcerting predicament that warrants profound reflection within all spheres of endeavour. In this particular instance, the construction industry is responsible for a substantial annual consumption of resources and a notable increase in negative environmental impact. This issue alone should serve as a compelling rationale for the research effort, particularly in the context of environmental engineering.

The work's relevance and originality stem from its interdisciplinary integration of research in construction materials with the concepts of sustainability and durability of the built environment. This integration is continuously correlated with aspects regarding environmental impact, while evaluating the implications for public safety and health. While the four thematic directions appear to be unilateral, they are all aligned with a shared overarching objective: "meeting present societal needs without compromising the ability of future generations to meet their own needs." Finally, the adoption of an applied research methodology renders the work highly interdisciplinary. Consequently, in order to achieve the research objectives, experimental research methods specific to several fields are employed, including construction and construction materials, electrochemistry, microstructural analysis, chemistry, and microbiology. These methods are adapted to the needs induced by the specificity of the analysed materials. The aforementioned elements collectively substantiate a substantial degree of originality and serve to illustrate the multifaceted professional development of the candidate.