DESIGN AND TECHNOLOGY. PEOPLE, ENVIRONMENT, SYSTEMS

AMMIN/DENERG - Sound-Driven Design: From Natural Materials to Perception in Parametric Acoustic Design

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Context of the research activity	The construction sector uses 40–50% of global materials, with a strong impact on climate and well-being, requiring a redesign aligned with the Green Deal and the New European Bauhaus vision. Therefore, the research proposes a multidisciplinary approach that combines parametric design, digital fabrication, and waste materials for sustainable sound-absorbing systems, integrating computational analysis and socio-psychological analysis methods.
Objectives	The research aims to develop a design framework for sustainable sound-absorbing materials and systems for architecture by integrating architectural acoustics, parametric design, material exploration, and innovative application processes. The primary objective is to improve the acoustic performance of low-impact mortars, plasters, and coatings by enhancing natural raw materials and waste/secondary raw materials, and by considering acoustic performance as one of the driving elements of the design process. Furthermore, the project systematically analyzes the architectural design process by integrating acoustics from the earliest design stages. It also includes aspects related to material perception, which can influence not only their aesthetic appearance but also their acceptability by the end user. The approach is multiscalar, starting from the acoustic behavior of materials and their parametric configurations, then extending to the scale of spaces and buildings, supporting sound-driven design decisions. From a methodological standpoint, the project is structured in two phases: The first phase involves a critical analysis of the state of the art through a systematic literature review and the identification of innovative materials. At this stage, innovation is pursued at the material scale through the experimental development of sound-absorbing formulations, characterized through standardized acoustic testing as well as non-acoustic tests to verify

	mechanical, hygrometric, adhesion, and shrinkage properties, ensuring compatibility with industrial application requirements. The second phase addresses innovation in installation techniques and surface geometry, exploring textures, stratifications, and modular solutions designed using parametric logic to enhance acoustic absorption. These solutions are then validated through real case studies, combining numerical simulations, in situ measurements, and perceptual studies to evaluate both objective acoustic effectiveness and impact on user experience. The expected outcomes include: advancement in knowledge on sustainable acoustic materials, the definition of sound-driven design and application guidelines, support for the transition toward circular design practices in construction, and the training of a highly interdisciplinary research profile capable of connecting material science, acoustics, computational design, and contemporary architecture.

Skills and competencies for the development of the activity	Skills are required in research management, from the conceptual phase to the development of an original scientific project. Specifically: - ability to interpret the results of acoustic measurements and relate them to design; - ability to collaborate with companies and laboratories for prototype development; - understanding of the relationship between digital models, materials, and construction processes; - scientific writing in English; - ability to communicate effectively, both in written and oral form, with the scientific community, colleagues, and the public.