Envisioning the futures

Designing and building for people and the environment

Trento, 11-14 June 2025

Book of abstracts

Editors
Rossano Albatici, Michela Dalprà, Maria Paola Gatti,
Gianluca Maracchini, Simone Torresin

UNIVERSITÀ DI TRENTO

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Colloqui.AT.e 2025
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The 2025 edition of the conference Colloqui.AT.e is an opportunity for an open discussion and debate on the need to systemise the essential aspects of the construction sector, according to the three criteria of integration (of people, buildings, communities), circularity (economic and efficient use of resources) and simplicity (in planning, design, construction), in order to imagine not one but multiple possible 'futures' that intercept the horizons of the new generations and that are able to interpret them with principles, processes, solutions, technologies and products also linked to digital transformation (in new construction as for the existing heritage), addressed in a synergic and integrated manner to the renewed needs of people and the quality of the indoor and outdoor environment.

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INTRODUCTION

Ar.Tec., the Italian Scientific Society of Architectural Engineering (AE), is responsible for organising the annual ColloquiATe conferences on topics of great relevance to the built environment sector, with the aim of promoting the cultural and professional development of scholars, researchers and practitioners in the field of building and architecture. In particular, the events aim to promote the dissemination of the research results of the academic community, to stimulate the development of the scientific activity of the associates in response to the rapid changes in the field of AE, as well as to support the qualified training of future academic figures.

Architectural Engineering plays a central role in the education of both engineers and architects, serving as a bridge between the two worlds of architectural design and technical feasibility. It explores the boundaries where the objectives of architectural projects meet performance requirements and technological standards. In fact, the scientific-disciplinary content focuses on the built environment, addressing its multiple architectural, typological, constructive, functional and performance characteristics.

Architectural Engineering provides students with tools, methods and models for critical, technological and systemic knowledge of the built environment during their training as engineers and architects. It enables the assessment of the performance and impact of existing and new buildings, evaluates technological solutions at different project scales, analyses complex systems to identify intervention scenarios, and provides processes, tools and models to improve the safety, resilience and sustainability of the built environment.

The 2025 edition of ColloquiATe will be held at the University of Trento. As in all previous editions, ColloquiATe2025 will offer all participants the opportunity to share their technical and scientific experiences, also in the light of the event's thematic core: ENVISIONING THE FUTURES - Designing and building for people and the environment.

The recent history of the construction sector is characterised by three main phases of development: the first, at the beginning of the so-called green revolution, characterised by a prevailing focus on the environment at different scales with the definition of sustainability issues in their different nuances (adaptation, mitigation, resource protection, reduction and recycling, circularity); the second aimed at a renewed interest in people and their needs, even primary ones (safety and security, user-centred environments, comfort, well-being, health); the third, the current one, more focused on digitalization tools in various fields, from data acquisition (sensors, IOT, 3D scanning) to process automation (robotics, 3D printing, drones) to digital analysis and information (multi-dimensional BIM, virtual and augmented reality, digital twins, AI-based technologies).

This process, now almost 40 years old, has been supported and steered by the driving force of European programmes (to which national and local ones have referred over time, most recently the PNRR) that have attempted to establish a common coordination and joint revitalisation of the sector, including the recent initiatives like the Green Deal, Horizon Europe and Digital Europe, the New European Bauhaus, the Recovery and Resilience Facility and InvestEU, to name the main ones.
However, the construction sector, which represents an important part of our country's and the EU's economy, remains in a continuous crisis largely due to economic aspects that hinder its development (temporary building bonuses and tax incentives, limited public investment, low liquidity of enterprises, progressive poverty of households), to the difficulty of constantly updating the technological (including digital) and managerial skills of the actors in the construction process, both public and private, and finally to the apparent dichotomy between the needs of industry and those of users, which are difficult to schematise in formally rigid and often poor quality logics, even if economically advantageous.
There is, therefore, a need to systemise the essential aspects of the construction sector, according to the three criteria of integration (of people, buildings, communities), circularity (economic and efficient use of resources) and simplicity (in planning, design, construction), in order to envision not a single, but multiple possible "futures" that intercept the horizons of the new generations and are able to interpret them with principles, processes, solutions, technologies and products also linked to digital transformation (in new constructions as for the existing heritage), addressed in a synergic and integrated way to the renewed needs of people and the quality of the indoor and outdoor environments.
This volume collects three valuable contributions of international keynote speakers: Eugenia Gasparri, Senior Lecturer in Architectural Technologies and Associate Dean of Research Education in the School of Architecture, Design and Planning at the University of Sydney, Australia; Charles Spence, Professor of Experimental Psychology and head of the Crossmodal Research Laboratory at the University of Oxford, UK; Werner Tscholl, Architect in Laces, Val Venosta, province of Bolzano, Italy.
The built environment and its relations with people, society, heritage and technologies are the common points of discussion and dissemination for the scientists who participate in the annual event of ColloquiATe.
All the contributions presented are collected in this volume and appropriately divided into three main themes:
A_Construction and Conservation History, B_Building Construction and Performance and C_Building Design and Technologies.

KEYNOTE LECTURES

Photo: Nicola Bailey ©

Eugenia Gasparri

School of Architecture, Design and Planning, University of Sydney

Eugenia Gasparri is a Senior Lecturer in Architectural Technologies and Associate Dean of Research Education in the School of Architecture, Design and Planning at the University of Sydney. Her research is multidisciplinary, applied and industry-oriented, with an emphasis on façade design and innovation to support the transition to net-positive built environments. She has a proven track record of research collaboration with the industry and esteemed research groups internationally and has secured over $3.5M in collaborative research grants to date. Her research on "Unitised Timber Envelopes" (UTE) is pioneering and has inspired market adoption of such systems across Europe, USA, Canada, Australia and Singapore. Since 2021, she worked with her team to establish "PHEBE Park", the first façade testing facility at the University of Sydney. Eugenia is currently leading several multi-disciplinary projects towards research translation, including the awarded "ALGA Façade", presented at TEDxSydney in 2024. She is the lead editor of "Rethinking Building Skins: Transformative Technologies and Research Trajectories", an agenda-setting book on the future of building façades that brings together 60 global innovators from academia and industry.

Rethinking Building Skins: What's Next on The Façade Horizon?

Facades play a pivotal role in architecture and the future of cities. They determine a building's aesthetic appearance and its relationship with the surrounding urban context. By mediating between indoor and outdoor environments, facades significantly contribute to occupants' comfort and well-being, buildings' energy performance, environmental impact, and adaptation to climate change. Ultimately, facades dramatically influence construction process efficiency and safety, particularly in high-rises that have become prominent in our densely urbanized cities. Therefore, facades have enormous potential to drive the building sector's transition to net zero and serve as perfect incubators for transformative innovation in construction.

In this talk, I will discuss opportunities and future research trajectories in facade design and construction through the lenses of both "product" and "process" innovation, envisioning a path towards a more sustainable and digitally integrated sector. I will then introduce some of my current projects on sustainable facade design and technology, emphasizing multi-disciplinarity and industry collaborations as key factors for innovation. My most recent work focuses on circular and regenerative facades to tackle the major challenges of future cities: increasingly high temperatures, more energy intensity, lack of fresh water, poor air quality, resource scarcity and food insecurity. Rethinking buildings as restorers rather than consumers is paramount to moving towards net-positive, resilient, and more equitable built environments.

Photo: Sam Frost ©

Charles Spence

Crossmodal Research Laboratory (CRL),
Department of Experimental Psychology,
Oxford University

Professor Charles Spence is a world-famous experimental psychologist with a specialization in neuroscience-inspired multisensory design. He has worked with many of the world's largest companies across the globe since establishing the Crossmodal Research Laboratory (CRL) at the Department of Experimental Psychology, Oxford University in 1997. Prof. Spence has published over 1,200 academic articles and edited or authored, 16 books including, in 2014, the Prose prize-winning "The perfect meal", and the international bestseller "Gastrophysics: The new science of eating" (2017; Penguin Viking) – winner of the 2019 Le Grand Prix de la Culture Gastronomique from Académie Internationale de la Gastronomie. His new book Sensehacking was published in 2021. Much of Prof. Spence's work focuses on the design of enhanced multisensory experiences, and he has recently published on the theme of multisensory architecture, and the impact of the multisensory environment on people's social, cognitive, and emotional well-being.

Sensehacking wellness

Traditionally, architectural practice has been dominated by the eye/sight. In recent decades, though, architects and designers have increasingly started to consider the other senses, namely sound, touch (including proprioception, kinesthesis, and the vestibular sense), smell, and on rare occasions, even taste in their work. As yet, there has been little recognition of the growing understanding of the multisensory nature of the human mind that has emerged from the field of cognitive neuroscience research. In this talk I will summarize the role of the human senses, both when considered individually and, more importantly, when studied collectively, in architectural design practice. It is only by recognizing the fundamentally multisensory nature of perception that one can really hope to explain a number of surprising crossmodal environmental, or atmospheric, interactions, such as between lighting colour and thermal comfort and between sound and the perceived safety of public space. At the same time, I will argue that the contemporary focus on synaesthetic design needs to be reframed in terms of the crossmodal correspondences and multisensory integration, at least if the most is to be made of multisensory interactions and synergies that have been uncovered in recent years. Looking to the future, the hope is that architectural design practice will increasingly incorporate our growing understanding of the human senses, and how they influence one another. Such a multisensory approach will hopefully lead to the development of living spaces that do a better job of promoting our health, and emotional well-being, rather than hindering it, as has too often been the case previously.

Photo: Manuel Ferrigato ©

Werner Tscholl

Tscholl Werner Architekt, Bozen

Werner Tscholl is a distinguished Italian architect known for his ability to integrate contemporary design into historical and natural contexts. After earning a degree in architecture from the University of Florence in 1981, he established his own firm in Morter, in the Vinschgau Valley (BZ), where he develops projects that blend innovation with respect for tradition and the landscape. His work has been widely published in Italian and international architectural journals and books and exhibited in major venues worldwide, including the Venice and Buenos Aires Architecture Biennales. In 2013, Electa dedicated a monograph to his work, Werner Tscholl Architetture. Among his many accolades, he received the Architetto Italiano award in 2016 and the IN/ARCH Triveneto Lifetime Achievement Award in 2020. From 2023 to 2024, he held the Adalberto Libera Chair of Excellence in Trento. In 2024, he was honored with the Architecture and Landscape Award at the Buenos Aires Biennale.

Concept follows context

Werner Tscholl's architecture is deeply rooted in its natural and social context. His works make a significant contribution to the characterization of a place, particularly by exploring its atmosphere to provide an architectural response.
A key focus of Tscholl's work is the relationship between the new and the existing, referring both to historical buildings and the surrounding environment. These themes, executed with consistency and credibility, give rise to works that establish a dialogue with their places of origin. The buildings are crafted with the utmost care and attention to detail, personally overseen by Tscholl throughout all project phases, from conception to construction management. This approach is made possible by a small and highly reliable team of internal and external collaborators, allowing the architect to maintain maximum control over his work.

A

CONSTRUCTION AND CONSERVATION HISTORY

Transitional architectures a response to contemporary needs in rural areas of Sardinia

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Abstract
Transitional architecture emerges as a derivation of the concept of temporary buildings and as a concretization of the phenomenon of transitory urbanism born in France. Temporary architectures, such as tents and capsules for emergencies, resolve momentary criticalities without lasting impacts on the context. However, transitory urbanism creates a qualitative link between past, present, and future uses of a site, differentiating itself from temporary occupation without long-term influence. Transitory urbanism, practiced in France for over a decade, involves the temporary occupation of spaces awaiting definitive use, often as a prelude to permanent interventions. Translating this concept to the architectural object, transitory architectures are defined as provisional devices that modify or reclaim a space, with short, medium, or long-term impacts on the place or social fabric in which they are situated. These architectures, like pioneer species, prepare the ground for more stable future uses, creating new places for meeting and culture. In particular, the idea of architecture emerges as a response to the contemporary needs of rural areas in Sardinia, illustrated with two case studies applied to this territory. The design principles include expandability, essentiality, reproducibility, divisibility, appropriateness, and self-sufficiency, ensuring flexibility, sustainability, and efficiency. Transitory architecture, therefore, not only responds to immediate needs but also generates a positive impact in the transformation of urban and rural landscapes.

Keywords
Transitory, Temporary, Rural-Landscape, Regeneration.

Digitalization and analysis of fragile and inaccessible architectural heritage: the case study of Masseria del Cristo in Matera, Italy

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Abstract
Digital 3D survey and modelling technologies allow to acquire easily and quickly high quality information, which together with traditional research techniques help to provide a very precise picture of Architectural Heritage and to catalogue its typologies, techniques and construction materials. These technologies are also useful for effectively disseminating the obtained results through consultation of 3D models available online useful for scholars, technicians and other users. The use of remote and "non-invasive" detection techniques can be applied for the protection of the Architectural Heritage at risk of disappearing and especially for inaccessible sites. The rural landscape of Matera preserves precious abandoned artifacts that are in critical conservation status. For these reasons their documentation and timely recovery are indispensable before an irreparable disappearance. The historical farmhouse known as *Masseria del Cristo*, which today is in a state of ruin, is an effective test bench for the proposed methodology. The study made it possible to understand the evolutionary phases of the case study through careful literature and archival searches on the topic. The case study was carried out with a UAV digital survey to elaborate a 3D digital model through Structure From Motion (SFM) processes, which formed the basis for an analysis of traditional materials and construction technologies. All the information acquired through the methodological steps has been merged into the model, in order to quickly and easily disseminate the acquired information through an existing web platform.

Keywords
Digitalization, Virtual Reality, Rural Heritage, Architectural Heritage, Traditional Building Materials and Techniques.

Investigating the use of augmented reality and BIM for architectural heritage: a systematic review

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Abstract

In recent years, digital methodologies such as Building Information Modeling (BIM) and its specialised variants for historic architectural heritage (HBIM) have revolutionised approaches to the conservation, management, restoration, and maintenance of existing architectures across various scales. The combined use of BIM/HBIM methodologies with immersive Augmented Reality (AR) technology enables the overlay of digital information onto real-world contexts, enhancing da-ta visualisation and user interaction. In these premises, this article explores the integration of AR-BIM/HBIM-based systems within architectural heritage at different dimensions and scales, providing an overview of their principal applications. To this end, a systematic literature review was conducted using the Scopus academic database. Following the PRISMA protocol, 17 records were identified and analysed. Outcomes highlight the single building as the predominant scope of application of the AR-BIM/HBIM-based system. This scale of the built environment facilitates conservation, management and maintenance disciplines, supporting users in digitalising documentation and providing diagnosis of critical issues. System of buildings follows as a scope with a focus on conservation, restoration and management, thanks to the development of systems that support the analysis, documentation and characterization of interventions. The least explored application scopes concern building components and historic districts. Despite these achievements, future activities must focus on the possible levels of interoperability of AR-BIM/HBIM models, their continuous updating for monitoring activities and the easy accessibility and unambiguous understanding of content to different classes of users.

Keywords

Augmented Reality, Building Information Modeling, Historic or Heritage Building Information Modeling, Architectural Heritage.

A large industrial building in the historic centre. Refurbishment and reuse of the Capra distilleries in Quartu Sant'Elena

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Abstract
The article is part of the research lines of DICAAR of Cagliari in the field of the regeneration of historical centres and the refurbishment of Industrial Architecture, and this case represents a point of convergence between two different research threads on the construction history and building techniques. The historical centre of Quartu Sant'Elena is one of the largest clay historical centres in the Mediterranean basin, which preserves an episode of industrial archaeology, the Capra distilleries, on which the University and the municipality plan to follow up on an integrated project to reuse the establishment as a research centre for technological innovation. The objective of the research is to define methods and techniques for the refurbishment of a complex factory of industrial archaeology in the historic centre by ensuring mixed uses. The building was constructed at the beginning of the 20th century as the headquarters of the distilleries of one of the most important Sardinian wine-producing consortia. It is configured as the result of a process of typological and construction hybridisation with the local tradition: a system of single-nave buildings articulated around a production courtyard, built with adobe bricks and covered with wooden carpentry. The restoration of an urban role is achieved through a typological inversion of the courtyard layout, which becomes a new public space for the historic centre, and through a system of structural integration by reinterpreting the continuous historic masonry architecture with CLT wood wall technology. The project therefore focuses on two central themes in the rehabilitation of the historic centre: the morpho-typological character and the building techniques, experimenting innovative approaches to the topic of refurbishment.

Keywords
Industrial Archaeology, Regeneration of Historic Centres, Raw Earth Heritage, University Spaces, Architectural Engineering.

Prefabricated construction systems for social housing in the florentine area

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Abstract
The urgent need for energy and environmental redevelopment of Europe's existing residential building stock is highlighted by the European Directive 2024/1275, aiming for a carbon-free economy by 2050. In Italy, public social housing built between the 1960s and 1980s presents structural, architectural, and energy inefficiencies due to aging construction, poor thermal performance, technological deficiencies, and outdated heating systems. This study systematically examines prefabricated and industrialized public housing in the provinces of Florence and Prato using Geographic Information System (GIS) tools to create a geo-referenced database with information derived from original design documents retrieved from the Casa S. p. A. archives. Through a statistical analysis of 72 prefabricated housing complexes, the study identifies the most prevalent construction systems and their defining features. The most significative construction solutions are detailed to analyse the technological aspects of each system. Two representative case studies are hence analysed in detail to assess their global energy performance and determine their energy classification. The evaluation highlights critical inefficiencies, including thermal bridging, inadequate insulation, and high heating demand, which contribute to poor energy efficiency ratings. The results provide a basis for developing targeted retrofitting strategies to improve thermal comfort, reduce energy consumption, and extend the lifespan of these buildings. The study contributes to the ongoing efforts toward sustainable redevelopment by offering a structured methodology for assessing and enhancing the energy performance of prefabricated public housing complexes.

Keywords
Public Social Housing, Prefabricated Construction, GIS Analysis, Energy Performance, Sustainable Retrofitting.

Universities, student housings and cities: a network for innovation and development

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Abstract

The contribution aims to analyze, through a historical excursus, the close relationship between the development of universities, student housing and cities. This relationship is built on synergies, continuous transformations and modifications in response to social, cultural, economic and environmental changes. Even today, the bond between cities, universities and colleges remains essential and constantly evolving.

Considering these premises, the contribution examines the University of Pavia and the city as a university campus, with colleges playing an active role, as an emblematic case study. This process follows a complex history but continues to shape transformation and renewal policies while respecting the historical memory of both the university and the city. Finally, a critical reading of this process is considered an opportunity to identify new policies for innovation and updating in response to changing needs, as well as to improve performance not only in compliance with regulatory guidelines but also with the belief that college structures play an active role in addressing contemporary issues.

Keywords

Student Housing, University Campus, Enhancement, Innovation, Memory.

Retracing proto-design for disassembly in Italy through industrial patents (1940s-1960s). Olga Caminati's inventions for demountable structures and constructions

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Abstract
This paper examines the evolution of demountable constructions in mid-20th century architecture through industrial patents, retracing early experimentation with principles now associated with Design for Disassembly and Adaptability (DfD/A). Conducted within the PRIN PNRR 2022 research project "Upcycling and Architecture in Italy. Forging and Promoting a Renewed Building Culture", this paper investigates how past innovations in prefabrication, modularity, and dry assembly anticipated contemporary design strategies aimed at saving non-renewable resources, later formalized in standards such as ISO 20887:2020. Using a rigorous archival research approach, the analysis focuses on patents filed in Italy between the 1940s and 1960s, a period of intense experimentation in construction industrialization, largely driven by post-war reconstruction. Through a systematic comparison of selected patents with DfD/A principles – reversibility, modularity, adaptability, and structural independence – this study highlights the technical and conceptual continuities between practices of the recent past and contemporary circular construction approaches. Particular attention is given to the patents filed by architect Olga Caminati (1943–1945), selected as a case study and examined through constructive redrawing and digital modelling techniques. Based on extensive archival research within the Italian Office for Industrial Patents and Trademarks (*Archivio Centrale dello Stato*) in Rome, this work contributes to bridging a critical gap in the historiography of industrialized construction, exploring historical precedents that help contextualize approaches and methodologies informing contemporary discussions on sustainability and circular design.

Keywords
Design for Disassembly, Upcycling, Construction History, Demountable Structures, Olga Caminati.

Digitisation of the existing built Heritage for reuse

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Abstract
Architecture is a constantly evolving process, characterized by layering and transformations that redefine its meaning and function over time. Reuse and redevelopment are key strategies for building heritage conservation and environmental sustainability, in line with the goals of the UN 2030 Agenda. Adaptation of existing buildings makes it possible to reduce land consumption and pollutant emissions while preserving the historical identity of places. Architectural rehabilitation addresses three main forms of obsolescence: technological, functional, and image. Through a careful process of analysis, which includes assessment of residual performance and stratigraphic reading of the building, targeted interventions compatible with the context can be identified. The integration of digital methodologies and advanced modeling tools makes it possible to optimize design solutions, improving energy efficiency and space quality.
The case study of the Pavia *Idroscalo* (seaplane base) exemplifies the challenges and opportunities of architectural rehabilitation. Built in the 1920s to support Italy's nascent civil aviation, the building has undergone transformations and is now in a state of disrepair. The design proposal aims to restore value to the building through a multifunctional approach that promotes public enjoyment, connection with the city and inclusion in a network of enhancement of the river territory. This case study, part of a Msc thesis research project, highlights how knowledge of the building, its history and its context are key elements for a sustainable intervention, capable of combining preservation and innovation, and of restoring new life to disused spaces through integrated recovery strategies, starting with digital modeling methodologies to support decision-making. Modeling and simulation tools make it possible to analyse residual performance and optimize interventions, ensuring a balance between conservation and innovation.

Keywords
Built Heritage, Preservation, Reality-Based Mode, Reuse of Existing, Intervention Strategie.

Valorisation of historical heritage and urban project: a methodological sight

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Abstract
The contribution is framed within the research fields of DICAAR, Department of Civil Environmental Engineering and Architecture of the University of Cagliari, on the topic of the regeneration of historical centres and the relationship between the valorisation of historical heritage and contemporary design. The following is a summary of a training experience in the context of the RCR XVII International Architecture and Landscape Workshop 2024, focused on the transmission of a precise methodology for the project. The architects' contribution concerns the construction of a design posture based on intentionality and a selective ability, which in turn is able to translate into a communicative awareness in the graphic elaboration and verbal exposition. One of the proposed design exercises questions the way in which the city of Barcelona can respond urbanistically to such a complex theme as the Sagrada Familia Basilica in the making, exploring issues related to the usability of the historical monumental heritage as an element endowed with an urban vocation, in its being a potential economic activator and social attractor. The issue is at the centre of contemporary debate due to the imminent completion of the temple's construction, including its main entrance for which Antoni Gaudì designed a grand staircase, now in conflict with the urban fabric of the present city. The projects elaborated during the workshop show different approaches with which to interpret the topic of accessibility in a cohesive manner with respect to an interpretative path guided by a precise methodological structure.

Keywords
Urban Regeneration, Historical Heritage, Building Heritage Recovery, Methodology, Accessibility.

Engineering and construction as a language: structures for production in Lazio

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Abstract
As part of the research project 'Carta della Cultura Industriale' (CdCI - https://dtclazio.it/cdci), which concluded in 2024, on the history of industrial architecture in Lazio in the post-war period (1945-1975), the authors of the contribution have concentrated their studies on the use of structure and technological component in the language of factory architecture.
The text highlights the main evolutionary lines of this theme in the built works.
In the absence of a real "style" dictated by the Cassa del Mezzogiorno Institute, as well as centralized typological directives, the designers involved in the construction of factories in Lazio pragmatically exploited the degree of formal freedom granted by the urban planning tools and building regulations of the individual municipalities. This allowed them to interpret the industrial theme, made specific by production and by the client, according to diversified construction and structural solutions.
The common architectural and construction matrix of the Lazio factories was the specific training and experience acquired by the professionals hired, especially from the Roman area or school, particularly active in private residential architecture and ecclesiastical architecture. These were designers almost always interested in using the construction elements in a linguistic key – as in the most typical works of architectural realism – left visible in the facades characterized by details designed ad hoc. They also used the same approach when designing a factory, although necessarily recalibrating their design to the different contexts and economic availability of the intervention.
Ultimately, the industrial heritage of the Lazio region represents a cross-section of what was happening in the rest of the country due to the technological evolution of the Italian construction.

Keywords
Industrial Architecture, Construction History, Structures, SIXXI Research, Lazio.

Industrial architecture and the "production of evil": the Risiera di San Sabba

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Abstract
Beyond the boundary that defines what is human and what is inhuman, architecture becomes the material evidence that narrates stories stratified over time and offers the stimulus to investigate dramatic events such as the Shoah. The lager became the instrument of a politics that turned totalitarian, despotic and violent. In this period, existing buildings often served as containers for the 'production of evil'. In Italy, with Ordinance No. 5 of 1943 and the forced deportation of Jews, numerous buildings were reused for these political purposes. In particular, the research aims to analyse an emblematic case study: the Risiera di San Sabba in Trieste. This is an industrial complex that was used as a Nazi camp and is the only existing case of an extermination camp in Italy.
The investigation is conducted through archival and documentary analysis to understand the processes of transformation that the building underwent and the layering of associated collective memory. The successive functional, architectural, and urban transformations are examined through a cross-sectional approach. This involves comparing the original design of the industrial building – a rice husking – its subsequent reuse, first as a Nazi camp and later as a refugee camp, and its current status as a Civic Museum. The remarkable adaptability of the spaces of this architecture demonstrates the relationship between technique, design, and the historical, urban, and territorial context, which has also led to a shift in the semantics of the place. The archival and documentary survey has highlighted reflections and discussions about the building and its several values. Related to this, the approaches, tools and limits of valorisation for transforming collective memory are critically investigated.

Keywords
*Risiera di San Sabba, Industrial Archaeology, Extermination Camps, Cultural Heritage, Memorial Valu*e.

The rehabilitation building yard as a tool for enhancing the architectural historical heritage in the Madonie inner area

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Abstract
This article represents an initial report for a broader doctoral research project in "Sustainable Architectural Design: A Human-Centered Approach," which will be conducted in the mountain Madonie internal area of Sicily. The primary objective is to introduce best practices and identify strategies for repopulating the 26 municipalities of this region, focusing on the recovery and enhancement of architectural heritage. Specifically, the research emphasizes basic construction techniques with the aim of innovatively reinterpreting traditional building methods and materials, working at the building scale. It also seeks to stimulate local production chains and identify strategies to create the conditions for re-urbanization in the area. Within the "state of the art" analysis, the research identifies best practices from the Euro-Mediterranean context that show similarities to the Madonie region and investigates their replicability in the internal area. It presents cases where rehabilitation building yard not only enhance and enable the reuse of existing heritage, but also serve as opportunities for training, dissemination, and experimentation with traditional architectural techniques and materials. These practices play a key role in achieving the sustainability goals outlined in the 2030 Agenda.

Keywords
Rehabilitation Building Yard, Re-Inhabit, Sicilian Madonie Inner Area, Vernacular Architecture, Valorization and Reuse of Traditional Built Heritage.

Safeguarding the anonymous industrial building heritage by an interactive catalogue of paradigmatic construction elements: the case of thin shells

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Abstract
The industrial buildings represent a key asset of the 20th Century cultural and technological heritage: the reuse of industrial heritage involves the essential phase of recognizing the intrinsic values of the industrial legacy, dealing within the development of specific safeguard strategy and tools. The ideation and the construction of specific digital tools to support the cataloguing of the industrial buildings, with specific reference to the anonymous industrial buildings is presented in this paper. A specific addendum of the cataloguing form and a typological database of geometrical and informative models of paradigmatic construction elements, featured by significant structural and building innovations are, thus, developed. The platform allows to disseminate the base knowledge framework of specific construction systems and automatize the customization of the cataloguing form related to the single building. Thin shells roofing elements, applied in Italy for industrial buildings between the 1930s and the 1960s, are considered as case study.

Keywords
Industrial Heritage, Anonymous Building, Digital Archive, Census/Cataloguing, Conservation/Reuse.

AI Assistant for heritage knowledge management: retrieving integrated data from ontology-driven HBIM and archival documents

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Abstract
Managing heritage assets nowadays requires systems capable of handling the complexity of diverse data types, from structured Heritage Building Information Models (HBIM) and information ontologies to historical and archival documents and investigation reports. Current practices struggle to combine these diverse types of information and formats, limiting the possibility of comprehensive heritage interpretation and reasoning processes.
This paper introduces an AI Assistant to integrate an ontology-driven HBIM with textual documentation for natural language querying, inference, and knowledge management.
The system consists of (1) IndArch ontology used to structure representation templates in the (2) HBIM model, where the parameters, such as spatial, structural, and historical event-based features, are extracted and converted into JSON format for compatibility with the AI model; (3) unstructured data, including a variety of documentation (pdf files) are directly processed through (4) the AI Assistant's backend, which leverages "file search" and "function calling" capabilities to query and cross-reference information.
The proposed framework, applied to the Sanctuary of Hercules and the former Segrè Papermill in Tivoli, Italy, reconstructs the room functions and the latest papermill production process; the AI Assistant demonstrates its ability to infer knowledge from structured and unstructured sources, enhance accessibility, and reduce technical barriers for heritage professionals.
Finally, the system is qualitatively evaluated to assess model performance and identify areas for improvement in the AI training phase.

Keywords
HBIM, Information Ontologies, AI Assistant, Architectural Heritage, Knowledge Management.

The nested building technique in cross-laminated timber for the recovery of abandoned rural heritage in the Hilly area of north-eastern Italy

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Abstract
The recovery of disused and decaying rural buildings aims to limit further land consumption, preserve the historical identity and cultural value of this heritage, and enhance the territory through the promotion of sustainable rural tourism in otherwise marginal and socially inactive areas.
A key preliminary step in building recovery projects is the study of the typologies and distinctive construction features within the area of interest, which in this research is the *Colli Euganei* (Padua).
The current condition of the buildings, resulting from natural deterioration and interventions carried out, along with the potential presence of historical-architectural constraints, guide the evaluation and validation of the Nested Building technique. In fact, this technique seeks to recover the built heritage by preserving the morphological and typological features of façades, which stand as testaments to the territorial and historical context being examined, while adhering to principles of minimal intervention, reversibility, and legibility. The comparison of different solutions and materials led this research to select cross-laminated timber panel as solution for several reasons, including site management, structural performance, thermal and acoustic behaviour, fire resistance, and intervention reversibility.
This paper presents the potential applications of the Nested Building technique through an exemplary case study, namely the rural annexes of villa Ca' Barbaro, located in Baone (Padua).

Keywords
Building Recovery, Rural Buildings, Rural Tourism, Nested Building, Cross Laminated Timber.

Analysis of adaptive reuse models for abandoned built heritage in small towns of inland areas: strengths, challenges, and opportunities

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Abstract
Adaptive reuse of abandoned built heritage is a major contemporary challenge in the conservation and enhancement of cultural, historical, and social heritage. Interest in this topic is increasing both in academic research and practical applications, as it allows abandoned buildings to be transformed into valuable assets for sustainable development. This study examines key adaptive reuse models, analyzing their strengths and limitations, with a particular focus on their applicability to small inland towns, where economic and social conditions often differ from larger urban centers. Among the most relevant models are ARP (Adaptive Reuse Potential), which evaluates the economic viability and sustainability of reuse; IconCUR (Integrated Conservation and Urban Regeneration), which integrates heritage conservation with urban renewal; and circular economy-inspired models, which view heritage as part of a continuous resource cycle. Other approaches include Campbell's Planner's Triangle, which balances economic growth, social equity, and environmental protection; the Historic Urban Landscape approach, which takes a holistic view of urban heritage management; and the Cultural Heritage Counts for Europe model, which highlights the economic, social, environmental, and cultural benefits of heritage reuse. However, applying these models to small inland towns presents several challenges. Most of them were designed for well-developed urban contexts and may be less effective in addressing depopulation, lack of services, and economic fragility. Therefore, more flexible and adaptable models are needed to respond to local needs and ensure that buildings heritage reuse becomes a strategic tool for sustainable and inclusive regeneration in marginalized territories.

Keywords
Adaptive Reuse, Participation, Model, Built Heritage, Inland Areas.

The reuse of disused industrial buildings: analysis and proposals for a case study

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Abstract

The discussed topic concerns "decommissioning industrial", i.e. the process of deactivating areas, sites or single buildings used for production activities. In particular, the subject of reuse is investigated as a practice to contrast the risk of degradation and as a possible solution to meet the usage needs of today's society. The functional reconversion of an industrial site can be an opportunity, leading to positive effects on both the environmental and the social and economic context, and can make a decisive contribution to sustainable land regeneration policies. The analysed case study, concerning the area of the Solofra industrial district and a former tanning factory now disused, shows how the reuse practice can not only meet the needs of contemporary life but, at the same time, preserve the soil from gradual consumption. The developed proposal is based on a multi-scalar model, which starts with the urban-functional reorganisation of the area and then addresses the reuse of a single building as a sample. The new use for the disused factory is the result of a needs analysis that gave rise to a project that aims to contribute to solving the problem of the housing crisis for disadvantaged people. Possible developments of the work could concern the deepening of intervention techniques to recover the building, the evaluation of the social impact of reuse and the setting up of an administrative structure model dedicated to the management, maintenance and development of real estate for social purposes.

Keywords

Industrial Buildings, Disused, Sustainable Reconversion, Building Reuse.

A cross-disciplinary approach for the safeguard of modern urban heritage: historical investigation, satellite measurement, structural vulnerability analysis

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Abstract

The safeguard of the modern urban heritage, densely inhabited, characterized by binding durability limits and exposed to different environ-mental of risk, is a main axis of the sustainable development territory policies. The present paper develops a cross-disciplinary and multi-data-driven approach to support the decision-making-process of safeguard, management and maintenance of the modern urban heritage. The methodology is based on the spatial analysis of georeferenced data derived from historical archive surveys, satellite radar surveys (SAR), and structural vulnerability and risk assessments. Results are managed on a WebGIS platform to produce interactive easy-to-use thematic maps. The methodology is tested on the case study of Verona, focusing on the Borgo Trento sector of the Adige riverfront, which represents a benchmark for the complexity of the morphological and technological characters of the heritage buildings and the infrastructures located in the area.

Keywords

Historical Archives, Taxonomy, Seismic Performance, Multi-Temporal Differential SAR Interferometry, WebGIS.

Toward a frugal-sustainable built environment: interdisciplinary design method to improve human well-being

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Abstract
Human health and well-being have a close correlation with the built environment, both at the urban and building scales, in the public and private dimensions. The importance of the role played by architecture is evident, because, in its role of organizing space at any scale, can affect human physical and mental well-being. The aim of this paper is to identify the main intervention strategies for healthy, ecological and frugal design, with a focus on the architectural and constructive aspects of the built environment and the psychological aspects of the users. On the basis of the analyses carried out, through a context-based approach and user needs, including through the participatory tool, critical issues related to safety, mobility and, above all, community well-being emerge, very often not considered by designers. The response to these needs is therefore searched with architecture in its widest sense, in that it should not be limited to the characteristics of the built environment, but should relate directly to the lifestyles and needs of the user. The interdisciplinary approach, starting from the assessment of user needs and going through a morphological and environmental study of the places under study, proposes design guidelines in the management and development of the relationship between public open space, built environment and user. Within this framework, it also aims to respond to the vulnerability of the built environment, especially the historic one, from the new challenges of climate change to the more treated seismic risk.

Keywords
Sustainable Design, Built Environment, Human Well-Being, Public Open Spaces, Frugal Design.

Smart villages in the Madonie Park. A relevant network for the competitiveness and enhancement of a Sicilian inner rural area

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Abstract
This Research provides an in-depth analysis of the challenges and opportunities within Italy's inner areas, with a specific focus on the Madonie Park in Sicily and its 21 municipalities. It promotes sustainable development and context-sensitive technological solutions within the Madonie UNESCO Geopark—a protected area renowned for its exceptional natural and cultural heritage—through the implementation of Smart Villages. The study's key outcomes include an extensive atlas of technological solutions, and a comprehensive set of strategies and innovations tailored to regional requirements, ensuring compatibility with built heritage constraints while enabling sustainable progress. Additionally, it offers detailed guidelines, best practices, management protocols, and business models to empower local communities with actionable tools for sustainable transformation. The pilot case guidelines for the village of Polizzi Generosa provide a practical and replicable model for trans-forming these territories into "smart" areas, consistent with the European Strategy for Smart Villages. This integrated methodology effectively combines the restoration and enhancement of historical and architectural heritage with sustainable repopulation strategies, allowing communities to embrace modern living standards while preserving cultural identity and traditions. The proposed solutions are both context-specific and adaptable, ensuring their applicability to other marginal areas through analogical or contrasting approaches. By integrating heritage preservation, sustainable technologies, and community revitalization, this study highlights the role of technology as a catalyst for inclusivity, accessibility, and resilience. It presents a scalable framework for the regeneration of Italian inner areas and similar regions globally.

Keywords
Smart Villages, Sustainable Technology, Italian Inner Areas, Smart Rehabilitation, Atlas and Guidelines.

Resilient green collective spaces. A lesson for UniPa Campus from case studies

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Abstract
As urbanization intensifies globally, universities play a crucial role in pioneering sustainable urban development strategies. This study explores the implementation of Naturebased Solutions (NbS) in university campuses, analyzing case studies that integrate ecological principles with intelligent systems to enhance environmental performance and user well-being. The first phase of the research examines the methodologies adopted, the specific strategies applied, and their effectiveness in improving both outdoor and indoor comfort. By identifying key lessons learned and best practices all over the world, this study provides a structured framework for adapting successful approaches to new contexts. The second phase of the research focuses on applying these insights to the campus of the University of Palermo, using a methodology transfer process to define strategies tailored to its specific environmental and climatic conditions. The goal is to improve thermal comfort, air quality, and overall livability of indoor and outdoor spaces through innovative, data-driven nature-based solutions. Special attention is given to technical application, interdisciplinary collaboration, stakeholder engagement, and adaptive management, ensuring that the proposed interventions are both scalable and sustainable. Moreover, the study addresses emerging challenges, such as the replicability of NbS across different geographic contexts, the integration of smart monitoring technologies, and the ethical implications of data-driven environmental management. Through this analysis, the research provides valuable insights into the potential and limitations of NbS, demonstrating how universities can serve as living laboratories for sustainable urban innovation while responding to the specific needs of their communities.

Keywords
Sustainable University Campus, Methodology Transfer, Outdoor and Indoor Comfort, Green Environmental Strategies, Adaptive Management.

Water towers through time. Guidelines, approaches, and practices for strategic valorization

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Abstract
This study analyses the development and technological functions of water towers worldwide, with a particular focus on their evolution in Italy, specifically in the city of Palermo. Originally conceived as prominent landmarks in peri-urban areas, Palermo's water towers once punctuated the agricultural landscape and suburban area, serving as critical infrastructure for water storage and distribution. Over time, as urban expansion reshaped the city and its fabric, many of these structures fell into neglect. This research examines the transformation of water distribution systems, emphasizing the pivotal role of water towers in both urban and rural contexts and exploring their rehabilitation. By conducting a comparative analysis of adaptive reuse strategies, the study identifies different approaches to their preservation and re-functionalization. For the case of Palermo, a preliminary technological classification is here proposed, distinguishing between urban and rural types based on architectural and constructive characteristics and functional purposes. This classification is aimed to guide rehabilitation and valorisation through the analysis of specific case studies. By examining case studies from around the world, this research identifies rehabilitation methodologies that can serve as valuable examples for Palermo, offering strategies adaptable to its specific context. Through the cataloguing and analysis of the technological attributes of Palermo's water towers, this study seeks to elevate their status as heritage assets and establish a foundation for their future conservation. It advocates for their preservation through adaptive reuse strategies that ensure public accessibility while respecting their historical and technological significance, bridging international best practices with the local implementation in Palermo.

Keywords
Water Towers, Industrial Architecture, Architectural Engineering, Compatible Rehabilitation, Palermo.

Repurposing rural objects of vernacular architecture as an engine of sustainable regeneration: an integrated approach for the enhancement of Lucanian farmhouses and Valencian barraccas through advanced technologies and digitisation

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Abstract
Minor rural architectures constitute a fundamental element of Europe's cultural heritage, contributing to the definition of territorial identity and the preservation of historical memory.
However, these structures are often excluded from protection priorities because of a conservation approach mainly oriented towards large monumental complexes.
This study proposes an enhancement of the ICCD's cataloguing system through the integration of a digital archive of historical memory, focusing on traditional building techniques and the tangible and intangible heritage associated with them.
The analysis focuses on the representative case studies of Basilicata (Italy) and the Valencian Community (Spain), examining criticalities and opportunities in the respective cataloguing models. The research aims to combine digital technologies (photogrammetry, 3D scanning) and community participation, aimed at the reinterpretation of rural architectural elements as symbol-objects. This reconversion transforms traditional artefacts into contemporary resources, acting as an engine for territorial and cultural regeneration. The multidisciplinary approach demonstrates how rural heritage can become an active tool for sustainable development, combining memory conservation and design innovation.
The results present a replicable model for other Mediterranean areas, in which vernacular architecture assumes a dual role: preserver of historical identity and agent of social and economic transformation.

Keywords
Vernacular Architecture, Traditional Building Techniques, Participatory Cataloguing, Memory of Places, Mediterranean Identity, Heritage Conservation.

Living inside the cliff. A research experience in the Prepyrenees

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Abstract
The article summarises the research experience within the Espluga de Cuberes International Workshop, organised by the RehabiMed association, with the collaboration of the University of Cagliari (DICAAR) and the Universidad Politécnica de Cataluña (UPC-EPSEB). The association has decades of experience in the production of studies investigating the possibilities of preserving and recovering the traditional heritage of settlement habitats in Mediterranean countries, offering opportunities for the dissemination of a shared constructive culture of living and its different regionalisms.
The workshop, held during the two weeks between August and September 2024, represented the start of a research on the theme of troglodytic habitats in the Mediterranean context, using as a case study Espluga de Cuberes, a micro-dwelling system created inside a cavity geologically originated in the Sierra de Boumort, in the pre-Pyrenean system of north-western Catalonia.
The structure of the workshop proposed by RehabiMed alternates propaedeutic activities, with an interdisciplinary dimension to acquire the notions of previous study of the site, with activities in which the physical presence in situ, in addition to being necessary to carry out accurate surveys of the material consistencies of the architectures, is fundamental to interpret and construct hypotheses on the living arrangements in extreme contexts and conditions such as those of the troglodytic habitat of the pre-modern period, in which the domestic environment is the result of the encounter between environmental conditions and the adaptability of the human being.

Keywords
Troglodytism, Habitat, Cultural-Landscape, Rural, Prepyrenees.

Compressive behavior of brick masonry columns confined with steel composites embedded in the mortar joint: experimental analysis and comparison with FRCM technique

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Abstract
Masonry columns in historic structures often exhibit reduced load-bearing capacity and vulnerability to seismic actions due to their brittle behaviour and limited tensile strength. Enhancing their structural performance while preserving architectural authenticity is a pressing challenge in the field of structural engineering and conservation. This study presents an experimental investigation into a novel strengthening approach involving the integration of pre-tensioned steel micro-cords within the horizontal mortar joints of brick masonry columns. The mechanical response under compressive loading is analysed for both circular and rectangular column cross-sections. The effectiveness of this technique is evaluated in comparison with Fiber Reinforced Cementitious Matrix (FRCM) jacketing, a more widely adopted confinement system. The experimental findings reveal that the embedded micro-cord system significantly enhances compressive strength, yielding an average increase of approximately 87%, outperforming the FRCM solution, which achieved a strength gain of around 45%. Additionally, the proposed method offers the advantage of being minimally invasive and visually unobtrusive, making it particularly suitable for heritage buildings where preserving original aesthetics is crucial. This research highlights the potential of mortar joint-based reinforcement as an efficient alternative to traditional jacketing systems, paving the way for further development of non-invasive strengthening methods for masonry structures.

Keywords
Bed-Oint Masonry Strengthening, Structural Retrofitting, Masonry Columns, Experimental Study, Heritage Conservation.

Conservation and valorization of the modern heritage: the case of the restoration of the restoration of the church of Ludovico Quaroni in La Martella

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Abstract
After World War II, post-war reconstruction and the construction of new rural villages in Italy represented an opportunity to experiment with modern ideas in urban planning and architecture in a context different from Fascist ruralisation but still strongly influenced by it. Modernity is often associated with cities, where urban planning and architecture have rationalised space; in the twentieth century, rural modernisation transformed the physical and settlement geography of many regions. This research focuses on the rural village of La Martella in Matera, specifically on the Church of San Vincenzo de' Paoli, designed by Ludovico Quaroni, a manifesto of the rural-Modern architectural language used in Southern Italy. This study aims to highlight the importance of preserving Modern architecture by proposing a methodology that enhances knowledge of architectural heritage through documentary and archival analysis, the study of construction manuals (which facilitate understanding standard building solutions), and on-site surveys. The critical analysis of this case study, with particular attention to construction techniques and materials used, becomes an essential tool for defining a correct and informed methodological approach for a restoration (or restoration of the restoration) project of this architectural heritage.

Keywords
Knowledge, Conservation, Modern Heritage, Restoration of the Restoration, Valorization.

Mario Ridolfi in Terni.
The Leonardo da Vinci middle school

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Abstract
The relationship between Mario Ridolfi and Umbria has always been marked by a particular depth, so much so that the Roman architect decided to spend the last phase of his life there. Ever since the competition for the fountain in Tacitus Square in 1931, his professional career has intersected on numerous occasions with the city of Terni, for which he was called in 1945, after the violent Anglo-American bombing in July 1943, to draw up the Reconstruction Plan and later, in 1960, the General Regulatory Plan. Ridolfi's contribution to the definition of the city's urban fabric was not limited, however, to the drafting of urban planning instruments aimed at recovering the identity lost as a result of the extensive damage suffered during World War II; in fact, he designed numerous buildings over the years, many of them residential, which, starting from the local building tradition and revisiting it through his particular material sensibility, contributed to outlining a new image of the city. The contribution presents the study of the Leonardo da Vinci school, built precisely in the area affected by the Reconstruction Plan and intended to meet the need to provide the city of Terni with a school building designed solely to accommodate middle school students. The troubled design process of the work, which began in 1951, developed for almost ten years during which three different projects and numerous variants were drawn up until, in 1961, the building was completed in which, as Sergio Poretti points out, «the conjugation of frame, masonry and window becomes a fundamental compositional motif from which springs that ineffable building realism for which the image magically reflects the atmospheres the tones the moods of the place.»

Keywords
School Building, Mario Ridolfi, Building Design, Construction Details, Sponga Stone.

Feature extraction of point clouds for cultural heritage monitoring and conservation

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Abstract
In the digital era, with the emergence of advanced reality-capture technologies, there is a growing recognition of the importance of documentation and monitoring of architectural heritage (AH) in conservation efforts. Techniques such as terrestrial laser scanning (TLS), mobile LiDAR, and photogrammetry generate high-resolution point clouds (PCs), providing detailed geometric and radiometric data for heritage structures. However, the complexity and unstructured nature of PCs can pose challenges related to data processing, segmentation, and storage.
One possible step in the right direction could be the identification of relevant geometric attributes, through a process of feature extraction, with the aim of optimising segmentation and classification processes. Segmentation, i.e. the subdivision of PCs into coherent subsets, could allow the efficient analysis, interpretation and visualisation of architectural elements. This process could in turn enhance the application of Heritage-Building Information Modeling (HBIM), degradation mapping and structural assessments, facilitating non-invasive monitoring and long-term conservation strategies.
Although the scientific community emphasises the use of artificial intelligence solutions and algorithms to automate processes, this contribution proposes instead the development of structured workflows for processing PCs, analysing the potential of geometric features in order to enrich 3D models with semantic information. The study is part of the Tech4You project within the National Recovery and Resilience Plan (PNRR).

Keywords
Cultural Heritage, Point Clouds, Segmentation, Feature Extraction, Monitoring.

Analysis of historic multi-leaf masonry behaviour under compressive load through Digital Image Correlation (DIC)

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Abstract

This research investigates historic multi-leaf masonry with a particular focus on the out-of-plane strains of historic masonry walls subjected to compressive loading. The specimens analyzed consist of two distinct types: three double-curtain walls with non-collaborating layers and three walls with two external curtains and an internal core. The primary objective is to study the behaviour of masonry under compressive load by comparing experimental results obtained using the traditional method of Linear Variable Displacement Transducers (LVDTs) with those derived from the novel technique of Digital Image Correlation (DIC). This comparison aims to identify the failure modes of multi-leaf masonry and to analyze the strains that develop when the walls are compressed. Another key aspect explored in this study are the data acquisition methodologies. Specifically, the research seeks to validate the innovative digital tool, DIC, employed in conjunction with the traditional LVDT method. It assesses the reliability of the DIC results by comparing them with those obtained from LVDTs, highlighting its numerous advantages. Unlike the traditional methodology, DIC, which employs optical cameras, does not require physical contact with the specimen during testing. It provides continuous data throughout the experiment and allows for the measurement of displacements and deformations across the entire specimen, as opposed to the localized areas monitored by LVDTs. Furthermore, this research contributes valuable insights into multi-leaf masonry and failure loads, which are essential for characterizing this type of masonry.

Keywords

Historic Masonry, Out-of-Plane, Uniaxial Compression, Digital Image Correlation, Multi-Leaf Masonry.

Qualitative indicators to assess the effectiveness of renovation interventions on industrial archeology

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Abstract
Before undertaking any intervention on heritage, it is essential to conduct a comprehensive evaluation that transcends traditional quantitative metrics. In the realm of industrial archaeology, qualitative indicators have proven to be indispensable tools for assessing the efficacy of any interventions. By emphasizing aspects such as historical integrity, cultural significance, community involvement, and environmental sustainability, these indicators offer a multidimensional framework for understanding the impact of interventions in industrial heritage sites. This study underscores the critical need to balance the physical preservation of industrial sites with the safeguarding of their social and cultural dimensions. It demonstrates how qualitative assessments can provide decision-makers with a deeper understanding of the broader consequences of their actions. As a case study, the research examines an abandoned industrial heritage site in Salerno, illustrating the limitations of an incomplete approach and exploring the potential of alternative regeneration strategies for the site.

Keywords
Industrial Archeology, Qualitative Indicators, Industrial Heritage, Sustainable Development, Architecture.

Construction ingenuity and aeronautical experimentation: the D.S.S.E. construction site in Guidonia as a laboratory of innovation

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Abstract
The site has always been a place where technological innovation meets new materials and construction techniques, and can be a real research laboratory, where experience and technique are combined to meet the needs of the reference context. In this perspective, the present contribution aims to decode the innovative approach adopted in the implementation of the Higher Direction Studies and Experiences of Guidonia and to understand the construction processes through the distinct phases of the construction site. The investigation, conducted by reading photographic documentation, has allowed to reconstruct the organization of the site and the strategies adopted to build buildings with advanced technological characteristics. Particular attention is paid to the construction of the site and its functions that have allowed the realization of complex futuristic, such as wind tunnels, hydrodynamic tanks and laboratories for aeronautical tests. This perspective highlights how the management of the construction site and the building process fits into an integrated knowledge system, where different skills are interwoven to give life to new architectural and engineering solutions. In a period marked by economic and political constraints, the site is not limited to being a simple place of "do" but becomes the place for new opportunities for research on materials and modern construction techniques, creating a significant model of synthesis between architecture and industry.

Keywords
Construction Innovation, Rationalist Architecture, Aeronautics, Experimental Techniques, Guidonia D.S.S.E..

Data, analysis, and Immersive digital models for the multi-risk assessment of built heritage: the Interconnecting project

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Abstract

Cultural heritage sites are increasingly at risk from environmental changes, degradation, and extreme events such as earthquakes. These hazards threaten the integrity of historical structures and artistic assets, highlighting the need for advanced conservation strategies that incorporate accurate data management, predictive modelling, and risk assessment tools. Previous research emphasizes the need to integrate multi-risk analysis and modern tools to support decision-making and the definition of intervention strategies. On the other hand, current approaches often fail to integrate diverse data sources, limiting their ability to offer comprehensive solutions. Additionally, only a few recent studies have started to consider the potential of immersive technologies for decision-making in conservation planning. This gap underscores the need for innovative approaches that combine advanced technology with environmentally sustainable solutions in heritage conservation. This paper provides an overview of the INTERCONNECTING project, which aims to develop an integrated platform for managing heterogeneous data and historical research. It will utilize Digital Twin models, multirisk analysis, and decision-making tools to optimize conservation strategies. INTERCONNECTING's novelty lies in combining immersive virtual reality, multirisk analysis, and sustainable decision-making methods. It will integrate historical data and predictive models to create a comprehensive approach to conservation. The project will develop a platform to manage and analyze data, improve risk assessment with surrogate models, simulate heritage site responses to risks, and identify areas vulnerable to climate change. It will also catalogue sustainable materials for restoration.

Keywords

Multi-Risk Analysis, Cultural Heritage, Digitisation of The Built Heritage, Virtual Reality, Digital Twin.

Experimental façade envelopes as "climate mediation devices" in modernist projects

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Abstract
In the 20th century, Modernism, neglecting the climatic and environmental characteristics of places, imposed technologies and languages unsuitable for hot and temperate climates; all those tectonic devices that made buildings habitable were lost, such as "courtyard" building types that favored natural ventilation, the orientation of buildings that promoted winter sunlight and limited summer sunlight, aided by deep loggias that created shaded areas, as well as the construction technology with thick walls of raw bricks that exploited the thermal inertia of the material; and systems that allowed for climate-controlled interiors by machines became widespread, at times that did not suffer from the enormous problem of climate change and the link this could have with the indiscriminate use of energy derived from fossil fuels.
In contrast to this approach, without ever falling into the vernacular and instead maintaining a dialogue with modern architecture, in the second half of the 20th century, Ubaldo Badas worked in Sardinia, an Italian island in the center of the western Mediterranean, in public buildings built in the 1950s and 60s, in which he experimented with detailed technological solutions that provided adequate responses to climatic and environmental issues, while also developing interesting architectural solutions. In the craft pavilion of Sassari (1951-56) and in the agriculture pavilion at the Cagliari Fair (1959), Badas designed some technical elements to promote the natural ventilation of interior spaces, which became architectural solutions of great interest.

Keywords
Mediterranean Architecture, Climate Mediation Devices, Naturally Refreshing Ventilation.

Effect of green roofs on external microclimate and runoff mitigation: do they work in historical contexts? A case study in Naples

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Abstract
In cities characterised by a dense urban fabric and high population density, the lack of green spaces is a critical problem, despite their well-known environmental and social benefits. However, the creation of new green spaces for public use is often complex. This study proposes an innovative solution by creating a green roof on the internal terrace of SS. Apostoli, an art high school in the historic centre of Naples.
The analysis was carried out using a framework that integrates the parameters of technical-environmental feasibility that are related to the baseline scenario, and the design variables related to substrate and vegetation of the green roof. The design of the greening strategy was validated through urban microclimate simulations, assessing its impact on air and surface temperatures, as well as through calculations of rainwater management, evaluating its effectiveness by analysing retention times and storage capacity in response to low permeability of urban soils.
The results show a significant improvement in terms of temperature reduction and stormwater management. The chosen approach is a pioneering model that can be replicated in similar urban contexts and shows that greening strategies, if carefully planned, can integrate sustainable solutions without compromising the historical-architectural value of the buildings on which they are applied.

Keywords
Green Roof, Urban Microclimate, Historical Building, Temperature Mitigation, Runoff.

Public and private projects in post-war residential construction. A comparative analysis to identify shared renovation techniques

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Abstract
The construction of residential buildings in Italy has followed a cyclical trend depending on their location linked to both demographic and economic tendencies. The result is a building stock with heterogeneous characteristics in terms of age, building techniques, and materials. This heterogeneity, combined with the high fragility of the territory, necessitates specific analyses be-fore planning building rehabilitation interventions, whether structural, energy-related, or functional. This requires time and economic resources, and does not allow for effective planning at urban scale.
This research explores the possibility of creating a process that can evaluate building rehabilitation interventions qualitatively and on a large scale. Two groups of buildings constructed with public funds in the municipality of Bologna in the period following World War II are compared. The analysis was conducted using a database compiled by the research group as part of an on-going study. It includes 468 building records and 211 attributes covering general data, construction characteristics, spatial organization, energy performance, structural integrity, and building functionality. Through specific queries, the parameters of buildings designed and constructed by private individuals (group PR) were compared with buildings designed by public agencies (group PU). The study highlights the main differences and similarities emerging from the analysis of the sample of constructions with regard to various aspects: (1) distributive; (2) technical; (3) energy-related; (4) structural; and (5) formal. The results obtained, and the expected performance derived in qualitative terms for each building, made it possible to formulate initial considerations in terms of the applicability of large-scale building interventions.

Keywords
Residential Building, Database, Construction techniques, Second Post-War Period, Data-Driven Approach.

Canal-related industrial building heritage in Emilia-Romagna: analysis and perspective

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Abstract
This research investigates the industrial building heritage associated with canals in the Emilia-Romagna region of Italy, systematically examining its spatial distribution, historical evolution, and impact on local economic and social development. Through ArcGIS analysis of 137 industrial heritage sites, the study finds that 70.5% of these sites are located within one kilometer of a canal, highlighting the critical role of waterways in industrial site selection. By analyzing representative cases in Bologna, Ferrara, and Ravenna, the study underscores the multifunctionality of canals in industrial production, transportation, and water resource management. The findings indicate that canals not only served as essential infrastructure for industrial development but also profoundly shaped regional industrial layouts and urban morphology. However, with the transformation of transportation systems and industrial structures in the 20th century, many canal-related industrial sites experienced significant functional changes. Their transformed status can be categorized into three main types: conversion into public service facilities, long-term abandonment, or partial restoration for original functions. Building on these findings and drawing on exemplary international cases, this study proposes five key aspects for assessing the development potential of canal-related industrial heritage: heritage condition analysis, ecological management of canal systems, spatial redevelopment potential, public–private collaborative development models, and the role of heritage in regional revitalization. The insights provided aim to serve both as a theoretical foundation and a practical reference for the conservation and sustainable development of canal-related industrial building heritage in the Emilia-Romagna region and similar sites.

Keywords
Canal-Related Industrial Heritage, Spatial Distribution Analysis, Industrialization History, Emilia-Romagna Region.

The architecture of retail: techniques of urban regeneration

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Abstract
The places and architectures of commerce have always played a central role in the development of cities. The genesis of the city is, in fact, more closely linked to trade exchanges than to the need for military defense. Commerce, along with civic and religious life, gave rise to places which represent one of the most significant inventions of humanity's creativity: squares, places for socialization, sharing information, experiences, and emotions. Retail Network plays a key-role in our cities in terms of social aspects, safety, urban economy. Nowadays this is especially true in Urban Regeneration projects. Understood the severe crisis the stores are currently facing, the goal is to define organic and structural strategies to revitalize the retail together with the public realm. The topic involves both the urban scale and the architectural scale. The paper talks about revitalization strategies typical of degraded suburban contexts with special reference to mall-retrofit, as well as projects for the Historic Centers. Finally, the article introduces the example of an Urban Retail Revitalization Plan for a medium-sized city.

Keywords
Urban Regeneration, Urban Retail, Place-Making, Building-Type, Mall-Retrofit.

Marginal futures. The research Borghi-Boschi for the Friulian mountain

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Abstract
The marginality is not a static concept, but a condition that evolves. The margin, therefore, is not a defined line, but an intersection space where contrasting elements confront each other, creating opportunities for projects embedded in the territorial context. The "Borghi-Boschi" research explores marginality through the context of the Friulian mountains, an area characterized by strong geographical, historical, and cultural fragmentation. The project focuses on the mountain as a margin, not only as a physical limit but as a dynamic space, in a continuous process of cyclical redefinition, through the overlapping of its different spatial definitions. The research develops from a design perspective, aiming to recover and revitalize the existing resources of the Friulian mountains, using architecture as a tool to interact with the local reality, preserving architectural and cultural heritage, but also addressing modern challenges such as the progressive depopulation of mountain areas. The project aims to highlight testimonies of the Friulian mountain that risk being forgotten, systematizing its architectural form and its connection with the landscape. In this process, the goal is to promote the culture of wood and the sustainable regeneration of the territory for the development of replicable design strategies that can be applied in other similar contexts.

Keywords
Wood, Edge, Mountain, Overlap, Decomposition, Project.

B

BUILDING CONSTRUCTION AND PERFORMANCE

Gypsum manufacturing and products: between tradition and innovation. A systematic review

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Abstract
Gypsum is a construction and building material, whose raw components are easy to find in nature and it is highly diffused worldwide for the numerous gypsum-sulphur outcrops almost in all the continents. Its applications in construction have always been extremely widespread since its origins dating back to the Bronze Age when it was used to replace other materials that required the exploitation of more resources for their production or application. Therefore, this paper will systematically review the traditional and most contemporary production techniques and products to critically compare the pre-industrialisation cases versus products that are currently on the market. That will allow to understand the evolution of the material's production and which traditional methods have influenced contemporary manufacture. This study will contribute to a deeper understanding of the material's potential, its environmental qualities, and how it can be used in accordance with the requirements of sustainability and circularity. This work is part of doctoral research in its initial phase, which will focus on developing waste-based gypsum products in synergy with the company Innovazioni Group s.r.l., which is co-funding the grant.

Keywords
Gypsum, Manufacturing Process, Construction Material, Industrial Chain.

Optimization of Plastic Mesh Shading Systems for Improved Daylighting and Solar Gain Control

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Abstract

Ensuring optimal daylighting and solar control in buildings is essential for improving occupant well-being while reducing energy demand. This study explores the potential of plastic meshes, commonly used in various industrial applications, as cost-effective, low-maintenance static shading devices. Through a technology transfer approach, 14 commercially available plastic meshes were selected from broader research, digitally reconstructed, and assessed for their shading performance. The present study focuses on two promising samples. Firstly, a rapid assessment methodology was developed through a parametric workflow using Rhinoceros-Grasshopper, combined with climate-based daylight simulations, to have a preliminary evaluation of the shading effectiveness potential of the 2 selected products. Then, a geometric optimization process was conducted aiming at improving the shading efficiency of meshes applied as static shading devices. The results demonstrated that optimized mesh geometries could achieve summer shading factors above 75% while maintaining adequate solar gains in winter, making them a viable alternative to conventional shading systems. The second phase of the research assessed the impact of these shading devices on visual comfort in a reference office space. Useful daylight illuminance (UDI) analysis showed that both samples effectively improved daylight conditions for desks near the window but led to reduced visual comfort further into the room. These findings suggest that such static shading solutions are best suited for spaces with limited depth. This research underscores the scalability and economic benefits of plastic mesh shading systems and their potential integration into adaptive façade design. Additionally, it lays the groundwork for future advancements, including the incorporation of dynamic movement to enhance performance.

Keywords

Visual Comfort, Parametric modeling, BSDF,Complex Fenestration Systems, Circularity.

Nature-based solutions for urban heat mitigation: the role of green facades at the UNIPA Campus

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Abstract
Urban Nature-Based Solutions (NBS) have emerged as a key strategy for enhancing urban resilience and mitigating the environmental impacts of urbanization. By leveraging natural processes, NBS contribute to temperature regulation, air quality improvement, and the overall well-being of urban populations. Among the most effective NBS for building-scale interventions are green façades, which integrate vegetative elements to reduce solar heat gain, enhance microclimatic conditions, promote biodiversity and support human health.
This study investigates the role of green façades as an NBS in urban environments, with a case study at the University of Palermo. The selected site is characterized by high pedestrian flow and significant solar radiation exposure, making it a critical area for assessing the potential benefits of vegetated façades. The research methodology combines pedestrian flow analysis and solar radiation assessment to define design criteria for an optimal green façade implementation. The findings emphasize the capacity of green façades to moderate urban microclimates, enhance pedestrian thermal comfort, and contribute to sustainable urban redevelopment.
By integrating vegetation into the built environment, green façades represent a scalable and multifunctional solution that aligns with broader climate adaptation strategies. This study contributes to the growing body of research on NBS-driven urban design, highlighting the relationship between user welfare and the effect on quality of indoor and outdoor spaces.

Keywords
NBS, Green Facades, Vegetation, Human Health, Comfort, Multicriteria Analysis.

Off-Site manufacturing for energy-efficient building renovation: a pilot case study

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Abstract
The construction sector is a major contributor to global energy consumption, with existing buildings representing a significant challenge in the transition toward energy-efficient and low-carbon solutions. Upgrading building envelopes is often constrained by site-specific challenges, the need for customized solutions, and budget limitations. In this context, prefabricated systems have emerged as promising solutions, offering advantages in terms of quality control, construction speed, and reduced waste and on-site disruptions. This contribution explores how off-site manufacturing (OSM) solutions, such as prefabricated panels, can enhance energy retrofitting efforts, comparing them with interventions carried out mostly on-site. It focuses on a pilot case study of an existing residential building, where two different renovation strategies were applied. One involves innovative, timber-based prefabricated panels, while the other adopts conventional retrofitting techniques—specifically, an external thermal insulation composite system (ETICS), a widely used solution, entirely realised on-site. The design approach and the details of the timber-based prefabricated panels are outlined, along with the entire intervention process—from panel production and on-site installation to the assessment of implementation challenges. The benefits and limitations of off-site manufacturing for renovation components are highlighted, comparing it with conventional renovation techniques and evaluating the scalability and replicability of such interventions. Key findings show that prefabricated systems can result in time and labor savings and improved quality control. However, challenges persist regarding higher initial costs and logistical complexity when compared to traditional methods.

Keywords
Energy Retrofit, ETICS, Existing Buildings, Sustainability, Timber-Frame Prefabricated Panels.

Experimental investigation of wood's hygroscopic behavior for adaptive shading systems in building façades

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Abstract
This paper presents an experimental study aimed at evaluating the hygroscopic behavior of wood for potential application in adaptive façade shading systems. Due to its intrinsic ability to absorb and release moisture, wood offers promising prospects for biomimetic designs inspired by the actuation mechanisms observed in conifer cones. A series of five experiments was conducted in a controlled climatic chamber, systematically varying humidity between 30% and 70% relative humidity. Each test was built upon the previous, enabling the progressive refinement of test parameters. The deformation of wood samples was monitored in real-time, with results showing a strong linear correlation (correlation coefficient > 0.85) between relative humidity variations and angular deformation. The experimental data revealed that a 1% change in relative humidity induces approximately a 1.1° angular deformation. Furthermore, during constant humidity phases, the deformation remained stable, confirming the material's suitability for passive adaptive applications. These findings provide a quantitative foundation for integrating wood into dynamic building skins, supporting future modeling efforts and energy simulations. This methodology overcomes current mechanical complexity, enabling the design of sustainable, low-energy façades capable of enhancing both thermal comfort and aesthetic quality while addressing climate change challenges.

Keywords
Adaptive Façade, Biomimetic Approach, Hygroscopic Wood, Humidity Variations, Material Deformation.

Review on the potential of olive waste reuse and valorisation for innovative green building solutions

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Abstract
The existing building stock presents problems of insufficient maintenance and low energy performance, with high resource and energy consumption. In response, directives such as the European Green Deal and Agenda 2030 promote a sustainable transformation of the sector, responsible for 40% of global greenhouse gas emissions. Achieving these goals requires innovative solutions that improve sustainability and energy efficiency, using natural, recycled, or waste-based secondary resource materials within the circular economy and industrial symbiosis. This paper presents a comprehensive literature review on the potential of reusing waste deriving from the olive sector for applications in construction. Specifically, samples were furnished by an oil mill and fully analysed to assess their possible uses in construction. The Mediterranean basin, a major producer of olives and oil, generates large quantities of residues that can be properly valorised and reused in construction, replacing traditional raw materials, reducing natural resource consumption, and fighting climate change. In particular, the considered olive waste was pomace, stone, and vegetation water, explored for green applications in construction. Through a state-of-the-art analysis and chemical/physical characterisation, the main features of these by-products are presented, and their possible applications as sustainable construction materials are evaluated. This study is part of a PhD research within the NEST Project, funded by the National Recovery and Resilience Plan (NRRP), focusing on the reuse of waste from various sectors in building materials to foster a more sustainable and efficient construction industry.

Keywords
Olive Waste Valorisation, Biocomposite Material, Circular Economy, Green Building, Energy Efficiency.

Interaction between buildings and UAM infrastructures: simulation of wind paths in the urban environment

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Abstract
The development of Urban Air Mobility as an emerging air transportation service requires a proper integration between air and ground infrastructures at the urban scale, whose investigation is still little explored in the literature. For instance, vertiports represent a crucial link between air and ground, requiring careful considerations for their placement. Among the factors most affecting the vertiports location, the wind paths in urban environments should be considered, as they could compromise both the safety and security of aircrafts. However, the wind effect at the urban scale is challenging to predict, as it is closely related to the urban morphology, which can also generate turbulence flows. Among the existing methodologies to study urban wind, computational fluid dynamics simulations could be a good approach. The present study aims to explore the interaction between buildings and UAM infrastructure by exploring wind paths in a suburban area of the city of Bari (Southern Italy), where some unoccupied areas are potentially suitable for the location of vertiports. The CFD ENVI-met software has been adopted to perform simulations, showing the strong influence of urban morphology on wind flows, thus requiring accurate wind analyses to support the vertiport placement planning in the urban environment.

Keywords
Urban Air Mobility, Vertiport, Wind Simulation, CFD Analysis, Architectural Engineering.

Evaluating and mitigating terrorist risk in historical outdoor open areas including user factors

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Abstract
Terrorist risk in historical outdoor Open Areas (OAs), such as urban squares, is one of the most relevant conditions to explore for users' safety, considering the attractiveness of these public outdoor spaces and their architectural, morphological and use-related features. Risk assessment tasks should be linked to risk mitigation analysis to support decision-makers in understanding which most probable terrorist threats and related effects could appear and how resilience-increasing strategies could be implemented while pursuing heritage preservation and ease of application. To this end, user factors in terms of behaviours in pre-emergency and evacuation conditions should be included, indeed. Nevertheless, structured frameworks to this end seem to be still lacking. This work proposes a novel, sustainable, user-centred framework for risk assessment and mitigation analysis to be applied in historical OAs such as squares. The framework relies on a simulation-based approach and incorporates tools validated within the BE S^2ECURe project for scenario creation (preferring quick-but-reliable approaches) and evacuation process analysis, incorporating users' behaviours. The framework is showcased on a relevant historical square, by defining and simulating pre and post-retrofit scenarios. In particular, mitigation strategies aimed at emergency management are mainly considered given their compatibility with preservation tasks. Results show how the framework can support local authorities in increasing resilience against terrorist threats.

Keywords
Terrorist Risk, Urban Built Environment, Human Behaviours, Risk Assessment And Mitigation, Outdoor Open Areas.

Preliminary results of a methodological algorithm for the categorization of BIPV façades through the support of generative AI

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Abstract
In recent years, the photovoltaic sector has continued growing, and in 2023 power generation from solar PV represented nearly 60% of the worldwide renewable energy produced. BIPV growth has also confirmed even if the market segmentation still faces difficulties to classify products, due to the wide range of technologies, designs, and materials. This study shows the process defined to categorize the BIPV products and prototypes through the analysis of 4,692 scientific papers indexed in Scopus, focused on BIPV façades, with the support of AI. The categorization is based on the one proposed by the International Energy Agency-Photovoltaic Power Systems Programme (IEA-PVPS). At first, the papers have been selected based on a keyword search. Then, fine textual information from both the Abstract and those sections where Methods and Results are described, has been automatically extracted. All the texts were arranged in a JavaScript Object Notation (JSON) structure, and corresponding embeddings were calculated via a Large Language Model (LLM) to obtain a Vector Database. The LLM then queried to retrieve the relevant documents from the vector database, according to a given query that can be useful for paper categorization. All the retrieved documents for each tested query were manually validated based on the coherence of the provided query. However, the method needs to be more refined in order to eliminate ambiguity in the definitions that impact on obtaining high values of consistency of the retrieved text chunks.

Keywords
LLM, Information Retrieval, BIPV Façades, Categorization, AI.

Public University Residences as a driver for energy renovation. Reflections on summer thermal performance

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Abstract
The focus on university housing introduced by Italian Law 338/2000 has led to mutations in the way the right to study is understood, addressing users who have changed over time in terms of geographical origin, social and economic background, age, gender, ethnicity, cultural and religious identity, living and eating habits and disability. The typology has certainly been affected since student space has been enriched with cultural, social and IT services; the relationship with the territory has been redefined, making it the object of urban regeneration; in terms of design/redevelopment, a confrontation with the principles of environmental, economic and social sustainability has been undertaken. Perhaps, this is the most lacking aspect, even if performance evaluations have recently become criteria for financing contracts (with PNRR). Regarding energy perspectives, a research project promoted by ENEA and underwritten by the Department of Engineering-UniMe is currently being defined about the issue of Cooling: increasing the contribution of summer cooling. An integrated approach with APE, SRI and BRP, in which the authors will participate with the activity line "Cooling solutions for university residential buildings: correlations between typological analyses and climatic zones to define improvement forecasts and lines of intervention". Therefore, firstly the university residential stock has been analysed, classifying it according to housing model, construction period, climatic zone, and then identifying the 1945-1975 authorial architectures that have undergone maintenance works. The aim has been defining a methodological path to identify strengths and weaknesses of the building-plant system in the process of energy modernisation in terms of cooling. A historical analysis and energy modelling of the Don Bosco College in Pavia have been then proposed to understand which passive strategies can make the building envelope more efficient, while preserving its cultural values.

Keywords
Census of University Residences, Cooling Climatic Degree, Collegio Universitario Don Bosco (Pavia), Energy Audit, Energy Retrofit Hypothesis.

Investigating optimal configuration for thermal comfort in small open urban spaces between buildings

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Abstract

Urban Heat Island (UHI) and exacerbated heatwaves impact heat-related mortality and morbidity, deteriorating citizens' wellbeing and limiting outdoor activities in the built environment. As the built environment has a huge potential in mitigating UHI, diffused green, blue and grey solutions in dense urban areas could benefit resilience. Although the cooling effect of large size parks has been studied, the microclimatic effect of small open urban spaces between the buildings has been overlooked. The goal of this study is to establish a database of solutions identifying the morphology potential of urban voids/pocket parks maximizing thermal comfort towards heat stress mitigation. The research is conducted by means of parametric computational simulations with Grasshopper and Ladybug plugins for Rhino3D. The simulations evaluate geometric configuration, including aspect ratio and orientation to assess thermal performance in the hottest day in Rome, as a significant case study. The study examines Universal Thermal Climate Index (UTCI) values three times of day to capture the diurnal variation in thermal comfort.

The analysis reveals that for all aspect ratios, the 315° orientation offers the best thermal comfort in the morning, while the 225° orientation provides the highest comfort during the afternoon. In the evening there is minimal variation in average UTCI across all scenarios. Additionally, as the aspect ratios increase, more pronounced differences in UTCI are observed among different orientations. The findings indicate the potential of small urban voids to act as diffuse resilience (pocket parks), depending on their configuration, as the bases to further improve their performance acting on their components.

Keywords

Pocket Parks, Parametric Design, Aspect Ratio, Orientation, Thermal Comfort, UTCI.

The impact of service life on the life cycle assessment of building envelope elements in a long-term perspective

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Abstract
Nowadays, a wide range of construction systems and envelope elements optimized for residential buildings is available. However, the selection among these solutions is rarely based on long-term environmental impact assessments. In this context, the initial assumptions regarding material durability and maintenance operations throughout the building's lifespan become fundamental in determining the final outcomes. For these reasons, this article analyzes a representative sample of twelve wall envelope configurations, including six from heavyweight construction systems (reinforced concrete frame) and six from lightweight construction systems (three with steel frames and three with CLT). The aim is to assess the impact of service life on the life cycle assessment and identify the least impactful solutions in terms of Global Warming Potential (GWP). To achieve this objective, four service life scenarios are considered for each configuration, representing standard, low, medium, and high maintenance levels for external layers over time, in order to determine variations in environmental impacts. The study's results highlight that, in the short/medium term (50 years), the variation in GWP impacts between heavyweight and lightweight construction systems remains limited due to reduced maintenance needs resulting from higher durability. In the long term (100 years), the use phase and maintenance operations become central in determining overall environmental impacts. Consequently, construction systems that require fewer re-placements emerge as the most sustainable solutions.

Keywords
Service Life, Durability, Construction Systems, Building Envelope, Life Cycle Assessment.

Impact of school design on indoor air quality and thermal comfort

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Abstract
This review examines the impact of school building design on indoor air quality (IAQ) and thermal comfort, focusing on the role of the building's energy performance and natural ventilation in ensuring good and stable indoor conditions. Educational facilities often face indoor comfort challenges due to high occupancy levels, outdated technologies, and limited maintenance budgets. The design of a school building is very important and is the first step in achieving good indoor environmental conditions. Starting from the orientation of the building, its shape, architectural and technological characteristics, the building is responsible for whether it can improve the IAQ and guarantee the right comfort. School building renovation measures to improve energy performance and indoor micro-climate conditions include those involving the HVAC system and those acting on the building envelope, improving its performance, airtightness and thermal insulation. Among the passive strategies, passive retrofit solutions such as thermal masses and night ventilation have proven to be particularly effective in ensuring a good balance between air quality, thermal comfort and energy consumption The review also addresses the complexities of maintaining good IAQ in schools and offers insights into sustainable design practices that balance comfort, air quality, and energy efficiency.

Keywords
School Building, Indoor Air Quality, Thermal Comfort, Energy Performance, Sustainable Design.

Indoor air and thermal quality in school buildings: demonstration of BIM-integrated IoT window signaling system

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Abstract
Indoor Environmental Quality (IEQ) plays a crucial role in the health, well-being, and cognitive performance of students in school environments. This study presents the integration of Building Information Modeling (BIM) and Internet of Things (IoT) sensors for real-time IEQ monitoring and dynamic ventilation control. A BIM-integrated window signaling system was developed using visual programming to process real-time sensor data and provide feedback on optimal window operation times. The methodology consisted of five phases: (1) development of a BIM model of the case study and calculation of window opening time, (2) on-site deployment of an IoT sensor system, (3) integration of real-time environmental data into the BIM model, (4) generation of a continuously updated digital twin for IEQ assessment, and (5) comparison between calculated ventilation times and measured environmental parameters. The system was tested in two classrooms of a school in Rome, Italy, where temperature and CO_2 concentration were continuously monitored. The results indicate that the calculated ventilation schedules effectively maintained indoor temperatures within recommended thresholds. However, CO_2 levels frequently exceeded the guide value threshold in one classroom, revealing discrepancies between the expected and actual window opening behaviors of occupants. The study underscores the role of occupant compliance in ventilation effectiveness and demonstrates how BIM can function as a dynamic decision-support tool by integrating real-time environmental data, automated parameter updates, and graphical trend visualization.

Keywords
School Buildings, BIM, IAQ, Thermal comfort, IoT sensor, IEQ.

Thermal comfort assessment and cognitive performance implications in educational environments: a case study from central Italy

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Abstract
Thermal comfort plays a crucial role in shaping the indoor environment of school buildings, with direct implications for student well-being and academic achievement. This study enhances the dynamic energy analysis of school buildings by investigating the intersection between objective thermal comfort assessments and occupants' needs. Focusing on a school in Central Italy, the research highlights how energy-inefficient infrastructure can impact occupant comfort and thinking performance outcomes. The study offers a general understanding of how environmental factors can influence students' well-being and cognitive function by establishing a quantifiable relationship between Predicted Mean Vote (PMV) values and productivity loss in thinking tasks. The research employs a range of climatic datasets, including historical, current, and projected future data, to analyse the building's performance across varying climate conditions. The results reveal significant thermal discomfort in the older section, particularly during peak temperature periods, while the newer building section demonstrates superior thermal performance. Notably, implemented energy retrofit measures successfully reduced summer discomfort projections by up to 66% through 2070, simultaneously decreasing cognitive impairment by up to 63%. Beyond technical considerations of energy efficiency, climate change mitigation, and cost savings, this research advocates for a paradigm shift in architectural and policy approaches, placing human-centric design at the forefront. It emphasizes the imperative for architects, engineers, and policymakers to integrate thermal comfort and cognitive performance alongside sustainability goals in the planning and renovation of educational spaces. By promoting a balanced approach, the study underscores the necessity of designing learning environments that support both well-being and academic success.

Keywords
PMV, PPD, Cognitive Performance, Climate Change Impact, School Buildings.

Evaluating the effectiveness of dynamic evacuation wayfinding signage systems: comparing real-world and immersive virtual reality experiments

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Abstract

The fire safety of building occupants can be improved by dynamic Emergency Wayfinding Signage systems (EWSs), since they can optimize path selection tasks thanks to real-time data. In view of costs and complexities of real-world testing of dynamic EWSs, Immersive Virtual Reality (IVR) can streamline their effectiveness assessments, increasing the number of reference scenarios and of involved participants. Nevertheless, the IVR reliability should be supported by cross-validation between real-world and IVR solutions. This work is aimed at comparing the effectiveness of a dynamic EWS in real-world and two IVR setups: a head-mounted display and a CAVE. The experiments involved 228 volunteers. The experiments investigated route selection on a real-world T-shaped layout, in a university building with and without simulated smoke and lighting. The effectiveness of a dynamic EWS was assessed using the Theory of Affordance. Differences in specific affordances exist between IVR and real-world tests. Nevertheless, the analysis of functional affordance (assessing the effectiveness of EWS in guiding occupants towards a safe area) shows that IVR tests provide similar results to real-world ones, by also not overestimating the EWS effectiveness. Differences among scenario conditions and CAVE or HMD tests were identified too. On the one hand, outcomes hence support outcomes of previous works, which remark that differences could be mainly due to the scenario brightness and to the level of immersion/presence in IVR. On the other hand, results encourage the use of IVR to actively contribute to preliminary behavioural-based design and testing of dynamic EWSs.

Keywords

Fire Safety, Virtual Reality, Evacuation Wayfinding, Occupant Behaviour.

Multi-objective optimization of building envelope and shading system for the retrofit of large social housing buildings

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Abstract
The built environment plays a crucial role in global decarbonization efforts, yet buildings remain a major contributor to energy consumption and CO_2 emissions. Retrofitting existing buildings is essential to decrease the environmental impact of the construction sector but also for mitigating energy poverty, which affected 10.6% of the European population in 2023. This study proposes a multi-objective and multi-disciplinary methodology for optimizing the energy retrofit of a social housing building. The approach integrates parametric modeling, energy and daylight simulations, and evolutionary optimization algorithms to enhance building performance while considering economic and environmental constraints. The optimization is structured in two phases: a first optimization of the building envelope focusing on passive strategies and a second one specifically on the shading system, taking into account the increasing energy consumption for cooling. Results demonstrate that the optimized building achieves an 86% reduction in heating energy consumption and a 41% decrease in cooling energy consumption. The methodology effectively balances energy efficiency, renovation costs, and CO_2 emissions while ensuring daylight availability and occupants' comfort. By utilizing mostly open-access parametric tools, the approach promotes accessibility and broader adoption. This study highlights the potential of multi-objective optimization in retrofit design, offering valuable insights for researchers, policymakers, and practitioners committed to sustainable building renovations.

Keywords
Multi-Objective Optimization, Social Housing, Building Performance Optimization, Building Energy Simulation, Daylight Simulation.

An innovative nature-based building tile for climate mitigation and adaptation: the LIFE CAPT-TILE projec

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Abstract

Nature-Based Solutions (NBS), such as green roofs and green walls, offer sustainable strategies to mitigate Climate Change and to address additional challenges associated with urbanization, such as air pollution, biodiversity loss, noise, and decreased ability to retain rainwater. Despite their widely recognized benefits, usually defined as ecosystem services, their adoption remains limited due to high costs, complex installation processes, and maintenance requirements. This work presents the EU-funded LIFE CAPT-TILE project, which introduces an innovative and modular tile solution to overcome these constraints by developing a lightweight terracotta-based tile named "CAPT-TILE" to be integrated with soil layers to support vegetation growth on facades and on pitched and flat roofs. The project follows a multi-phase methodology, including laboratory trials, operational testing through the realization of two mock-ups, and practical in situ demonstration of CAPT-TILEs' performance. This includes their installation on roofs and a green façade on two buildings located in Italy and Poland. The project aims to demonstrate the environmental and socio-economic benefits of CAPT-TILEs, including GHG sequestration (i.e., each m^2 of CAPT-TILE surface has the potential to absorb 1.1-1.8 Kg of CO_2 from the atmosphere and store it as plant biomass), biodiversity promotion, and mitigation of noise and temperature. Furthermore, market validation and sustainability assessments, conducted through Life Cycle Assessment and Life Cycle Costing, will support the CAPT-TILE technologies' commercialization and facilitate their widespread adoption. The LIFE CAPT-TILE project represents a significant effort toward democratizing urban greening systems by bridging the gap between environmental goals and socioeconomic constraints.

Keywords

Nature-based Solutions, Green Roofs, Green Façade, Climate Change Mitigation, Ecosystem Services.

Back to the Nature. Bio-inspired design for creation and construction of shell structures

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Abstract
Throughout history, humanity has drawn inspiration from Nature to fulfil basic survival needs, such as providing shelter to live in perfect harmony and in respect of Nature. However, in the last centuries, the rapid progress of industrial development has transformed this relationship from respect to exploitation of the environment, producing pollution and altering the ecosystem. The building and construction industry is the first example of this trend, as it is particularly harmful to the environment and the largest emitter of greenhouse gases. This paper will provide an alternative outlook by considering and analyzing potential solutions – deployed in various regions around the world – for implementing buildings that adapt to changing socio-environmental conditions. Bio-inspired design approach involved several bio-disciplines, including biomorphism, biomimicry, and bio-utilization. Each discipline explores Nature as a complex system of various organisms and elements, serving as a source for forms, functions, and materials of contemporary buildings. This analysis considers different economic, geographic, and social factors, as well as the different construction needs that may arise in specific contexts, leading to the design of bio-inspired buildings. The paper aims to explore bio-inspired design solutions for constructing shell structures, emphasizing the factors that enable their seamless integration with the surrounding landscape.

Keywords
Nature, Environment, Shell Structures, Bio-inspired Design.

Application of the e-SAFE retrofit technologies on a pilot building

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Abstract

A significant portion of the building stock in European seismic regions was constructed without incorporating energy-efficient or anti-seismic design principles. To address the urgent need for deep renovation, the e-SAFE H2020 research project has developed innovative retrofit technologies tailored for reinforced concrete (RC) framed buildings. These solutions include prefabricated timber-based panels that provide both structural reinforcement and thermal insulation. Applied to the building's outer envelope, these panels significantly enhance seismic resilience and energy efficiency. In addition to the envelope improvements, the e-SAFE approach integrates advanced full-electric systems to meet energy demands for domestic hot water, space heating, and cooling. These combined technologies have been implemented in a pilot building in Catania, Sicily (Southern Italy). This paper presents the final design outcomes of the core e-SAFE technological components and outlines the application strategies used to validate the retrofit intervention in the pilot project.

Keywords

Integrated Renovation, Prefabrication, Timber-Based Panels, Cross-Laminated Timber, RC Framed Buildings.

Energy efficiency strategies for Mediterranean school buildings: a comparative study of Italy and Greece

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Abstract
This study presents a comprehensive comparative analysis of school building stock in Italy and Greece, focusing on the cities of Padua and Volos. The research, part of the ongoing SchoolNet FSE project, aims to bridge the gap in comparative studies between different European contexts and develop strategies for energy-efficient renovation of school buildings. The methodology involves a three-level analysis: national overview, detailed case studies of Padua and Volos, and an in-depth examination of a specific school building in Volos. The study reveals that both countries face similar challenges, with over 60% of school buildings constructed before the introduction of stringent energy efficiency regulations. Significant differences in building distribution, morphology, and management reflect diverse educational policies and approaches to space optimization. The Greek case study demonstrates the potential for substantial energy efficiency improvements through targeted interventions, with an estimated 48.7% reduction in the annual primary energy consumption. The research highlights the importance of adapting renovation strategies to local specificities while considering energy efficiency, occupant comfort, and educational opportunities. It also emphasizes the potential of integrating technologies like green roofs and photovoltaic systems to transform school buildings into educational tools for sustainability. This study provides a foundation for developing targeted energy renovation strategies in the school building sector, contributing to the European Union's sustainability goals and promoting environmental awareness among future generations.

Keywords
School Buildings, Energy Retrofit Strategies, Sustainable Refurbishment, Greece, Italy.

Adaptive solar control strategies for visual comfort and sustainable building performance

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Abstract
Achieving a balance between energy efficiency, thermal comfort, and visual comfort in office buildings during the summer months is a critical objective for sustainable design in Mediterranean climates. This study focuses on optimizing the use of solar shading in an existing office building located in Madrid to enhance indoor visual comfort during the summer period. The building features a large, glazed façade equipped with horizontal blade solar shading on the southeast elevation, which is currently manually operated. User comfort was assessed through an online survey, revealing significant visual discomfort among occupants working near the windows. To address this issue, a dynamic simulation of the solar shading operation was conducted using a detailed energy model of the building developed with Design Builder, while illuminance levels were obtained from the Daylight-Radiance module. The shading control strategy was designed considering indoor air temperature, incident solar radiation on the façade, and sun position, and it was applied to different configurations of the shading system, starting from the current operation mode (Analysis 0), which involves manual adjustment of the blade inclination. The implementation of the optimized control logic (Analyses 1-2-3) and the advanced shading configuration (Analysis 4) demonstrated a significant improvement in visual comfort, achieving up to a 50% reduction in illuminance levels at workstations most affected by visual discomfort. This optimization contributes to a more sustainable and comfortable indoor environment.

Keywords
BEMS, Office Buildings, Visual Comfort, Passive design, Mediterranen Climate.

Do we know how we really feel? Towards a methodology for investigating space and well-being

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Abstract
This paper seeks to lay the basis of a wider research program, which investigates how users relate to the built environments in a more holistic and inclusive vision of comfort that integrates emotional responses to spatial features. As a matter of fact, the physical, thermodynamic aspects of the built environment are increasingly acknowledged as critical factors shaping perceived human comfort and human behaviour; as opposite, emotional states and cognitive processes are often disregarded in this context. In parallel, the field of neuroarchitecture is emerging, showing the possibility of a significant advance in exploring the influence of the built environment on performance and user satisfaction. The paper proposes an investigatory framework for future research on the relationship between built environments and human well-being, drawing from existing literature, in an attempt to extrapolate the interrelation/interdependence between physiological and psychological effects in architectural spaces. The presented literature review considers the effects of Indoor Environmental Quality (IEQ) factors – including lighting, temperature, acoustics, and air quality – on the comfort, productivity, and psychological state of occupants in various building types, such as offices and hospitals, as well as the effectiveness of green building certifications in achieving optimal IEQ. Starting from the literature review, the paper proposes a theoretical framework that examines the intertwined relation between functional needs and other, often disregarded, experiential aspects related to human emotions and cognition that positively influence human well-being.

Keywords
Holistic Comfort, Cross-Modal Interactions, Well-Being, Neuroarchitecture, Situated Cognition.

Upgrading existing façades by integrating seismic interventions with vertical green solutions: the undergoing project at the University of Parma

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Abstract
Upgrading existing buildings to enhance seismic safety and provide climate adaptation presents significant challenges both today and in the near future. The issue of how to effectively integrate seismic interventions with sustainable solutions to improve the microclimatic performance of existing buildings remains largely underestimated. The present study investigates the role of various vegetated green solutions applied to the metallic framework utilized for seismic enhancements at the teaching headquarters of the Department of Engineering and Architecture at the University of Parma. In this context, in addition to the essential seismic interventions aimed at improving the building's earthquake resistance, a microclimatic assessment has been conducted, focusing on green solutions, orientations, and stages of plant growth. The paper aims to examine the extent to which three distinct green solutions can be implemented during the installation phase of seismic measures to provide shade for the building envelope and enhance outdoor thermal comfort near green façades. These solutions include a green wall supported by vertical metal mesh anchored to the existing façades, a green-covered wooden pergola aligned with the St. Andrew's cross bracings, and a green wall that grows directly on the existing walls. Each solution, which must avoid interfering with the metal framework, has been climatically evaluated using ENVI-met in both current and projected future scenarios, taking into account the Leaf Area Index (LAI) of *Parthenocissus tricuspidata*. The findings indicate that incorporating vegetation into seismic structures from the initial stages can provide significant cooling benefits by lowering the Mean Radiant Temperature and the Universal Thermal Climate Index, depending on orientation, leaf density, and outdoor temperature.

Keywords
Vertical Green Façade, Seismic Interventions, Microclimate Modelling, Climate Change, Leaf Area Index.

Impacts of stone waste replacement for Portland cement on the mechanical properties of cement pastes and future fields of application

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Abstract

The natural stone industry in Italy is one of the largest in the world in terms of production and exports. As one of the country's most important sectors, stone quarrying and processing are influenced by the increase in the number of construction projects due to the heavy use of natural stone as a permanent building material. However, the increased demand for natural stone increases waste, which is produced at multiple stages from quarrying to cutting and processing. The waste generated in all processes can reach up to 70% of the total volume, of which 80% is solid waste, which is relatively easy to reuse, while the remaining 20% of waste is in a semi-liquid state that is typically more difficult to recycle and often ends up in nature. The literature on the use of stone semi-liquid waste or stone slurry is extensive. This paper provides a review of the state of the art on the use of stone slurry in cement pastes and addresses its effects on the mechanical properties of fresh and cured pastes. Mechanical properties are investigated through a series of tests, which are performed to determine the flow, workability, flexural strength, and compressive strength of several samples at a constant water-to-binder ratio. The samples are prepared with increasing levels of replacement of cement with dried stone slurry using a CEM II cement. The results are compared to the literature to aid in the decision of choosing an appropriate mix for non-structural and non-load-bearing elements. Based on the characterized properties, this paper outlines a set of possible fields of application.

Keywords

Stone Waste, Stone Slurry, Limestone Waste, Waste Utilization, Sustainable Cement, Cement Mechanical Properties.

Towards a user-centred assessment of building envelope retrofit effects in summer season: insights from an application to social housing

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Abstract

In light of climate change, the European Renovation Wave aims to boost building renovation due to their fragilities (i.e., aged and inefficient stock) and importance to human lives. Financial incentives have been introduced for energy performance improvements in residential buildings, particularly lower-income housing, with the primary application of traditional retrofit measures, such as external thermal insulation, window replacement, and space conditioning. Their efficacy has been widely confirmed in the winter season for improving heating energy consumption. However, the suitability of these strategies in the cooling season remains understudied, along with retrofit economic assessment prioritized above social aspects and end-users' dimension. This paper investigates the impact of building envelope retrofits on indoor environmental conditions, cooling energy consumption, and occupants' satisfaction with the renovation in summertime. To this aim, a holistic approach combining measured data in 6 rooms of 3 households in two residential social housing buildings (objective perspective) and occupant surveys (subjective perspective) was adopted. The comparison of the pre and post renovation periods highlights mixed results: positive effects were observed in north-facing rooms, where retrofits reduced indoor temperatures and cooling energy demand (up to 30%); negative effects were detected concerning and in-crease in relative humidity and CO_2 concentration and indoor temperatures in south-facing rooms despite increased air conditioning use (up to 13%). These findings underscore the limitations of traditional retrofit strategies during the cooling season, thus highlighting the need for alternative and tailored retrofit solutions like innovative passive cooling technologies, such as Ventilated Permeable Roofs and HERO-Tile Based Roofs.

Keywords

Residential Buildings, Building Retrofit, Indoor Environmental Quality, Energy Consumption, Thermal Comfort.

Energy efficiency in hospitals: a review of design strategies for resilience

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Abstract
Climate change represents a critical challenge for the healthcare sector, influencing operational efficiency, environmental comfort and the resilience of hospital facilities. This literature review analyses the intersection between hospital design, sustainability and energy efficiency, with a particular focus on climate change adaptation strategies for existing buildings. The healthcare building sector is responsible for a significant share of global greenhouse gas emissions, making the development of innovative and sustainable construction practices imperative.
The literature review highlights the importance of a multidisciplinary approach in hospital design, integrating user-centred design, advanced technologies such as Building Information Modelling (BIM) and spatial syntax analysis, as well as retrofitting strategies for energy efficiency improvement. In addition, the growing adoption of the Digital Twin Immersive Design Process (DT-IDP) allows for more accurate modelling of healthcare environments, improving the quality of care and the patient experience.
Despite progress, current research on climate resilience, energy efficiency and hospital design remains largely disjointed. The review emphasises the need for an integrated framework that combines climate adaptation strategies with a holistic approach to healthcare design. The adoption of predictive models for energy management, optimisation of hospital layout and the use of sustainable materials are essential to ensure resilient, efficient hospitals that are able to respond to future environmental challenges.

Keywords
Climate Resilience, Energy Efficiency, Hospital Design, Sustainable Construction, Digital Twin.

Rapid estimation of urban system vulnerability and exposure in building risk assessment model

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Abstract
Falling debris from building envelopes, such as collapsed cladding, plasters and cornices, poses significant threats to public safety, referred to as Building Risk. To mitigate this risk, it is essential to quantify the hazards posed by buildings on their surroundings, as well as assess the system's vulnerability and exposure, which are the three key parameters in Building Risk formulation. This paper presents standardised technical sheets to be used for urban system exposure and vulnerability rapid assessment. Urban sections are analysed based on morphological and functional characteristics influencing vulnerability and exposure values. The city of Pozzuoli, located in the Phlegraean region, is selected as a case study due to its diverse configurations enabling different risk scenarios analysis. Data collection, conducted through field surveys and remote analysis, led to the development of 14 standardised technical sheets for urban sections along emergency escape routes. The proposed sheets provide a replicable framework for comparative analysis, ensuring consistency and adaptability. Their novelty lies in the ease and speed of application. Also, their integration into a GIS environment enhances interoperability and future data expansion. The results support rapid Building Risk assessment by identifying sections at potentially high risk, supporting risk analysis prioritisation and better-informed decision-making.

Keywords
Building, Risk, Vulnerability, Exposure, Façade.

Vertical greenery systems for building stocks: application of type solutions and evaluation models

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Abstract

The topic of resilience to climate change has long been addressed on a global scale with repercussions at the local level. The UN Agenda 2030, Goal 11 (2023) and the European Green Deal (2019) identify Nature Based Solutions (NBS) as strategies for the climate resilience of cities. Among the NBSs, Green Infrastructures (GI) are of particular interest, which, when applied to building stock, are articulated in Living Wall (LW) and Green Facade (GF).

A review of the state of the art has shown that research concerns the performance of greenery assessed both with simulation models and on investigations of test rooms; moreover, even the applications of vertical greenery, examined through recent realisations, only concern new construction in the European and international landscape. Therefore, in view of the multiple benefits of greenery on a building and urban scale and with the aim of comparing it with existing buildings, the research focused on the built heritage of the second half of the 20th century in the area of social housing and on possible greening interventions. The paper addresses the topic of vertical greening of the existing building stock in a Mediterranean climate; it intends to investigate the compatibility of 'technological green' with the building stock, hypothesising its application to a case study. Finally, we propose a multi-criteria model to support the design of interventions for the integration of VGS on the existing buildings.

Keywords

Building Retrofit, Green Façade, Social Housing, Multi-Criteria Model, Well-Being.

Assessing vegetation health in green roofs: an overview on methods based on reflectance spectroscopy

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Abstract
The increasing popularity of green roof solutions stems from their numerous benefits, including improved building energy efficiency and urban environmental quality. However, the long-term success of these systems re-lies on the presence of healthy vegetation, which indeed is often subjected to urban stressors such as extreme temperatures and air pollutants. These stress factors frequently act over time and may not produce immediately visible effects, making continuous vegetation health monitoring essential. Reflectance Spectroscopy (RS) has emerged as a valuable solution for this purpose. RS methods provide versatile and scalable insights, enabling assessments from individual leaves to entire canopies and larger areas. RS data can be gathered and processed even by non-experts and automatically classified using simple spectral indices or advanced machine learning approaches. This overview explores the spectral characteristics of stressed vegetation and demonstrates how RS tools can detect these changes, detailing their configurations and associated challenges. Furthermore, spectral data classification techniques are presented, while current limitations and future research perspective are discussed. By addressing these aspects, this paper aims to serve as a roadmap for researchers and practitioners interest-ed in leveraging RS techniques for monitoring the health of green roof vegetation.

Keywords
Green Roof, Remote Sensing, Reflectance Spectroscopy, Vegetation Health, Vegetation Stress.

Surrogate models for outdoor thermal comfort evaluation and improvement: a systematic review of an emerging field

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Abstract
Enhancing the thermal resilience of our cities has become increasingly important. To enable designers, urban planners, and policymakers to improve outdoor thermal comfort, there is a need for new, fast, and user-friendly tools to simulate the city environment. This systematic review, based on the PRISMA guidelines, focuses on identifying emerging methods for quickly predicting thermal comfort indices, such as UTCI (Universal Thermal Climate Index) and PET (Physiologically Equivalent Temperature), using Surrogate Models—mathematical models that can replace time-consuming simulations. This approach aims to facilitate data-driven performance assessments and urban design improvements. The findings indicate that current research primarily focuses on two different applications of these models: OTC evaluation and OTC improvement. In the first approach, Surrogate Models are used to evaluate the thermal comfort conditions of existing environments and to study the relationships between various factors that influence thermal perception in the built environment. In the second approach, these models can assess the effectiveness of different design strategies based on comfort performance, along with single and multi-objective optimization algorithms to identify the best-performing options. In conclusion, this review discusses the main advantages and disadvantages of adopting this methodology, highlighting the opportunities it presents for accelerating time-intensive simulations and exploring design options. Despite the promising nature of this approach, only a limited number of studies have embraced it comprehensively. Therefore, this review aims to consolidate previous scientific achievements and encourage the future adoption of this methodology.

Keywords
UTCI, Machine Learning, Optimization, Design Exploration, Thermal Stress.

Durability of cycle-pedestrian glulam bridges and footbridges: research onto good design and maintenance practices

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Abstract
In the early 2000s, experimental research was carried out at the DICA (later merged into the DPIA) of the University of Udine on the subject of the durability of cycle-pedestrian glulam bridges and footbridges. The contribution reports the main results of that research together with the progress of a subsequent investigation on the same subject that is still in progress. The analysis of a series of works located in the Friuli and Veneto Regions in different climatic and environmental situations had been summarised in analytical sheets, identifying the parts of the structures most subject to degradation, while defining some general principles (guidelines) for design choices and a series of technological solutions considered valid for limiting degradation pathologies. Almost twenty years later, a re-examination of the documentary material produced at the time was carried out in order to critically re-read it. The evolution of pathological phenomena was thus verified in relation to the type of technological solution and, where possible, also to the type and regularity of maintenance. The durability of the technological component was then evaluated, correlating for the individual nodes the system of combinations between their material, constructional and functional characteristics and their conformation/location in relation to their behaviour with respect to external agents. Considering the solutions with the highest score, an abacus of the construction details that have proven to be particularly effective with respect to durability requirements, as well as generally functional for a correct global solution of the technological node, is being created. The monitoring of the footbridges built in the early 2000s showed how the degradation processes heavily affected the construction heritage in question.

Keywords
Building Technology, Timber, Glulam Footbridges, Glulam Maintenance, Designed Durability.

Integrating physical vulnerability and exposure with user factors in flood risk assessment and mitigation for historic built environments

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Abstract
The exposure and vulnerability of users critically influence urban flood risk, particularly considering the spatiotemporal dynamics and patterns shaped by user density and profiles during the utilization of buildings and open spaces. Flood hazard and urban vulnerability are crucial in Historic Built Environments (HUBE), due to their unique physical and construction characteristics, and territorial morphology. Integrating user factors with these considerations is thus essential in flood risk assessment and mitigation. This work introduces a novel spatiotemporal methodology to incorporate user factors into the definition of flood risk scenarios, facilitating improved risk assessment actions. The proposed methodology accounts for user factors such as density loads, age, familiarity with the HUBE, and spatial positioning using hour-by-hour data. Static risk assessment, based on flood hazard and an established physical vulnerability method, is combined here with user factors through the Analytical Hierarchy Process, thereby providing a comprehensive framework for risk evaluation and mapping. The methodology is applied to a case study characterized by high user concentration, complex flood dynamics, and high building vulnerability. Comparisons between risk assessments that include or neglect user factors are provided to demonstrate the capabilities of the proposed methodology. The results reveal that user factors dynamically shift flood risk peaks during daytime hours when public areas experience the most intensive use. This approach generates time-sensitive risk maps, enabling urban planners to identify high-risk areas and implement targeted interventions. By focusing on user dynamics, the proposed framework also supports the selection of adaptive, resilience-oriented strategies for HUBEs.

Keywords
Flood Safety, Risk Assessment, Users' Exposure, Users' Vulnerability, Ur-ban Vulnerability.

Earth-based plasters with recycled additives

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Abstract
In the wake of the 2030 Agenda, many strategies have been implemented globally, in order to fulfill its goals. Amongst these, reaching sustainability and low environmental impact of construction materials is a greatly important topic, mostly carried out by the adoption of recycled and low embodied energy construction materials. Based on such premises, the ITER project aims at testing and optimizing the mix design and the production process of sustainable raw earth-based plasters stabilized using byproducts from the agriculture supply chain (natural fibers) and stone supply chain (marble dust obtained from stone sawing and processing).The aim is to reduce manufacturing impacts by finding new uses for materials that are considered waste by an industry, but that can be a valid resource for another one. The use of unprocessed raw earth in substitution of energy-demanding cement mortars and other local materials is the key to a sustainable product. Furthermore, the use of marble dust and waste plant fibers, represents a concrete example of how the application of industrial symbiosis can transform an environmental problem into an opportunity.
The plaster mixes thus designed were tested in order to also guarantee compliance with the required mechanical and physical performances. Results in terms of density, shrinkage, flexural and compressive strength and capillary absorption are presented in this paper. Such results are a preliminary assessment which will serve as a starting point for the subsequent phases of the ITER project.

Keywords
Raw Earth; Supply Chain By-Products, Marble Dust, Natural Fibers, Mechanical Properties.

Proposing a new 3D modeling pipeline for churches geometrical acoustic simulations: the case study of San Flaviano

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Abstract
This paper addresses the need for a more streamlined and automated pipeline for generating 3D models of Cultural Heritage buildings, particularly churches, for acoustic simulations. Traditional methods often rely heavily on manual reconstruction from point cloud sections, which is time-consuming and prone to inaccuracies. To overcome these limitations, this research introduces a novel modeling pipeline that enhances efficiency while maintaining geometric accuracy. The methodology begins with the acquisition of point clouds through Terrestrial Laser Scanning (TLS), followed by an optimized point cloud processing and mesh generation workflow. CloudCompare is utilized for cleaning and surface reconstruction using advanced algorithms such as Delaunay Triangulation and Poisson Surface Reconstruction. The generated meshes are further refined in Blender, where operators like decimation, smoothing, and remeshing improve quality while reducing complexity. A verification step ensures the mesh is watertight and free from defects, making it suitable for acoustic simulations. The pipeline was tested on the Church of San Flaviano in Giulianova, Italy, demonstrating that this approach produces accurate models in a significantly shorter time compared to traditional methods. The primary results indicate that the proposed methodology successfully delivers a high-quality, simulation-ready model with improved efficiency. Future research will focus on comparing the models obtained from the new methodology and the traditional one and integrating a material layer system to enhance acoustic accuracy, ensuring broader applicability in architectural research and Cultural Heritage conservation.

Keywords
Geometric Acoustics, Cultural Heritage Acoustics, Mesh Model, Point Cloud, Open Source.

Evaluation of "hot spots" for pedestrian risk assessment and mitigation in flood-prone historic built environments

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Abstract
Pedestrian safety in flood-prone built environments is a significant challenge, especially when extreme events occur in areas without effective structural measures. Historic Built Environments (HBEs) are critical scenarios due to their complex layouts, high tourist presence, and limited risk-mitigation strategies. This work proposes a simulation-based approach to support decision-makers for effective evacuation planning towards the identification of HBE "hot spots" in emergency scenarios and the definition of suitable mitigation strategies for pedestrians, such as deployment of safety devices, street furniture, and risk/wayfinding signage. A parametric HBE scenario, featuring a river and a grid-like street network, is employed to simulate evacuation dynamics under consolidated environmental conditions (i.e. hydrodynamic effects) and pedestrian behaviours (i.e., pursuing the optimal evacuation strategy). Usage patterns provide information on "hot spots" requiring safety interventions based on critical floodwater-pedestrian interactions, and on the individual pedestrian's vulnerability, depending on age. Findings highlight that streets parallel to the river flow are more suitable to host shelters, as they benefit from building screening, while crossroads and streets perpendicular to the river flow are priority areas for installing urban furniture and signage to improve pedestrian stability and wayfinding/decision-making. Furthermore, large squares could be equipped with raised platforms and sidewalks, allowing pedestrian practicability, given the potential for high water depths in case of extreme events. This approach advances current methodologies by linking pedestrian dynamics with mapping floodwater hazard and users' vulnerability, providing insights at the HBE open spaces scale, and a comprehensive framework for improving resilience in safer, more adaptive HBEs.

Keywords
Historic Built Environment, Flood Emergency Planning, Human Safety, Evacuation Simulation, Urban Furniture.

A novel tailored rating system towards sustainable mountain huts

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Abstract
Mountain huts, crucial to alpine and nature-based tourism, support over 100 million visitors annually, reflecting the sector's rapid growth. However, these structures, often aged and underperforming, face significant challenges due to increasing tourist flux and the fragile alpine environment, heavily impacted by climate change. Addressing these issues requires understanding their current sustainability performance to guide renovations and interventions. Mainstream sustainability rating systems, while effective in broader contexts, are not suited to assess the unique characteristics of mountain huts. This paper presents a novel sustainability rating system tailored specifically to mountain huts. Developed by Montana Spa, tested by Politecnico di Milano's Department of Architecture, Built Environment, and Construction (DABC), and supported by the Italian Alpine Club (CAI), the system was designed to be comprehensive yet easy to apply. CAI's involvement ensured the system's alignment with the practical needs of hut management, supporting the refinement of the rating categories through a constant dialogue. The methodology involved a literature review and gap analysis of existing systems, which informed the creation of indicators relevant to mountain huts. The developed rating system was tested on Galassi Hut, a case study chosen for its cooperative management and exemplary practices, leading to framework refinement. This research provides a practical tool for assessing mountain hut sustainability, supporting evidence-based renovations, and addressing critical information gaps in alpine infrastructure management.

Keywords
Mountain Huts, Sustainability Rating System, Sustainability Assessment, Gap Analysis, Building Performance.

Integration of vertical greenery in existing buildings. Design and application of a construction system

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Abstract
The ongoing climate change, resulting from increasing levels of environmental pollution, requires tangible actions aimed at the pursuit of truly sustainable global development, as indicated by the 17 Goals of the UN 2030 Agenda. Among human activities, the construction sector, notoriously a consumer of energy and raw materials, as well as a producer of waste and climate-changing gases, requires special attention from all stakeholders. One of the possible strategies to increase the sustainability of urban systems, restore degraded ecosystems and mitigate the effects of climate change is the adoption of Nature Based Solutions, including Green Roofs and Vertical Greenery Systems. In particular, in high-density urban areas, vertical greening strategies are emerging as a possible solution to address the shortage of green spaces, not requiring the occupation of land. Unlike what happens with new buildings, in which Vertical Greenery Systems are integrated into the building envelope already at the design stage, their application in the redevelopment of existing buildings is not an immediate solution, as it must be confronted with the morphological, volumetric, technological and material characteristics of the buildings to be renovated. The paper presents the progress of a research project that, through the design of a modular construction system, adaptable to the different characteristics of existing buildings, aims to allow the easy application of Vertical Greenery Systems in buildings constructed since the 1950s, which are most in need of energy and architectural retrofit.

Keywords
Sustainability, Climate Change, Built Environment, Vertical Greenery System, Redevelopment.

Framework for assessing digitalization in construction companies and sites

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Abstract
Digital innovation is profoundly transforming the construction sector, enhancing efficiency, safety, and sustainability. Emerging technologies improve productivity and quality while creating safer and more sustainable work environments. However, adopting these technologies requires cultural change and continuous training, with significant long-term benefits for all stakeholders. The effects of digitalization on Italian businesses are receiving increasing attention, particularly after the pandemic, which accelerated digital transformation across various sectors. Digitalization is significantly impacting Italian contractors, but its adoption and impact still vary greatly depending on the size of the company, the sector, and its technological maturity. Analyzing the state of digital transformation helps identify key technologies, adopted solutions, and challenges. Understanding these elements also raises questions about how digital innovation impacts construction companies and their production processes in practice. Given this scenario, the paper describes a framework, based on a playful approach, developed as a facilitative tool for mapping the main digitized or digitizable processes of the company, including its supply chain and the variable coalitions in which the company itself is involved. As a result, following the analysis of the summary report, the construction company can decide whether to proceed with a more in-depth assessment to establish a digitalization action plan. This strategy would focus on organizational and management reconfiguration, employee and supply chain training, recruitment of new profiles, and the acquisition of tools and outsourced services. These intentions must be accompanied by metrics and performance indicators to evaluate the return on investment.

Keywords
Digital Innovation, Construction Company, Construction Process, Digital Maturity, Digitalization.

Mechanical ventilation and Indoor Environmental Quality: experimental comparison between two decentralised systems in school classrooms

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Abstract
This paper presents a comparison between two types of controlled mechanical ventilation (CMV) decentralised systems in school classrooms: one with an internal unit within the classroom (I), and one with ducts located in the ceiling (C). The main results show that, in terms of indoor air quality evaluation, CO_2 levels in classrooms are influenced by both the opening or closing of doors and windows, as well as by the mechanical ventilation system. Only the classroom with the ceiling-hosted system (C) maintains acceptable CO_2 levels solely through the system's contribution, without the need to open the windows. The three-dimensional comfort mapping demonstrates a uniform microclimatic condition in the C classroom, while the I classroom records localised discomfort

Keywords
Three-Dimensional Comfort Mapping, Perceived Comfort, Controlled Mechanical Ventilation Systems, Thermal Manikin, User Behaviour.

Assessing residents' perception of noise and dust production during building facades' retrofit using traditional and prefabricated technologies

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Abstract
Offsite prefabrication for building retrofits can offer advantages in terms of construction time reduction. This study examines noise and dust production during the energy retrofit of residential building facades, comparing traditional External Thermal Insulation Composite Systems (ETICS) with the installation of prefabricated wooden facade panels, both applied to different portions of a building located in Povo (Trento, Italy). Interviews with residents, complemented by on-site acoustic monitoring, revealed that noise levels during the installation of prefabricated facade panels were not perceived as significantly lower (-30%) compared to those generated during ETICS thermal insulation; in fact, they were reported as more disruptive, a finding confirmed by sound pressure level measurements. Conversely, all respondents agreed that dust production during the installation of the prefabricated system was significantly lower (-30%) than during the ETICS facade insulation process. Despite the limitations of the assessment methodology employed, this study highlights the importance of a mixed-method approach in evaluating the impact of construction activities, combining instrumental measurements with self-reports from residents.

Keywords
Noise Annoyance, Dust, ETICS, Prefabrication, Retrofit.

The role of warm ambient fragrances in shaping winter thermal comfort: a linear mixed models analysis in office spaces

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Abstract
This study explores the interaction between olfactory experiences and thermal perceptions, focusing on the effect of a warm vanilla scent, perceived as a "warm fragrance", on thermal sensation in wintertime. The laboratory experiment was conducted in Bolzano (Italy) and involved two identical rooms: one without odours (control) and the other diffused with a vanilla scent via a ScentAir Direct™ atomizer. Twenty-four participants experienced the two different olfactory conditions, rating their thermal sensation on a 7-point scale. Data were analysed using linear mixed models (LMM) and showed that the vanilla scent significantly increased thermal sensation (+0.77 points compared to the odourless condition, $p<0.001$). This effect may be attributed to cross-modal correspondences between vanilla olfactory experience and a warm thermal sensation. These findings suggest that integrating warm olfactory elements into building design could enhance perceived winter thermal comfort without raising temperature levels, thereby potentially contributing to energy savings.

Keywords
Indoor Smellscape, Indoor Air Quality, Indoor Environmental Quality, Multi-Domain, Multi-Sensory, Odours.

Ventilated facade cladding systems subjected to fire load: proposal of a finite element calculation and verification methodology

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Abstract

The research addresses the topic of the mechanical behaviour of ventilated facades in case of fire. Whereas Italian and international regulations mainly focus on the reaction to fire of adopted materials, they don't pay specific attention to the structural resistance of the façade. Most of the substructures adopted for ventilated facades are made of thin-walled steel or aluminium profiles, whose mechanical properties decay dramatically as the temperature increases. Furthermore, relevant thermal expansions modify the static design scheme, leading to the onset of indirect actions and eventually to the structure's failure. Due to the interconnection between the substructure and the cladding elements, the latter are also affected by these phenomena and susceptible to local damage. The falling of broken slabs could seriously compromise the safety of escaping building users and firefighters called to intervene. The article discusses the effect of fire on the structural resistance of ventilated facades, comparing the sensitivity to this phenomenon of profiles made of aluminium, carbon steel and stainless steel, with light and heavy cladding and different support systems. A finite element model was created to evaluate the temperature's evolution over time and the consequent mechanical response for the various configurations. It is eventually demonstrated that not all current solutions can guarantee the stability of the façade.

Keywords

Ventilated Facades, Fire-Mechanical Analysis, Thermal Expansion, Architectural Engineering.

From traditional materials to geopolymers: history, performance, sustainability and 3D printing applications

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Abstract
Traditional construction materials, such as gypsum, lime, cement, and concrete, have played a central role in the construction sector. On the other hand, recent sustainability requirements make some of these materials less appealing (e.g. cements). Indeed, the construction industry is responsible for 37% of global CO_2 emissions, with 28% originating from building operations and 11% from the embodied carbon in materials and processes. The transition toward low-carbon construction is crucial for reducing its environmental impact. In response to these challenges, the emergence of geopolymers – materials derived from the alkali activation of aluminosilicates – has become a promising ecological alternative to traditional construction materials. This study aims to achieve two main objectives: (1) provide a critical review of both traditional and innovative construction materials, analysing their historical evolution, production cycle stages, mechanical, physical, and thermal properties, as well as aspects related to sustainability and printability; (2) examine the potential applications of these materials in emerging technologies, with a particular focus on 3D printing for construction, to promote more efficient and environmentally sustainable building solutions. The systematic literature review was conducted using an integrated approach, combining qualitative analysis with bibliometric investigation to ensure a comprehensive and rigorous assessment of the state of the art in construction materials research. This study highlights key limitations, including the lack of a comprehensive overview of geopolymer matrix properties, particularly regarding durability, structural compatibility, and the standardization of 3D printing processes.

Keywords
Literature Review, Geopolymers, Building Construction Technologies, 3D Construction Printing, Building Performance.

Neural network tree identification from street view images to estimate CO_2 sequestration

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Abstract
This paper presents a novel framework for estimating urban tree dimensions and their associated CO_2 sequestration potential using neural network-based image segmentation applied to Google Street View imagery. Our approach combines a dual image acquisition strategy with geometric modelling based on the pinhole camera lens model to automatically extract key tree metrics such as trunk diameter and overall height. By leveraging road width data to approximate the distance to trees and applying trigonometric equations, pixel measurements are converted into real-world dimensions. To facilitate large-scale analysis, a custom neural network that builds on established models was developed – fine-tuning a Faster R-CNN/ResNet-50-FPN architecture with extensive data augmentation from both the Urban Street Tree Dataset and local imagery. Validation against ground truth measurements shows that while tree height estimates achieve high accuracy (within 3% error), diameter estimations exhibit greater variability, highlighting areas for future improvement. The derived tree dimensions are then used to compute CO_2 sequestration using standard forestry equations, demonstrating the method's potential to inform urban sustainability assessments. Overall, this integrated pipeline offers a scalable solution for urban tree inventory and environmental impact studies.

Keywords
Green Infrastructures, Nature-Based Solutions, Environmental Sustainability, Neural Networks, Machine Learning, Urban Tree Mapping, Tree Size Estimation, CO_2 Sequestration.

Eco-efficiency in refrigerated warehouses' design and management. A critical literature review

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Abstract
In recent years, increasing attention to environmental sustainability and the reduction of greenhouse gas emissions has prompted industries to seek innovative solutions to improve their energy efficiency. In this context, industrial cold storage facilities, which are essential for the storage and distribution of perishable products, are an area of particular interest. These facilities, which are characterized by high energy consumption due to controlled temperature requirements, can benefit significantly from integrated energy management strategies.
Both researchers and practitioners are already working on innovating the planning and management of this kind of buildings, and this article aims to examine the lines of research and innovation that are already addressing Industry 5.0 and the new priorities of sustainability and resilience in this context. It also aims to identify and categorize strategies for optimizing the performance of these industrial facilities, contributing to an optimal management model from both an operational and economic perspective, as well as from an environmental perspective.
The article finally highlights the research gaps, limitations and further development windows that might lead both researchers and practitioners to the sustainable planning and management of industrial, energy-demanding buildings.

Keywords
Eco-Efficiency, Industry 5.0, Refrigerated Warehouses, Sustainability.

Digital revolution for building management: a methodological approach using advanced technologies

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Abstract
The Architecture, Engineering and Construction (AEC) sector is central to the global economy, contributing significantly to GDP and providing employment to millions of people. However, it faces challenges such as low productivity, high construction costs, project delays and poor sustainability. In fact, the sector is responsible for a significant share of CO_2 emissions and consumption of natural resources, making it urgent to transform the sector towards more sustainable practices. In this context, the digital transition is proving to be a crucial element, driven by the adoption of advanced technologies such as Building Information Modeling (BIM), Digital Twin (DT), Internet of Things (IoT) and artificial intelligence (AI). These technologies, along with targeted investments and stricter regulations, intend to optimize the life cycle of buildings and reduce operating costs. In this context, this study aims to formulate a methodological proposal that combines these technologies to improve building management and maintenance practices. Applied to individual buildings, thanks to an automated comparative evaluation of digital models and the analysis of static and dynamic data of similar buildings, the methodology could optimize maintenance, with benefits in terms of durability, sustainability and cost reduction. At the urban scale, this methodology could improve the management of building stock, contributing to make cities safer and more sustainable.

Keywords
Artificial Intelligence (AI), Internet Of Things (IoT), Predictive Maintenance.

C

BUILDING DESIGN AND TECHNOLOGIES

Open BIM for the Gran Sasso National Laboratory. Integration of ISO 81346 reference designation system in IFC for the Bellotti Ion Beam Facility

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Abstract

The choice of a classification system is particularly relevant in the BIM for Asset Management, because it is crucial to arrange the data set in a logical way and comply the specific characteristics of heterogeneous components of the built environment.
ISO/IEC 81346 is the standard selected by the technicians of the Gran Sasso National Laboratory for the BIM management of the entire National Institute for Nuclear Physics building asset and it was used in the framework of the research project PNRR Tecnodigit. ISO/IEC 81346 methodology was adopted to enable structured and computerized data management, which provided guidelines for structuring, classifying, and reference designation of assets. In order to facilitate communication and collaboration of different sectors, the proposed solution is based on a Reference Designation System, described in the standard, solving the critical issue of having different nomenclatures and identifications that are often inconsistent in different contexts and sectors of use. The ISO/IEC 81346 methodology was applied for the information modelling of the underground structure of the Ion Beam Facility (IBF), the latest structure developed by the LUNA collaboration (Laboratory for Underground Nuclear Astrophysics). Through the comparison of ISO/IEC 81346 with the most conventional classification systems and the description of the consequent arrangement of WBS and IFC files, the paper aims to describe the methodology used to integrate this uncommon standard for the information modelling of a special building, with the aim of enhancing continuous data sharing and flexible interoperability in the broader view of open BIM.

Keywords

BIM, Breakdown Structure, Reference Designation System, ISO/IEC 81346, Gran Sasso National Laboratory.

Towards the Digital Twin of a Deep Underground Laboratory. The information modelling of the LNGS experiment facilities

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Abstract

Digital Twin technology within the AEC industry is a crucial topic for the effective management of the built environment. The PNRR-funded research project Tecnodigit also focuses on this strategy, proposing a more effective integration of sensor data into BIM models to guarantee a higher level of building safety and sustainability. Among the case studies involved in the research project, the underground facilities of National Gran Sasso Laboratories represent an exceptional example not only for their unusual location, but also for their unconventional building typology mixing buildings and infrastructural features. The challenge of developing a federated BIM model of the central tunnel containing the experiments within for physics particles involves the overcoming of several criticalities that are described and highlighted in the paper, along with the proposal of possible solutions that represent the first phases for the application of a DT system.

Keywords

BIM, Digital Twin, Deep Underground Laboratories, LOIN, Federated models.

Material passports in AEC sector: critical success factors and issuing protocol towards standardization

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Abstract
A shift towards Circular Economy (CE) necessitates long-term documentation and dissemination of information for reusing materials and products in the existing built environment. Serving this purpose, Material Passports (MPs) encompass the composition and specifications of materials used in building components throughout their lifecycle, facilitating reuse, recycling, or remanufacturing of materials in future construction projects. However, the processes for compiling MPs remain unstandardized, lacking consensus among stakeholders and governing bodies. This work outlines a standard procedure for MP compilation by reviewing previous literature and current practices. To this aim, Systematic Literature Review (SLR) is employed to explore the state of the art of the research related to MPs for CE assessments. Using text-based coding in NVIVO, Critical Success Factors (CSFs) of MP compilation and their interrelationships are extracted. To work out the significance of the CSFs and their interrelationships, the article categorizes CSFs into operational, foundational requirements and data management factors, and illustrates the interrelationships in terms of explicit, implicit and managerial dependencies. Based on these insights, the study proposes guidelines for developing comprehensive MPs. The proposed MP protocol introduces a standardized approach for digital integration, stakeholder engagement, and policy adoption to enhance MP implementation in the building industry.

Keywords
Material Passports, Standardization, Protocol, Critical Success Factors (CSFs), Policy Adoption.

Life cycle analysis of innovative cement-based materials using stone waste: state of the art and opportunities for Apricena marmettola

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Abstract
The construction sector is one of the most polluting, due to emissions, resource consumption and waste production. In particular, the environmental impact of cement production and stone processing waste is a significant challenge for the sector. The growing focus on sustainability has encouraged the development of innovative materials, reducing environmental impact and waste. In particular, stone waste can be changed into secondary raw materials for cementitious composites, promoting circular economy. The aim of this research is to establish how the integration of stone waste into cementitious composites can mitigate the environmental impact, by analysing the contributions in the literature that use Life Cycle Assessment analyses for these products. The methodology involves screening contributions on various scientific databases such as Scopus, Google Scholar, ScienceDirect, using appropriate keywords. The aim is to assess the environmental benefits of using this waste. By comparing the chemical-physical characteristics of the analysed stone waste with characteristics of marmettola of Apricena, it is possible to deduce that the marmettola can also bring similar environmental benefits, due to comparable parameters with examined stone waste. The adoption of this approach promotes the transition to a circular economy, helping the reduction of environmental impact and the recovery of waste materials.

Keywords
LCA, Stone Waste, Marble Waste, Concrete, Cement.

4D printing of adaptive shading components

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Abstract
Understanding the weaknesses currently affecting the construction sector reveals that excessive consumption, high emissions, and resistance to adopting substantial technological innovations remain key challenges. One of the most impactful elements for improving a building's energy efficiency is undoubtedly the external envelope – the façade – which serves as a filter, protecting the interior from external influences. Given its pivotal role, recent decades have seen growing interest in technological solutions such as kinetic façades and adaptive envelopes, known as Climate Adaptive Building Shells (CABS). These systems effectively regulate solar radiation through controlled opening and closing of façade components. While these innovations mark significant progress in integrating advanced solutions into construction, their reliance on motors for operation inevitably results in energy consumption. To overcome this limitation, this study explores the application of 4D printing, a technology that utilizes additive manufacturing and smart materials capable of adapting their spatial configuration in response to external stimuli (e.g., temperature, light, or humidity), to develop a kinetically responsive facade component.
This component, powered by 4D-printed actuators, adjusts its configuration solely based on environmental triggers and reverts to its original state once the stimulus is removed. This research begins with predefined specifications by defining the panel's morphology and shape-changing mechanisms, followed by simulations in Rhinoceros and Grasshopper to evaluate design efficiency based on predefined performance metrics. Finally, the study focuses on selecting and preparing liquid crystal elastomer as the active material, employing direct ink writing as the deposition technique.

Keywords
Kinetic Façade, 4D Printing, Smart Materials, Computational Design.

The reuse of steel components towards the evolution of the European and national regulatory framework related to the CE marking

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Abstract

The circular economy implies new challenges and targets to mitigate the impact of new production cycles by using post-production processes, such as the reuse and repurposing of components in the case of steel, whose high potential is already acknowledged for recycling. The PRIN 2022 research project, titled "Buildings and Circular Economy - Steel from Production to Post-Production - Law and Responsibility Issues" focuses on this operational scenario. The research project aims to define methods and tools for reusing metal components resulting from buildings decommissioning, and, in the case of designing new structures, strategies for an efficient design that integrates both disassembling and reassembling construction elements. The first results of the research project are summarized in this contribution, which aims to reconstruct the regulatory framework at both the national and European levels, related to the practice of reuse and, in particular, to the application of CE marking. This process can play a crucial role in the start of a new phase of the circular economy, pushing the reuse of steel products for the reduction of environmental impacts and the development of a new and promising economic model.

Keywords

Circular Economy, Reuse, Steel Components, Regulatory Framework, CE Marking.

Circular data flowchart for sustainable ecodesign

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Abstract
The transition to a circular economy is essential to reduce the environmental and climate impacts of current linear patterns of production and consumption, particularly in the construction sector, which has one of the highest environmental impacts. Among the actions of the Commission, aimed at concretising the ecological and digital transition of Europe, there is the ESPR Regulation 2024/1781 that introduces the Digital Product Passport (DPP) as a key tool to ensure transparency and traceability along the entire product value chain, improving resource management and supporting ecodesign. In the construction sector, the Material Passport (MP) and the Building Heritage Material Passport (BHMP) are key tools for documenting the technical characteristics and environmental impacts of materials, to ensure that ecodesign requirements, deconstruction, reuse and recyclability are met. In addition, these tools give an identity to enhance and protect the materials and construction techniques of traditional architecture, especially the interior areas, which are often forgotten. This study examines the major European regulatory actions in favor of circularity, the most significant examples of experimentation of MPs (Material Digital Passport) in the construction sector and the challenges associated with the implementation of this tool, including standardization, Data protection and interoperability. The study proposes an informative Flowchart for data management in DPPs, which divides the product life cycle into three macro phases, identifying stakeholders and key specifications inherent to each phase; the study also highlights the active role of the "prosumer" in the circular process, underlining the importance of informed participation in product selection and management; and how this actor can influence design from a sustainable and ethical point of view. The use of digital identity is a key step towards decarbonisation and resource optimization in the industrial and construction sectors.

Keywords
Digital Product Passport (DPP), Eco-design for Sustainable Product Regulation, Construction Products Regulation, Prosumers, Give-and-take Model.

The adaptive reuse of architectural heritage in dynamic hubs for innovation and sustainability

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Abstract
The paper describes an integrated design methodology for the adaptive reuse of architectural heritage based on the new models of circular economy and innovative design thinking that stimulates the creativity of the people involved in the working group. The methodological approach involves the use of non-destructive diagnostics, advanced material analysis and context analysis to identify degradation factors and develop reversible and sustainable restoration strategies that preserve historical integrity while improving the technical performance of the building. Furthermore, the use of Life Cycle Thinking allows a holistic assessment of the environmental, economic and social impacts throughout the building's life cycle, supporting selection of sustainable materials and technologies.
The design methodology has been applied to the case study of the Carafa Castle in Colobraro, a small town in the Province of Matera, which became famous in the post-war years as a city of bad luck for a series of folk tales about the rite of "fascination", able to provide evil according to popular belief. The castle has had several restoration interventions from 2009 to 2017 that have not solved the pathologies resulting from rising damp. The adaptive reuse project aims to solve the problems caused by biological degradation and the formation of efflorescence and detachment of plaster and to re-functionalize the Carafa Castle into a dynamic hub of innovation and sustainability with creative laboratories and public spaces for events promoting sustainability and collaboration between local communities, academic institutions, public authorities and research centres. Following a modern Bauhaus vision, the dynamic hub fosters co-creation and experimentation in flexible and multifunctional spaces to satisfy community needs and to boost cultural and economic regeneration.

Keywords
Adaptive Reuse, Diagnostics Techniques, LCT, Sustainable Conservation, Cultural and Economic Regeneration.

Reuse and reversibility as circular approach strategies to building design

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Abstract
The reuse of existing buildings, in the context of the current climate crisis, can play a crucial role in reducing the environmental impact of buildings, using a circular approach in the construction sector. Repurposing existing structures to prevent underuse or, in extreme cases, abandonment offers multiple benefits, including reducing the need for new constructions, minimizing construction and demolition waste, and lowering the embodied carbon of the built environment. In the field of circularity strategies in construction, there is significant field for research and development to explore new design approaches that integrate circularity and sustainability considerations—not only in material and technical solutions but also in the overall design concept. This paper presents a design proposal for the reuse of the Youth Summer Retreat in Ohrid (North Macedonia) through the methodology, principles and strategies of Reversible Building Design (RBD). This approach provides an innovative circular perspective to architectural design, applicable not only to new constructions but, more importantly, to the adaptive reuse of existing buildings.

Keywords
Reuse, Circularity, Reversible Building Design, Embodied carbon, Recycling.

Designing a new collaborative educational platform on glass design and engineering: a case study

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Abstract
The widespread adoption of glass as construction material, driven by significant advancements in its manufacturing techniques, has changed the design of modern buildings in the 20th and 21st Century. Currently, the development of high-performance glazing systems – such as highly Insulated Glazing Units (IGUs), selective coatings, adaptive devices, etc. – has allowed the design of new fully glazed buildings capable of integrating natural light, architectural aesthetics, and energy performance. Nevertheless, the development of these new types of buildings and technologies has not always been followed by a proper advancement of specialistic training networks and tools for professionals and students. It follows that, currently, glass design and engineering is a wide and complex topic developed unevenly across different cultural and economic areas. The aim of this paper is to describe a case study regarding the development of a new open-source collaborative content platform on glass design and engineering. This project allows to create and collect high-quality Open Educational Resources (OERs), revised and validated by experts in the field, in an open access platform providing a useful tool for both students and practitioners. The platform addresses the core and emerging topics in research, innovation and application of glass in the building field through five main collections: fundamental, applications, codes and standards, sustainability, projects and research. This paper describes the structure adopted for the platform, the review process, and the current status of the project in order to provide a first overview of this new tool.

Keywords
Glass, Educational Platform, Architectural Engineering, Digital Innovation, Open Educational Resources.

BIM-LCA early-design stage workflows for public administration: a comparison

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Abstract
This study explores two different strategies for integrating Life Cycle Assessment (LCA) with Building Information Modeling (BIM) to support public authorities in the early design stages of new construction projects. In compliance with Italy's Minimum Environmental Criteria (MEC) for the building sector, contracting authorities are required to assess the feasibility of interventions on their building stock before initiating procurement procedures. While MEC encourages the use of LCA to evaluate environmental impacts, it does not specify how to apply LCA in early design stages. The lack of clear guidance and the complexity of LCA processes pose significant challenges for public administrations. This research reviews and compares two BIM-LCA integration strategies that have been found in the literature to streamline and enhance LCA assessments. The goal is to identify the most suitable strategy and tool for facilitating LCA application in early public building designs in Italy with BIM methodology.

Keywords
BIM-based LCA Study, BIM-LCA Integration Strategies, Early-design Stage, Public Administration.

History and overview of lean construction fundamentals

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Abstract
The history of Lean Construction (LC) includes diverse implementations that have evolved since 1988. LC theory is supported by extensive academic contributions and empirical experimentation, with numerous pilot projects tested worldwide. The original goal was to improve the efficiency of the construction production flow. The most modern goal has been to make the construction industry structure more sustainable, always considering Respect for People, one of the two fundamental pillars of LC. The LC sector in Europe is facing new challenges due to shifting economic conditions, geopolitical factors, and resource management constraints. Interestingly, this situation resembles the context in which Toyota and Mr. Taiichi Ohno developed the foundations of this discipline through the Toyota Production System. This work has its roots in the Implementation of Lean Construction in Finland, which explored, back in 2022, how different construction companies in Finland were applying LC tools such as BIM-based software or LC elements such as Transparency, Collaboration, and Integration Project Delivery. How has the concept of lean thinking evolved over the years? What happened in the past three years? This overview will represent the first step of the research project on Lean Construction Implementation. It aims to lay the foundation for future work on Lean Construction related to waste management, circularity, resource management, and contract management.

Keywords
Lean Construction, Contract Management, Construction Projects, BIM.

Thermal comfort in urban areas: comparing numerical results with citizens' perspectives. A case study in Trento, Italy

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Abstract
Thermal comfort is increasingly becoming an urgent concern due to the rising temperatures in urban areas affecting liveability and health. This study aims to investigate microclimate conditions and outdoor thermal comfort in the historical center of Trento, Italy. A mixed-method approach was adopted for this purpose based on microclimate monitoring, simulations and surveys with citizens. Quantitative and qualitative findings are made spatially explicit and compared in the study area. The former are based on microclimate simulations carried out with the ENVI-met software for a hot summer day showing areas more exposed to heat stress, and validated through the on-site monitoring. The latter involves an online survey where citizens could point out thermally comfortable and uncomfortable places providing perceived hotspots. Areas do not always overlap mainly because mental schemes are also determined by frequency of visits, type of activity and long-term memory. Areas that overlap may be the most prone to the implementation of adaptation measures. The study provides results that can be useful for planners and decision-makers in improving thermal comfort in urban areas.

Keywords
Historical Centers, Outdoor Thermal Comfort, ENVI-met, Collaborative Map, Urban Form.

Optimizing daylight and outdoor view in healthcare environments: enhancing patient well-being through facade design and spatial configuration

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Abstract

This study aims to identify a balance between natural light and external views to enhance environmental comfort in indoor spaces, with particular attention to healthcare facilities. The spatial configuration of transparent and opaque surfaces, as well as their ratio within a building's facade, has a direct impact on the quality of natural light and the psychophysical well-being of the occupants. Literature has highlighted a correlation between visual connection with natural and dynamic elements and stress reduction, thereby accelerating the healing process in patients. Building on this background, the paper implements light and visual analyses based on current, established calculation frameworks referenced in professional standards and implemented through a widely adopted simulation software solution. The aim of the study is to evaluate the complexity of the outcomes achievable within current professional practice, specifically enabling a comparative assessment of lighting and visual performance in the particular context of healthcare design. A parametric simulation approach is applied to an idealized building, assessing the impact of factors such as orientation and obstructions caused by trees and surrounding buildings. The results confirm that a meticulous design approach and the strategic positioning of glazed surfaces significantly enhance the quality of the indoor environment. Furthermore, they introduce a comparative assessment based on a spatial-oriented methodology, which evaluates comfort zones through a cross-analysis of multiple parameters. This approach allows for a comprehensive understanding of how different environmental factors interact, enabling the optimization of indoor conditions to maximize occupant well-being.

Keywords

Indoor comfort, Daylight, Outdoor View, Healthcare design, Patient well-being.

Self-building and sustainable construction: theories, models and innovations

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Abstract
The construction sector is responsible for a high environmental impact, prompting a review of building models and processes in a green key, in view of the 2030 Agenda goals and the ecological transition. In addition, the growing housing crisis is becoming an increasingly widespread issue, affecting not only developing countries but also more industrialised ones. The main reason for this crisis is the rise in house prices, combined with a decrease in employment levels and a consequent increase in social disadvantage. In response to these phenomena, self-building can be seen as a possible alternative to traditional building processes, offering considerable advantages: reduced construction costs and time, buildings "tailor-made" to the real needs of users, use of ecological and local materials, increased sense of community and belonging. With these premises, the work presents an initial investigation of the self-building topic which, drawing its origins from the key principles of vernacular architecture, is investigated through some significant modern and contemporary theories and experiences. Next, the main self-built models experimented in recent years are analysed, with a focus on innovative materials most suitable for self-building processes. Finally, the current and most recent definition of "self-building" is given, which is based on the active participation of the future inhabitants in all phases of the building's construction (from design to execution), supported and assisted by experts in the field. The conclusions summarise the findings, highlighting the main potentials and critical issues of the investigated approach.

Keywords
Self-building, Sustainable Construction, Housing Crisis, Innovative Construction Models, Innovative Materials.

Occupant-based digital predictive management to improve the built environment

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Abstract

Facility management requires the proper management of a set of information coming from different areas to grant the correct allocation of resources for the safety and health of the workplaces. Assuming the variety of domains, different types of data must be combined, integrated and managed to create accessible knowledge and push towards correct decisions. The EU has proposed whole lifecycle digital logbooks for buildings as a digital repository supporting building management tasks. However, integrating dynamic occupancy data into this type of digital repositories and using these data to predict the impact of alternative strategies are relatively unexplored fields. A common digital framework for building management, based on common languages/interfaces/data matching methods, is still lacking, as underlined by the EU. DIGITMAN (Occupant-based DIGITal predictive MANagement to improve the built environment) is a PRIN2022-financed project aimed at developing a predictive approach based on occupancy data integrated into a common digital framework to improve building stock management by supporting the correct allocation of technical and economic resources during the operation of buildings. In the project, UNIVPM (coordinator), UNIBO, and POLIMI are developing a digital tool to support facility managers and building owners in considering occupancy data collected through BAS (building automation systems) and CMMS (computer maintenance management systems). The proposed approach is based on a set of predictive analytic methods (e.g., ML, MAS) and simulation-oriented multicriteria analysis techniques (e.g., BPS) ap-plied to the main pillars of building management (i.e., operation, maintenance, safety).

Keywords

Occupancy Data, Facility Management, Digital Logbooks, Predictive Methods, Resource Allocation.

Parametric modeling and multi-performance analysis of 3D-printable clay brick models

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Abstract
With the increasing demand for sustainable and efficient building materials, there is a pressing need to explore innovative solutions that combine advanced manufacturing techniques with environmentally friendly materials. This study aims to identify the key parameters influencing the performance of 3D-printable clay bricks. To this purpose, Voronoi parametric models are used for a multiperformance analysis, – including thermal, structural, and acoustic assessments – supported by detailed statistical evaluation. The research demonstrates the versatility of Voronoi diagrams in creating complex geometries and identifying critical parameters such as wall thickness and cell distribution that affect performance. The thermal analysis highlights the importance of minimizing thermal path length (TPL) to reduce thermal transmittance. In structural evaluations, geometric regularity is shown to enhance stability. Acoustic assessments indicate that increasing wall thickness and cell density improves sound insulation (Rw). Finally, the study also emphasizes the potential sustainability of clay as a building material, noting its lower environmental impact compared to cement and its compatibility with 3D printing technology. The findings provide a framework for optimizing design processes and lay the groundwork for future research focused on performance-driven, sustainable construction methods.

Keywords
Voronoi Geometry, 3D Printing, Parametric Modeling, Sustainable Materials, Multi-Performance Design.

The environmental performance of the construction site in compliance with CAM and DNSH

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Abstract
The Minimum Environmental Criteria are environmental and ecological requirements, defined by the Italian Ministry of the Environment, aimed at guiding the choices of the Public Administration towards sustainable products, services and works. These criteria are defined within the scope of what is established by the Action Plan for the environmental sustainability (PAN GPP) of public administration consumption. The principle of "doing no significant harm" to the environment (DNSH principle, i.e. "Do No Significant Harm") was created to combine economic growth and ecosystem protection. Regulation (EU) 241/2021, establishing the Recovery and Resilience Device, provides that only measures that comply with the DNSH principle, introduced by Regulation (EU) 2020/852, the so-called "Taxonomy Regulation", may be financed within the individual National Plans. The study aimed to correlate the environmental parameters on which the construction phase im-pacts, i.e. corresponding to: CAM - Technical Design Specifications Relating to the Construction Site (DM 256/2022; art. 2.6); DNSH - Sheet 5 - Building and general construction works not connected with the construction/renovation of buildings (EU Regulation 2020/852).
With regard to the scenarios of simultaneous satisfaction of CAM and DNSH, a possible implementation of the improvable criteria has been developed, for the purpose of the development, by the economic operator, of a Most Economically Advantageous Offer

Keywords
CAM, DNSH, Construction Phase, Construction Site Sustainability, Public Procurement.

Marble waste and disposed fishnets: a new polymeric composite material supporting circular economy

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Abstract
Circular economy imposes to think of innovative ways to reduce the amount of energy consumed as well as the amount of waste produced by the construction sector. This study delves into the development of a novel composite material synthesized from marble slurry and discarded fishnets, offering a sustainable solution to two major environmental pollutants. The choice of these types of waste lies behind the fact that they are both extremely polluting, and that they are available in consistent amounts. Furthermore, the legislation concerning the disposal of these two types of waste is either lacking or improperly followed, making it difficult to fully assess the magnitude of their environmental impact. However, research on such composite materials – especially in construction sector – is still almost unexplored, leaving the possibility to create something innovative as well as environmental-friendly. The marble slurry acts as filler in the polymeric matrix, in the attempt to enhance the properties of the polymer, making the resulting composite a suitable material for construction use. The material was fabricated by combining finely ground marble waste with recycled polymer fibers extracted from disposed fishnets, both locally collected, forming a composite material through three processes: extrusion, thermal compression molding and FDM 3D printing. Although preliminary results suggest promising mechanical properties, including high elastic modulus, the study is still in its early stages, and further testing is required to comprehensively assess the material's long-term performance, environmental resistance, as well as potential applications.

Keywords
Marble Slurry, D*isposed Fishnets, ALDFG, Polymeric Composite, Waste.*

Accessible spaces and active stakeholder engagement processes

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Abstract
Vulnerable communities often face socio-spatial exclusion due to insufficient institutional attention, limited social awareness, and top-down decision-making processes that hinder equitable access to urban spaces. This paper explores the right to the city (Lefebvre, 2014) and socio-spatial justice (Soja, 1996; Harvey, 2012), emphasizing the need for inclusive environments that enhance well-being through multidisciplinary collaboration and participatory action research (Lewin, 1946). International frameworks, such as the UN Convention on the Rights of Persons with Disabilities (2006), highlight accessibility as a fundamental human right, yet enforcement remains inconsistent. In Italy, legislative advancements from the late 1960s to the PEBA plans have aimed to address architectural barriers, but gaps persist due to limited political will and societal awareness. Community-based participatory research (CBPR) is presented as a method to foster inclusion by actively involving vulnerable groups in urban planning. This approach draws on feminist and action research methodologies, emphasizing empowerment and collaborative knowledge production. A key case study is the DeafSpace project at Gallaudet University, which exemplifies best practices in accessible design tailored to the deaf community's needs. DeafSpace guidelines cover spatial proximity, sensory reach, mobility, lighting, and acoustics, ensuring environments that promote communication, safety, and well-being. The research underscores the importance of participatory processes that transform affected communities from passive subjects to active co-creators of their environments. It calls for political commitment, academic dissemination, and societal awareness to dismantle ableist structures, highlighting that only through collective responsibility and stakeholder engagement can truly accessible and equitable spaces be created for all citizens.

Keywords
Accessibility, Socio-spatial Justice, DeafSpace, Community, Action Research.

Green BIM: Sustainability and Innovation for the Building Heritage managed by Public Administration

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Abstract
In a society where the attention at the sustainability is one of the most urgent community objectives to be achieved, the Construction Sector, and Technical Architecture itself are called upon to actively contribute to the change. The urgency of reducing environmental impact requires constant updating on the latest physical and digital innovations that can be used to achieve the Global Goals. This contribution proposes a decisive key of interpretation, identifying the existing Building Heritage managed by Public Administrations as the largest group and, at the same time, with the best margin of improvement in terms of conversion into Green Buildings. In this context, the Building Information Modeling, or BIM's method, is configured as an essential tool, demonstrating that it can optimize the design, construction, and management of buildings and infrastructure, with an increase in efficiency of 30%. Its application not only improves the quality of the building process but also contributes to a more sustainable and conscious management of the life cycle of buildings. The integration between these innovative technologies and environmental needs has given rise to the concept of Green BIM, which represents a unique and concrete approach to achieving global sustainability goals. By combining the power of BIM and the commitment to greener architecture, a viable path is created towards a more responsible and environmentally friendly future. This contribution, by a comprehensive review, aims to address the need/requirements to direct the activities, supported by EU programs, towards the green enhancement of existing Building Heritage with the BIM method.

Keywords
Green BIM, Public Administration, Sustainability, Innovation, Heritage.

Scan-to-BIM methodology for installation of prefabricated panels on existing building façades: from point cloud data to native BIM categories

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Abstract

The application of prefabricated technologies to be applied on the façades of existing buildings for their integrated seismic and energy renovation is becoming increasingly widespread. To this end, dedicated scan-to-BIM work-flows need to be developed to create precise as-built representations of the building. This paper introduces an innovative methodology to transform point cloud data acquired through 3D laser scanning into precise 3D models of existing building envelopes, which can be seamlessly integrated into BIM environments for further analysis and modification. This methodology follows two distinct approaches depending on the presence of façade interruptions, such as balconies. It involves the systematic application of software tools, including CloudCompare to automate curve extraction from point clouds, and Rhinoceros to interpolate these curves into surfaces and solids, resulting in accurate as-built models. The generated geometric elements are then imported into a BIM environment as editable families, enabling comprehensive building information management. Beyond digital modelling, this approach provides essential data for the correct installation of prefabricated elements, ensuring their seamless integration with the new envelope with the existing structure and optimizing the overall performance of the renovated building. The methodology is validated through its application to a 1964 residential building in Catania. The validation process includes an accurate as-built survey of the existing façades and the definition of alignment planes for the installation of a new prefabricated wood-based envelope.

Keywords

Prefabricated Technologies, Scan-to-BIM, BIM Methodology, Point Cloud, Integrated Renovation.

Architecture and engineering in the AI era: definition and validation of a new AI-driven design workflow

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Abstract
In recent years, Artificial Intelligence (AI) has become increasingly prevalent across various sectors, including the Architecture, Engineering, and Construction (AEC) industry. AI-powered software tools are being developed to automate tasks and optimize design processes.
This paper explores the integration of AI tools including ChatGPT, Midjourney, Stable Diffusion, and ComfyUI with parametric design software such as Grasshopper and Revit, assessing their potential to transform traditional design workflows. The use of AI chatbots like ChatGPT enables efficient data analysis, allowing for rapid evaluation of urban parameters, climate data, and local energy requirements. In addition, AI-driven image generation tools, such as Midjourney and Stable Diffusion, in combination with ComfyUI, facilitate the rapid exploration of multiple design possibilities. These tools enable iterative and real-time generation of architectural visualizations, providing an almost infinite pool of design options. Additionally, they significantly enhance the efficiency of design control and modification by reducing the time traditionally required for rendering tasks.
Furthermore, the study highlights the critical role of parametric design environments as a foundational framework for AI-assisted design, supporting iterative exploration and optimization. This effectiveness and limitations of the proposed methodology are evaluated through its application to a case study.

Keywords
AI-driven Design, Parametric Design, ComfyUI Workflow, Image Generation.

Mechanical Optimization of 3D-printed Earth Blocks based on Triply Periodic Minimal Surfaces

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Abstract

The construction sector is undergoing a deep transformation driven by digital transition, with increasing interest in advanced technologies such as 3D printing. In the path towards ecological transition, the integration of this manufacturing process with low environmental impact materials like raw earth has opened new opportunities for developing sustainable and high-performance building components.

This study presents a parametric design workflow for raw earth blocks, featuring an internally optimized infill based on the use of generative geometries. Specifically, the infill is realized with triply periodic minimal surfaces, renowned for their high mechanical properties. The proposed workflow aims at enhancing the mechanical performance of these blocks, ensuring both structural efficiency and sustainability. The final part of the study involves the prototyping of the blocks using 3D clay printing is presented, serving as a tool for validating the proposed design and production process.

Keywords

Parametric Modeling, Raw Earth, Additive Manufacturing, Mechanical Optimization, Earth Construction.

Evaluating the applicability of innovative deep renovation solutions for seismic and climate vulnerable urban areas. The case study of Athens

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Abstract
The existing European building stock is responsible for a relevant impact in terms of greenhouse gas (GHG) emissions and total energy consumption. Effective renovation strategies need to be defined and tested to meet the European Union 2050 decarbonisation target. In this context, urban mapping supported by a GIS-based procedure allows for the identification of eligible areas to evaluate the applicability of deep renovation solutions. This research studies the applicability of the innovative technologies e-PANEL, e-CLT, and e-EXOS, defined within the framework of the European H2020 project "e-SAFE – Energy and Seismic AFfordable rEnovation solutions". They are characterized by assembly with dry construction techniques according to the principles of circularity and low environmental impact, as well as reduced disturbance for the inhabitants. Their combination enables energy retrofit (e-PANEL) and seismic resistance enhancement (e-CLT and e-EXOS) of existing buildings. The presented methodology supports the identification of a sample of suitable urban blocks in the Municipality of Athens, part of the Athens Metropolitan Area (AMA), one of the most vulnerable areas to seismic risk and climate change. The main outcome is the identification of implementation rates for each e-SAFE system as a preliminary indicator/decision support tool to measure the impact and guide targeted long-term strategies for building retrofitting.

Keywords
Deep Renovation Solutions, GIS-based Methodology, Athens Metropolitan Area, Low Disturbance, CLT panels.

Image segmentation for the automatic recognition of historic masonry walls

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Abstract
This study approaches the potential of image recognition based on artificial intelligence to automate the construction analysis of stone walls, as support to the typological study of historic masonry. Santo Stefano di Camastra, Sicily, was used as case study. A set of 60 photos, each representing one of the visible walls in the historic centre, were assessed in six aspects of image quality and three aspects of wall complexity. Each photo was segmented through the open access tool Meta AI and a score was assigned to the quality of segmentation. The association was analyzed between the quality of segmentation and the variables on image quality and wall complexity, considered individually or in linear combinations. Somers'D index was used. The study suggests that image quality is partially associated with the result of automatic segmentation through the presence of other building components and external elements in the picture, and the focal distance of photography. Association was not observed between segmentation and construction features of masonry, while the relationship is strong with features describing the appearance of wall surface.

Keywords
Historic masonry, Image segmentation, Artificial Intelligence (AI).

Preliminary feasibility studies aimed at greening strategies for the urban regeneration. The case study of the Monte Po district

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Abstract
This paper is part of a research project that aims to define an integrated framework for analyzing and evaluating basic scenarios for possible greening and urban regeneration projects. These projects aim to improve aspects such as climate, health and well-being, aesthetics, environmental conditions, safety, technology, and innovation development. The strategy adopted in this research focuses on prioritizing building-scale interventions, particularly involving public structures and facilities of collective interest within specific urban areas and districts. In the literature, there are several examples of greening systems integrated into the building envelope (horizontal and vertical enclosures) from the design phase, mainly for new constructions. However, the same cannot be said for existing buildings. In the case of existing buildings, implementing greening systems integrated into the envelope is more complex. It is necessary to develop a preliminary feasibility analysis phase aimed at defining factors such as morphology, volume, construction technologies, material consistency of the building, and the presence or absence of surrounding spaces suitable for planting vegetation. The preliminary feasibility analysis phase aims to identify a set of indicators related to the characteristics of buildings and surrounding spaces in terms of their suitability for greening interventions. These indicators were identified by correlating qualitative and quantitative data, recorded in two types of specifically designed cataloging sheets, with the characteristics of indirect green façade systems. This paper presents the first results obtained from the application of this analysis in a case study focused on the Monte Po public housing district in Catania.

Keywords
Sustainability, Climate Change, Vertical Greenery System, Requalification.

Technique in the era of digital architecture: a critical perspective on the transition from Le Corbusier's work to 3D printing

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Abstract
The evolution of technology has shaped architectural paradigms throughout history, in this context, the convergence between tradition and innovation is configured as a central axis in the development of new architectural proposals. This article explores through a comparative analysis of three key projects of Le Corbusier's late work, such as Le Cabanon, Chandigargh, Saint-Pierre de Firminy, which highlights the change in the architect's approach from functionalist rigidity to projects that integrate symbolism, spirituality and materiality. In parallel, a similar analysis was made of contemporary case studies such as the Traditional House of the Future, Nadarra and TECLA that illustrate the creative process through which digital technologies, in particular 3D printing, are moving. While these innovations offer unprecedented opportunities, they also raise ethical and cultural questions about the role of technology in shaping human environments. This study, through its critical nature, invites us to rethink architectural practice in the digital age by merging the legacy of the past with the innovations of the present to configure human environments that respond to today's ethical and cultural challenges.

Keywords
Technique, 3D Printing, Le Corbusier, Digital Architecture.

Using a behavioural survey to structure an Immersive Virtual Training for energy and comfort awareness in summer season

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Abstract
It is now well known that human behaviour plays a crucial role in overall building energy consumption. Thus, for decades, researchers have explored the drivers of human-building interactions, leading to the development of various behavioural theories. Recently, an interest in developing strategies able to raise occupant awareness of energy-related behaviours is emerging. In this context, training activities are emerging to promote more energy-efficient habits. However traditional trainings are not typically based on preliminary behavioural data collection, showing historical or real-time data rather than the future consequences of occupants' choices, and rely on displays or brochures, making them less engaging. Immersive Virtual Environments (IVEs) offer new opportunities to overcome these challenges. This study presents the creation and testing of a data-informed immersive virtual training activity inspired by a behavioural survey. To identify critical energy-wasting habits and the underlying drivers, 104 participants completed a survey based on the Motivation-Opportunity-Ability and the Theory of Planned Behaviour frameworks. The insights obtained were used to design an immersive pilot training, in which participants could interact with virtual building systems (i.e., air conditioning, windows, and blinds) under controlled discomfortable summer conditions. The relationship between declared and observed behaviour in the IVE was examined. Discrepancies were detected in cooling set-point selection and the operation of windows when air conditioning is active. Findings demonstrate that integrating the behavioural frameworks is a promising strategy for designing effective IVE training activities, highlighting the need and the potential of immersive training experiences to address knowledge gaps and persistent habits.

Keywords
Occupant Behaviour, Immersive Virtual Environments, Energy-related Behaviour, Behavioural training, Building Energy Consumption.

Recovery of aggregates for plaster production

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Abstract
Waste and rejects, even from sectors apparently far from the building industry, can represent a strategic opportunity for the development not only of new products, but also of new 'circular' supply chains and industrial symbiosis processes. In order to activate an economy that is not only 'circular' but also 'sustainable', it is necessary to assess the actual sustainability of the choices made in a life-cycle perspective on a case-by-case basis. The application of the LCA methodology is one of the main tools to assess the benefits that can be obtained from the recovery of various types of waste, planning processes to develop sustainable solutions and strategies to support the circular economy. This contribution returns the first results of a research developed in collaboration with Laterlite S.p.A. Paying attention to sustainability aspects, the study envisages the recovery of selected aggregates from furnace production waste or from controlled demolition and coming from locations not far from the Melilli (SR) plant. The methodological procedure applied in the development of the project and the results of the first mix design and characterisation phases are reported here. The results obtained will be used as a reference for the appropriate corrections required to guarantee product performance.

Keywords
Plasters, Aggregates, Circular Economy, Building Production.

Embodied energy for sustainability in construction and other production sectors. The EmCoin experience

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Abstract
In order to achieve the sustainability objectives of the UN Agenda 2030 and the climate neutrality objectives of the European Union 2050, in recent years in the building sector, design and construction efforts have been mainly aimed at containing consumption for heating and cooling and reducing dependence on fossil gases. In particular, the construction sector has paid increasing attention to the performance of the building envelope, both opaque and transparent, in search of solutions that allow the building to achieve high energy performance while consuming as little energy as possible during its useful life. However, the energy actually used in building processes and in all industrial processes includes a non-negligible share of "hidden" energy, the so-called grey or embodied energy, which corresponds to the overall quantity of non-renewable primary energy necessary for all the processes involved: from the extraction of the raw material to the production and processing processes up to disposal, including that necessary for transport and secondary processes. This paper aims to highlight the importance of calculating embodied energy for the purposes of a correct eco-balance and the overall sustainability of the building and reports on a recent research experience aimed at creating an application useful for this purpose, which can also be exported to the building sector.

Keywords
Embodied energy, Building Sector, Sustainability, Digital App.

Traditional processing and digital transition MWK - MOBILE WALL KERFING

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Abstract
In study, the results of a recent investigation related to wood and kinetic architecture. More precisely, a study was conducted on the bending technique known as kerfing, which allows commonly rigid materials such as wooden boards or panels to be bent for aesthetic purposes. The research involves an integrated parametric approach to evaluate the formal and functional aspects of the construction system. With reference to the structural aspects, a preliminary calibration procedure of simplified models is proposed. It's based on homogenisation techniques of the mechanical properties, aimed at a first expeditious evaluation of the structural performance. Finally, the technology was applied to a case study with the aim of verifying its architectural functionality.

Keywords
Wood, Kerfing, Bending, Modelling, Parametric Design, Homogenisation Techniques.

Patchwork as an innovative practice among the fragments and waste of the Anthropocene. Composite materials and reuse strategies for regenerative coverings

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Abstract
We live in Anthropocene era, a period in which human activity has a significant impact on the planet, irreversibly altering the climate and natural resources. Artificial and organic materials intertwine in ways that seem irreversible. With the depletion of natural resources, architects, engineers, and designers are investigating the potential of increasingly abundant waste streams to transform them into raw materials for the future. In this context, the research project – developed in collaboration with the Department of Engineering and Architecture at the University of Catania, the company Stiltenda by TS s.r.l. and the Institute of Polymers, Composites and Biomaterials of the National Research Council, Catania – aims to explore new solutions for managing waste generated from the production of awnings. The company primarily uses acrylic material, a polymer known for its high resistance but also for its environmental impact of such materials but also to experiment, through the «patchwork» technique, with new innovative forms of habitability and expressing a critiqué of planned obsolescence in industrial production. Through the experimentation of composite materials for modular roofing, where acrylic scraps are used as reinforcement, the research proposes a new paradigm for sustainable design, integrating waste and fragments into a process of material and cultural regeneration.

Keywords
Patchwork, Upcycling, Circular Design, Composite Materials, Textile Architecture.

Design for disassembly as a circular design strategy: toward an environmental and economic assessment of single-family houses

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Abstract
The building and construction sector is one of the most impactful for the environment, contributing to high CO_2 emissions, waste generation, and raw material consumption. Design for Disassembly (DfD) emerges as a promising circular economy strategy to enable material reuse and extend the building lifecycle. However, to the best of the author's knowledge, its large scale implementation, especially in the residential sector, remains underex-plored. This study aims to assess the environmental and economic impacts of applying DfD principles to single-family houses, which constitute a pre-dominant segment of the European building stock. Using a research design integrating Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) methodologies, the study evaluates different technological scenarios ranging from traditional construction to varying levels of DfD integration. Currently, a representative building typology has been developed based on Europe-an data and modeled in a Building Information Modeling (BIM) environment, allowing detailed material quantification. The next steps will involve implementing the LCA and LCC analyses. Evidence from the literature suggests that while DfD enhances circularity and resource efficiency, its economic feasibility may remain a challenge due to high initial costs and market constraints. This research could contribute valuable data to inform sectoral policies and macroeconomic models supporting sustainable building strategies.

Keywords
Circular Economy, Life Cycle Assessment, Life Cycle Cost, Building Information Modelling, Average Residential Building.

Digital, architectural modules in sustainable, lightweight materials. Design of mountain huts for Etna volcano

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Abstract
Natural sites are a strategic resource for society and the environment, therefore they must be adequately preserved and enhanced. Easily assembled, sustainable and low-cost architectural artifacts can meet the traditional needs of society in different areas, such as responding to the needs of visitors in landscape sites. Recently, mountain refuges represent the result of innovative and sustainable technical construction solutions, with a careful eye on the relationship of the building with the surrounding environment. To achieve this goal, it could be useful to plan a series of intensive training activities aimed at university students in the field of Architecture, Engineering, Construction (AEC). Recently, a research group formed at the Department of Civil Engineering and Architecture of the University of Catania has started this type of action. All the events have taken as an open-air laboratory several sites of notable naturalistic interest. In this case, Etna volcano was chosen for its unique naturalistic and cultural value, as well as addressing the issue of the information and reception function with low environmental impact. In the document that will be presented, the authors develop a description of the mentioned activities and share some considerations on this topic, based on the experiences acquired.

Keywords
Lightweight Architecture, Rapid Prototyping, Cardboard Architecture, Higher Education Experiences.

Towards a database of structural typologies and construction systems in steel for the components reuse/repurpose

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Abstract

Steel has always expressed great potentiality for circular economy due to the high durability, remarkable flexibility and excellent recyclability, which allow the total reintegration into the production cycle. Steel structures at the end-of-life therefore represent a significant source of raw material for new buildings, reusing/repurposing the steel components and exploiting the embodied energy incorporated in them during the transformation and construction processes. In the construction sector, the first application of circular strategies primarily concerned the materials recycle in the phase of building decommissioning through the management of controlled demolitions and the next reuse in production cycles. For reuse/repurpose, however, it is necessary to define new methods and tools coherent with the Italian laws. A useful preamble to start writing new systems of rules is understanding how much and what has been built of steel, creating a database of the most diffused structural typologies and construction systems in Italy since 1950. The paper describes the methodology of the cataloguing activity and its operational tools, validated on the collected cases, implemented with the aim of characterizing the steel components, potentially reusable according to predefined parameters. The work is part of the Project of Relevant National Interest (PRIN) "Buildings and Circular Economy. Steel from production to post-production. Law and responsibility issues", conceived with the goal of expanding circular economy strategies in the construction sector through the development of practices/processes useful for supporting the design and management of possible post-production scenarios of structural systems and steel components.

Keywords

Circular economy, Reuse/Repurpose, Steel structures, Steel components, Database.

Digital integration for sustainable construction: automating material credit verification in green certification systems

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Abstract
The Architecture, Engineering, and Construction (AEC) sector is a major contributor to global energy consumption and carbon dioxide emissions, highlighting the urgent need for sustainable practices. This research investigates the integration of Building Information Modeling (BIM) with sustainability assessment frameworks, specifically focusing on the "Materials" category in green building certification systems such as LEED and BREEAM. By conducting a systematic literature review using the PRISMA methodology, this study identifies 11 key articles addressing frameworks, tools, and methodologies for automating the verification of material-related credits. The analysis categorizes these frameworks into three sustainability categories: Lower Environmental Impact Materials (Sc1), Responsible Sourcing and Renewable Materials (Sc2), and Sustainable Waste Management (Sc3). Findings reveal that while BIM enhances sustainability assessments through improved data management and automation, challenges such as interoperability issues, limited material databases, and reliance on specific software persist. This study underscores the critical role of automation and digital tools, including visual programming languages and APIs, in streamlining credit verification processes and promoting sustainability objectives. Future research should focus on expanding material databases, addressing interoperability barriers, and leveraging emerging technologies such as Artificial Intelligence and Digital Twins to foster a more sustainable and technologically advanced construction industry. These advancements align with the global goals of digital and green transitions, contributing to a more sustainable built environment.

Keywords
BIM, Environmental Performance Assessment, Digital Workflows for Sustainability, Sustainable Materials Evaluation, Rating Systems, LEED.

Inclusive and affordable modular housing: a sustainable approach for Latin America

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Abstract
This paper explores the role of affordable and inclusive design principles applied to a concept of modular housing systems for low-income communities in Latin America. Focusing on self-construction and energy self-sufficiency, the study investigates how flexible building solutions can respond to the diverse needs of vulnerable families, while reducing environmental impact. By analyzing the potential of wooden components production for prefabricated modular wooden houses that are easy to build and to disassemble, the paper aims to address challenges related to affordability, adaptability, and energy self-sufficiency through simulation of energy demands and the integration of renewable energy systems.

Keywords
Prefabricated Building, Wood Components, Energy Efficiency, Rainwater Usage.

Design for manufacture and assembly for urban regeneration: the case study of the Genoa Cornigliano market

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Abstract
The adoption of strategies for mitigating and adapting to the effects of climate change in the construction sector has triggered a series of innovations affecting all aspects of the building process (i.e., from design to construction and management). Ongoing research into efficient methods for designing and constructing buildings aims to enhance on-site efficiency while optimising time and costs.
Recent research has unveiled new processes, frequently drawing inspiration from the manufacturing sector. A notable example is Design for Manufacturing and Assembly (DfMA), a system based on a detailed design that classifies individual elements and shifts most construction processes to industrial facilities, leaving only assembly operations for on-site execution. The DfMA approach has redefined traditional concepts like prefabrication and modular architecture, pushing them to new frontiers for better control over the construction process. Despite its potential, DfMA remains underutilised in the Italian context, with only recent applications, predominantly for existing structures.
This paper investigates the potential of a specific DfMA technique, Prefabricated Prefinished Volumetric Construction (PPVC), applied to the regeneration of a historic structure in a deep retrofitting project without direct intervention on elements under heritage protection: the Cornigliano market in Genoa. The project employed a BIM-based design and factory-produced PPVC modules, achieving over 50%-time savings and a 59% cost reduction compared to traditional approaches.

Keywords
Architectural Engineering, DfMA, Deep Retrofitting, PPVC, Modular Construction.

Virtual learning environment applied to road construction sites

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Abstract
In today's world, workplace safety is crucial in many countries and across all productive sectors, particularly in the construction industry. Some of the major challenges include the workers' attitudes, the expenses associated with simulating actual working conditions, and the time needed to adequately train all activities. This research outlines the steps taken and the outcomes of collaboration with Virtual Safety Lab, which focuses on developing a virtual reality environment aimed at instructing safety protocols for the construction and maintenance of roadwork sites. The established virtual reality environment targets mobile construction sites, explicitly addressing the review, integration, and placement of road signage within work activities amidst vehicular traffic in compliance with Italian national regulations. The Virtual Reality environment consists of three modules: one theoretical and two practical. Through the first module, workers are acquainted with virtual settings and gain an understanding of signage and safety regulations. The remaining two modules cover best practices and procedures for mobile construction sites. Training through the developed modules enables users to safely acquire the operational methods essential for the secure management of mobile roadwork sites. Furthermore, this system may facilitate the optimisation of processes and decision-making by training users in best practices that help to reduce costs while fostering a safer and less stressful work environment.

Keywords
Safety Training, Mobile Construction Sites, Virtual Reality Devices, Virtual Learning Environments, Immersive Technologies.

Prioritising categories of controls for their automated check in a digitalised building permit process in Europe: insights from a survey study

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Abstract
The building permit process in Europe is still largely manual, causing assessment errors, issuance delays, and limited environmental oversight. In response, the European Union advocates for digitalisation through an interoperable, scalable, and open system aligned with national regulations. Central to this transformation is the automated verification and control of regulatory compliance using GeoBIM, integrating Geographic Information Systems (GIS) with Building Information Models (BIM). However, the complexity of regulatory frameworks, which vary across countries, poses a significant challenge to define the scope of relevant controls for their digitalisation. Therefore to digitise the process of verifying design compliance within the Digital Building Permit (DBP), it is primary to identify priorities, considering the integration of building data with that of the urban context. In the Horizon Europe CHEK project, which aims to digitalise the building permit process, a study was conducted to identify which types of regulatory controls should be prioritized for automated verification. Initially, four European municipalities collaborating in the project distinguished five typical checks internally performed and nine types of checks performed by third parties, and identified urban indices and distances between buildings as digitalisation priority. Subsequently, a survey was distributed to the CHEK community of practice – including municipalities, research institutions, designers, and software developers – to evaluate the importance and urgency of these categories. The analysis led to the development of prioritisation matrices, providing a systematic approach to ranking controls by relevance, based on 31 survey responses, including 14 from European municipalities and 11 from research institutions. The findings highlight the need to focus the digitization priorities of building relative controls in relation to the urban context rather than on the building itself. This consensus offers a baseline approach for streamlining regulatory controls, prioritising the digitalisation of the most impactful and scalable solutions.

Keywords
Digital Building Permit, Automated Compliance Checking, Priority Matrix, BIM, GIS.

Production process analysis of earth-based plasters

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Abstract
Amongst the strategies proposed by governments worldwide to achieve energy efficiency and low environmental impacts from anthropic activities, many address the construction sector, which has proven to be the most energy-demanding one in the modern era. Some approaches include adopting low-embodied energy construction materials and promoting the transition to Circular Economy as standard practice. The study presented is part of a broader research project, titled ITER, aimed at the development of entirely recyclable earth-based plasters, formulated with additives derived from waste materials of the agricultural and stone processing sectors (specifically, natural fibers and marble dust, respectively). This project aims to optimize both the material (enhancing its physical, mechanical, thermal, durability, and hygienic performance) and the production process (by minimizing environmental impacts and promoting industrial symbiosis, turning waste into resources). Specifically, this paper addresses one of the initial phases of the ITER project, in which the production and transformation processes of the individual components are examined in detail, along with the final manufacturing process of the premixed plaster formulation. The objective is to identify the most critical operations throughout the entire production cycle. In addition, a preliminary assessment of the carbon footprint is carried out to identify the most impactful phases, which will need to be improved in the subsequent stages of the project. The outcome of this assessment is the identification of existing limits and critical manufacturing activities of the current production process, which will be the baseline for the development of the implemented process in the future research steps.

Keywords
Raw earth, Marble industry by-products, Agriculture by-products, Production Process, Carbon Footprint, Circular Economy.

Experimenting bioprinting for wood waste upcycling in architecture and design. Preliminary assessments and application scenarios

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Abstract
Reclaiming timber waste poses a significant challenge for wood-intensive industries such as construction and design, where it is often downcycled or landfilled. Biofabrication with natural fibers has emerged as a promising method to transform wood debris into high-value products, extending its lifecycle. It is already demonstrated how biopolymer composites – blends of water, glycerol, organic binders, and fillers – can be 3D-printed to create full-scale architectural and design components. Despite this potential, however, further research is needed to address material limitations, assess environmental impacts, and explore design applications. In this sense, a deeper understanding of biopolymers' material properties and performance is critical for realizing their full potential.
This interdisciplinary study bridges Architectural Technology, Engineering and Material Science to investigate biofabrication with wood waste at material, environmental, and design scales. It proposes and tests a methodology for evaluating the performance of 3D-printed biopolymers, employing a Life Cycle Assessment (LCA) framework to measure environmental impacts. Additionally, it identifies application scenarios for architecture and design, offering a foundation for scaling this technology.
Starting from previous studies on "Bone Glue", a protein-based biopolymer, novel bioprinting was implemented incorporating wood waste deriving from a local sawmill. Results demonstrate promising potential applications in dry and controlled environments, but also exhibit significant limitations in water-rich or high-humid conditions. Design application can find places where its biodegradability, lightweight

structure, and renewable origin are prioritized, but improvements in water resistance and bio-deterioration prevention are necessary for broader adoption, while preserving its eco-friendly attributes.

Keywords
Bioprinting, Wood Waste Upcycling, Circular Economy, Life Cycle Assessment, Design Scenarios.

Transforming the built environment through computational techniques: an overview of parametric, generative, and algorithmic design

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Abstract
Computational techniques in the architectural and engineering fields have become widespread in recent years, revolutionizing the whole discipline. The use of these tools has great potential to enable more conscious, controlled, and sustainable design processes, which is why they have become one of the most current and innovative topics in the field. Specifically, algorithmic and parametric modeling allows designers to explore a large number of alternatives and assist in identifying the optimal solution based on specific selected inputs.
This article aims to provide an overview of the current state of the art on computational techniques in the Architecture, Engineering and Construction (AEC) field. As such, this study offers a clear distinction between the various existing terms, an overview of the available digital tools, and an analysis of significant case studies that have employed these techniques, with a particular focus on parametric design, generative design, and algorithmic design. To achieve this objective, a review of numerous studies published between 2018 and 2025 was conducted, synthesizing the progress made so far and suggesting key directions for future development, thereby contributing to the growing adoption of these tools in the architectural domain.

Keywords
Computational Design, Parametric Design, Generative Design, Algorithmic Design.

Assessing environmental impacts of buildings: an LCA comparison of technological construction solutions for a building refurbishment in Italy

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Abstract
Buildings play a central role in global decarbonization efforts, given their substantial contribution to greenhouse gas emissions throughout a building's life cycle. To address this challenge, it is essential to minimize the environmental footprint of the construction sector through holistic assessment tools and innovative solutions. This study conducts a comparative Life Cycle Assessment (LCA) of two technological construction solutions, steel and reinforced concrete, within the context of a 14-story building refurbishment project in Pisa, Italy, with the final goal of determining the potentiality of the LCA methodology in identifying the most suitable solution in terms of sustainability and environmental impacts. Adopting a cradle-to-grave approach, the analysis examines the environmental trade-offs of these systems across 13 impact categories outlined in the Level(s) framework, using localized datasets and ISO 14040-44 methodology. The research identifies critical differences in the carbon footprint of the two solutions, with the steel frame exhibiting 23% lower carbon emissions than the concrete frame. Furthermore, the study evaluates the potential of using Recycled and Renewably Produced (RRP) steel elements to enhance sustainability further. The findings highlight the importance of integrating LCA in the early design phases to make a sustainable choice in terms of construction materials and technological solutions. By highlighting context-specific environmental impacts, this research provides actionable insights for professionals, Small and medium-sized enterprises (SMEs) and policymakers aiming to advance decarbonization efforts in the built environment.

Keywords
Life Cycle Assessment, Comparative Analysis, Technological Construction Solutions, Environmental Impacts.

Artificial Intelligence (AI) in Architecture

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Abstract
Artificial Intelligence is composed of all the technologies by which computers are able to learn, analyse data, understand and even make decisions, unlike previous systems that simply collected, systematised and analysed data. Artificial Intelligence is able to manipulate forms, optimise and generate solutions, interact with the client, manage and control design, construction, management and monitoring processes.
Artificial Intelligence is therefore a part of Computer Science that can simulate cognitive processes. Artificial Intelligence AI is based on the use of advanced algorithms, neural networks and "machine learning" techniques. In architecture, it is concerned with optimising and enhancing all processes ranging from design to the construction of spaces and pieces at the building and urban fabric scale, always keeping functionality and sustainability in mind.
These technologies essentially include: BIM (Building Information Modelling), Internet of Things (IoT), Virtual Reality (VR), Augmented Reality (AR), Parametric Design, Generative Design, the latest generation of geometrically complex Renders.
Only the Catholic Church, as is always its custom and its strong worldwide role, sometimes unheeded, has spoken out on the matter.

Keywords
Intelligence, Artificial, Architecture, Technologies, Algorithms.

Amplifying bio-based materials integration in construction: a multi-criteria approach for regenerative development

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Abstract
Achieving sustainability in the construction sector requires a shift towards resource sobriety, minimizing environmental impact while maximizing material efficiency. Bio-based materials offer a regenerative alternative to conventional building materials, yet their adoption remains limited due to economic, technical, and market-related barriers. This study presents a multi-criteria assessment framework to evaluate bio-based materials, considering social, economic, environmental, technical, and human factors. The framework aims to support informed decision-making in early design stages, promoting local short supply chains and circular economy principles.
A structured evaluation model was developed by defining strategic objectives and introducing an innovative set of evaluation indicators, integrating both quantitative and qualitative aspects. The model was tested on a comparative case study of insulation panels made from rice and hemp biomass, alongside conventional insulation systems. The first results show that bio-based materials distribute their impacts more evenly across key sustainability criteria. This research contributes to overcoming stakeholder resistance by simplifying material assessment and enhancing transparency in bio-based material selection. Future work will refine the framework through stakeholder engagement and extend its application. Additionally, the study lays the groundwork for a tool integrating localized datasets on bio-based resources, supporting their widespread adoption in sustainable construction.

Keywords
Bio-based Materials, Sustainability Assessment, Multi-Criteria Analysis, Circular Economy, Early Design Stages.

Towards semantic integration of BIM and emerging technologies for facility management: a review

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Abstract
Effective facility management (FM) relies on timely access to operational and maintenance data. In this context, Building Information Modeling (BIM) has become a crucial tool, serving as a centralized digital repository on information log. To optimize FM workflows, BIM should support processes such as predictive maintenance and lifecycle management, which requires its additional integration with emerging technologies. This integration is achievable with Semantic Web Technologies (SWTs). Despite growing research on FM digitalization, the conceptualization of SWTs applications is widely scattered in the literature, particularly in the domain of FM. This study aims to fill this gap by reviewing the emerging technological synergies and their interrelationships to enhance FM workflows. The article achieves this by a thematic analysis of relevant studies, with a particular focus on SWTs and advanced technologies and their relationships. The findings illustrate categorization of technologies into four key clusters: *Automation Technologies*, *Data Infrastructure Technologies*, *Sensing Technologies*, and *Semantic Web Technologies*. The review reveals various implications of these technologies in the operation and maintenance phases of construction lifecycle. The article also offers insights into the evolving role of innovative technologies in FM, identifies gaps and suggests directions for future research.

Keywords
Building Information Modeling (BIM), Semantic Web Technology (SWTs), Ontology, Construction Facility Management, Linked Data.

Design collaboration mediated across different decentralised semantics

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Abstract
The objective of collaboration in the design process is to combine the dis-tinct knowledge held by the participants into an integrated, consistent and significant intellectual product. The aggregation of individual participants' data alone does not provide sufficient understanding, analysis, discussion, acceptance, or integration of the ideas brought in by other participants into their respective sections of the project. Several researchers believed that centralised data structures were the solution to the problem of common understanding. They thought that using unified data structures would make it easier to translate one form of representation into another and reduce the potential for errors caused by these translations. BIM process relies on the interchange of documents, frequently utilising proprietary formats filtered and transmitted via Industry Foundation Classes (IFC). Instead of promoting collaboration, this centralised form of representation confirmed that the AEC/O (Architecture, Engineering, Construction and Operations) ecosystem is highly fragmented, making the data-centric approach frequently im-practical due to technical and procedural limitations. The IFC shared database, not only in large scale projects, rapidly becomes excessively voluminous and difficult to manage, hindering the dynamic process of multi-disciplinary collaborative design. This research work introduces an innovative approach based on a distributed model that incorporates semantics into participants' ontology representations, to promote a more efficient flow of knowledge. The paper refers to current developments and future trends of standards for federated multi-models (e.g. using the potentials of the Semantic Web and Linked Data) to address design challenges. In addition, we propose an early framework for the process of authoring and publishing semantics through an intelligent filter mechanism, which facilitates a greater level of common understanding among the participants.

Keywords
Design Knowledge Modelling, Distributed Multidisciplinary Collaboration, IFC, Semantic Network, Ontology.

Recycling end-of-life tyres into finishing products

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Abstract
The growing need of a circular economy within the construction industry has led to the development of several research works focused on the reuse of waste materials. This study investigates the incorporation of end-of-life tyres (ELTs) as a recycled component in cementitious mixtures for nonstructural applications. The experimental work focused on evaluating the mechanical performance of innovative mixtures with varying rubber content, particularly in terms of flexural and compressive strength. The research is part of a larger international project between the Universidad Politecnica of Madrid and the Federico II University of Naples, which analyses the recycling potential of different materials and extends this knowledge by exploring different replacement rates and material behaviour over time. The results indicate that while the inclusion of ELT rubber reduces compressive and flexural strength compared to traditional cement mixtures, it provides enhanced elasticity, impact resistance, and adaptability to ground deformations. These properties make it particularly suitable for sustainable urban pavements, playgrounds, and other nonstructural applications requiring high durability and shock absorption. However, mixtures with rubber replacement rates exceeding 65% exhibit significant strength reductions, highlighting the need to optimise material formulations. Future research directions include evaluating the adhesion properties, fire reaction, thermal and acoustic performance, and the potential combination of ELT rubber with other recycled materials. This work contributes to the broader goal of sustainable construction by diverting ELTs from landfills and reducing the environmental impact of building materials.

Keywords
End-of-Life Tires, Sustainable Construction, Circular Economy, Cementitious Composites, Recycled Materials.

Low-carbon and cost-effective design solutions for rural housing in Uganda

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Abstract
The housing crisis in Africa, exacerbated by rapid population growth and inadequate infrastructure, demands sustainable and cost-effective construction solutions. This paper presents a research initiative focused on developing low-carbon and affordable housing for rural Uganda, emphasizing the use of locally available materials and innovative construction technologies. A service-learning approach, in collaboration with the non-profit organization *I Bambini di Antonio*, enables the practical application of research through the design and implementation of *Il Villaggio di Antonio*, a pilot rural housing project in Uganda. The general research methodology includes an extensive context analysis, the identification of alternative sustainable construction solutions, adaptive comfort-based design for a sustainable rural village model, experimental material testing and the realization of the pilot project.
The first three steps have already been developed and are presented in this article, while the additional two phases will serve as validation for the completion of the research. Findings confirm the feasibility of merging traditional and modern sustainable technologies to create replicable, community-driven housing models. Future research will focus on refining construction techniques, expanding real-world applications and assessing the socio-economic benefits of these solutions. Additionally, further investigation will explore the scalability of the proposed model and evaluate the technical and economic feasibility of 3D printing in this context. This study contributes to global discussions on sustainable development by proposing a scalable framework for low-carbon housing in Central and Tropical Africa.

Keywords
Sustainable Housing, Low-carbon Materials, Affordable Constructions, Rural Development, Uganda.

The future of construction cost management: AI-driven BIM integration for enhanced decision-making

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Abstract
Accurate cost estimation is a critical factor in the success of construction projects, influencing financial planning, resource allocation, and sustain-ability. Traditional cost prediction methods often rely on historical data and manual processes, limiting their accuracy and adaptability. To address these challenges, the construction industry is increasingly integrating Building Information Modeling (BIM) and Artificial Intelligence (AI) to enhance cost estimation. This study provides a comprehensive literature review on the state-of-the-art BIM-AI cost prediction models, identifying key methodologies, algorithms, and interoperability challenges. The research systematically analyses 18 highly relevant articles selected from Scopus, focusing on AI-driven cost estimation techniques across various construction lifecycle phases. The review highlights commonly used AI models, including Artificial Neural Networks (ANN), Genetic Algorithms (GA), Deep Learning (DNN, CNN), and Random Forest (RF), evaluating their accuracy and efficiency. The study also explores BIM tools (Revit, Navisworks) and data exchange formats (IFC, gbXML, Excel), identifying interoperability and standardization challenges in AI-BIM integration. Findings reveal that while BIM-AI models significantly improve cost prediction accuracy, their application is largely concentrated in pre-construction and construction phases, with limited research on operation, maintenance, and demolition costs. Future research should focus on developing standardized data exchange protocols, optimizing AI models for cost prediction in later project phases, and integrating real-world validation case studies. This study contributes to advancing digital transformation in construction, promoting AI-BIM methodologies for enhanced financial decision-making and cost management.

Keywords
BIM, Artificial Intelligence, Cost Estimation, Predictive Modeling, Digital Transformation, Machine Learning.

BIM-LCA Integration for comparative analysis of building materials and external walls

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Abstract
The building industry is responsible for producing more than one-third of greenhouse gases. Greenhouse gases are one of the leading causes of climate change, and one of the most important consequences of these changes is global warming. Life Cycle Assessment (LCA) evaluates the environmental impacts of materials and processes throughout their life cycle. Integrating LCA with Building Information Modelling (BIM) offers a powerful approach to enhancing sustainability in construction by leveraging BIM's detailed modeling capabilities and precise data management. The BIM-LCA integration is an innovative approach to sustainable design. This integration improves the ability to assess and reduce the environmental impacts of construction materials and processes throughout the project's life cycle, from design and construction to operation and demolition. The main purpose of this research is to investigate the functionalities and limitations of the BIM-LCA integration by performing LCA evaluation on single building materials to compare different design solutions for external walls. The LCA scopes, stages, and impact assessment categories are based on EN standards. The results highlight the potential of BIM-LCA in optimizing material selection, reducing environmental impact, and supporting informed decision-making during the design phase. However, challenges remain, including limitations in database availability and inconsistencies between software datasets, which can affect the accuracy of sustainability assessments. By embedding LCA within the BIM workflow, this research demonstrates how sustainability considerations can be integrated into early-stage design processes, promoting greener construction practices. Despite existing challenges, BIM-LCA is an innovative and effective way for advancing sustainable building solutions and facilitating the transition toward more environmentally responsible construction methods.

Keywords
Sustainability, Sustainable Design, Building Information Modelling, Life Cycle Assessment.

Sustainability in the italian construction sector: the role of voluntary certifications and environmental regulations

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Abstract
The construction industry, responsible for over one-third of global greenhouse gas emissions, is central in transitioning towards more sustainable models. Sustainability in this sector is a goal and a crucial component for achieving the Sustainable Development Goals. This study explores the Italian context, analysing the role of voluntary certification protocols—such as LEED, WELL, and ENVISION—and current regulations, including the Minimum Environmental Criteria (CAM) and the Do No Significant Harm (DNSH) principle. The research provides an overview of the national regulatory framework and the growing interest in voluntary certification tools, highlighting how they support adopting innovative practices and promoting functional and safe buildings that respect environmental and social sustainability values. Particular attention is given to the ENVISION protocol and CAM, which are considered strategic tools for guiding the sector's transition towards a more responsible and conscious approach, thanks to their ability to integrate principles of circularity, energy efficiency, and impact reduction throughout the entire building life cycle. The study explores how the combined use of these tools can enhance sustainability in road infrastructure design by analysing points of convergence and potential areas of integration. Furthermore, it proposes an assessment of the alignment of specific criteria from the European Taxonomy with the DNSH principle, offering practical insights for designers engaged in developing low-impact infrastructure. The research highlights how end-user demand, combined with an evolving regulatory framework and incentive policies, represents a powerful driver of change for the construction sector. The interaction of these factors is reshaping the industry's future, steering it towards more sustainable solutions.

Keywords
Sustainability, Sustainable Design, Sustainability Certification Protocols, DNSH, Envision Protocol.