ARCHITECTURAL ENGINEERING IN ITALY AND WORLDWIDE
COMPARING EXPERIENCES
Book of Abstract

Editors
Rossella Corrao,
Tiziana Campisi, Simona Colajanni, Manfredi Saeli, Calogero Vinci

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Introduction

Ar.Tec, the Italian Scientific Society of Architectural Engineering (AE), is responsible for organizing the annual Colloqui.AT.e conferences on themes of great relevance in the Built Environment sector, with the aim of promoting the cultural and professional development of scholars, researchers, and practitioners in the field of building construction and architecture. More particularly, the events seek to promote the dissemination of the research findings from the academic community, stimulating the evolution of the scientific activity among the associates in response to the rapid changes in the field of AE, as well as to support the qualified training of the 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 examines the boundaries where the goals of architectural projects meet with performance requirements and technological standards. In fact, the scientific-disciplinary contents focus on the Built Environment, addressing its multifaceted architectural, typological, constructive, functional, and performance characteristics.

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

In particular, the contents of AE focus on: the technologies of architecture and construction systems, including their historical development; technologies for the construction and rehabilitation of buildings; the design, testing, and innovation of materials, components, and systems; the integrated design of buildings; the analysis of performance and economic-environmental impacts of buildings, extended also to the urban scale; the analysis and quality control of projects and construction works; and the management of building design and maintenance processes.

In 2024, the annual Colloqui.AT.e conference is hosted at the University of Palermo. As in all previous editions, Colloqui.AT.e 2024 offers all participants the opportunity to share their technical and scientific experiences. Starting from this year, it also includes the experiences of architectural engineers from international universities, in line with theme of the event: Architectural Engineering in Italy and Worldwide. Comparing Experiences.

As before underlined, AE has been identified as the academic discipline with the highest potential in the fight against climate change. It promotes the construction of sustainable, resilient, adaptive, and high-performance buildings to meet the needs of increasingly evolving, sophisticated, and cutting-edge users. In countries with a high Human Development Index (HDI), these users push designers to rapidly think about new ways of inhabiting buildings and cities to ensure the well-being, safety, and health of occupants, alongside the rational use of resources and the protection of the environment.

The gradual technological innovation and field experimentation, implemented over the years, aimed at constructing buildings and cities in different climatic contexts, exploiting materials that vary from country to country and using different cultural approaches, but always underlying the same need: building places for living, capable of measuring and composing the space "between earth and heaven" (as Heidegger stated during the 1951 conference "Building Dwelling Thinking"). This innovation led to the disciplinary definition of Architectural Engineering, which is capable, today, of providing "tools, methods, and models, including digital ones, for the knowledge and design of buildings, from the critical, systemic, functional, typological, technical, and constructive point of view".

By comparing training, research, and project experiences, the role of the Architectural Engineer in Italy and worldwide is discussed, from the perspectives of design, construction, and building management, in the past and/or future.

The Architectural Engineering multi/interdisciplinary approach can effectively contribute to the analysis and resolution of problems affecting buildings, cities, and the built environment, in Italy and in the world, proposing innovative technical solutions, materials, and components to ensure the preservation of the identity of places.

This volume collects three valuable contributions of international keynote speakers that open the three conference sessions: James W.P. Campbell, Professor of Architecture and Construction History at the University of Cambridge and Director of Studies in Architecture and History of Art in Queens' College, Cambridge, UK; Mattheos Santamouris, Scientia, Distinguished, Professor of High Performance Architecture at University of New South Wales (UNSW), in Sydney, Australia, and past Professor in the University of Athens, Greece; Joachim Eble, Architect, founder and owner of Eble Messerschmidt Partner, Tubinga, Germany, as the brief abstracts of their plenary sessions point out.

Built Environment and its relations with people, society, heritage, and technologies are the common points of discussion and dissemination for scientists who participate in the annual event of Colloqui.AT.e. All the presented contributions are collected in this volume and properly divided into three main topics:

A_Construction and Conservation History

B_ Building Construction and Performance

C_ Building Design and Technologies

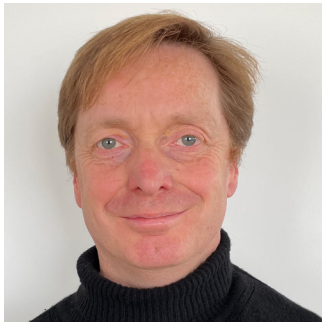
Rossella Corrao, Tiziana Campisi, Simona Colajanni, Manfredi Saeli, Calogero Vinci

KEY LECTURES

Lessons from Construction History: why architectural engineers need to understand the past to design for the future

James W. P. Campbell
Professor of Architecture and Construction History
University of Cambridge

Construction History is an area that has grown in the last twenty years across the world.
This lecture looks at the questions it can ask and the role it can play, not only in understanding the past, but also informing future design for architectural engineers.
It looks specifically at Christopher Wren and how he developed the designs for St Paul's Cathedral in London. It starts with how the project demonstrates that designers in this past were often closer to architectural engineers than to architects. This leads to a discussion of the various approaches to construction history and its uses and how the survival of the original documents (in the form of contracts, letters, drawings and building accounts) allows us to trace processes in the past. It looks at the way at St Paul's, the site was organised and how the demolition of the previous building was carried out. It looks at the problems of finance and construction supervision. It then discusses the lessons from St Paul's about geotechnics, particularly the necessity of monitoring, with a brief excursion into the issues of historic buildings and earthquake design. It then explores the construction of the masonry walls, the materials used, the problems of the weathering of walls and the necessity of sacrificial materials. The roofs are then discussed, both as examples of the architectural engineer at work and of the transfer of technology across cultures.
The lecture discusses the extraordinary staircases and their place in the history of staircase design, how the windows relate to modern structural glazing and how it uses an ingenious drainage system to ensure the structure is not damaged.
Finally, it looks at the problems of designing, the doors, finishing the dome and deciding when a building is complete. In this way the lecture seeks to use St Paul's to give a very brief overview of what construction history can bring not only to the understanding of one particular building to modern world.



James W. P. Campbell
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James W. P. Campbell is the Professor of Architecture and Construction History at the University of Cambridge and the Director of Studies in Architecture and History of Art in Queens' College, Cambridge. He was Head of the Department of Architecture from 2019-23, leading his department through COVID, doubling its size, and adding four new degrees. He is currently on a year of sabbatical leave writing a book on the history of fountains and water supply and editing a book on windows. Professor Campbell has been the Chairman of the Construction History Society since 2006. He trained as an architect at Cambridge, working in the UK, Hong Kong and the United States before returning to Cambridge to do a PhD on Christopher Wren and the development of structural carpentry. This research led on to his book Buildings St Paul's (2007). His other books include: Brick: a World History (2003, published in ten languages), Library: a World History (2013, published in twelve languages), Staircases: History, Repair and Conservation (2014, with Michael Tutton) and Doors: History, Repair and Conservation (2020, with Michael Tutton) as well as over fifty peer-reviewed articles. He is a Fellow of the Society of Antiquaries.

Counterbalancing the impacts of Urban Climate using Super Cool Materials

Mattheos Santamouris
Distinguished Professor
Anita Lawrence Chair of High Performance Architecture
University New South Wales, Sydney, Australia

This lecture analyses the latest knowledge on the impact of urban overheating on the energy supply and demand of urban buildings, health including mental problems and wellbeing, human productivity, survivability of low-income population and environmental quality of cities. The consequences of the actual urban overheating as well as of the expected future increase of the urban temperature, on the energy demand of buildings and their environmental quality is presented. The challenges around the very serious rise of the energy demand in the developing countries and the corresponding impact on environment and economy is discussed. Proper adaptation techniques aiming to respond to the overheating challenge, decrease the energy consumption of buildings, improve the environmental quality in cities and produce added value to the local economies is analysed. The combined impact of advanced adaptation and mitigation technologies is depicted.

Additionally, the lecture presents and describe the state of the art on the development of innovative mitigation materials, and especially of the daytime radiative super cool materials to offset the impact of urban overheating.

Recently developed, efficient heat mitigation technologies based on the use of super cool materials, implemented in large scale urban projects, able to decrease the peak ambient temperature of cities up to 5°C, is presented. The monitored energy and environmental performance of innovative super cool materials for buildings and urban structures is analysed. Results from large scale urban heat mitigation projects show that implementation of the innovative mitigation technologies can reduce the cooling energy consumption of buildings up to 40%, decrease the concentration of harmful pollutants up to 50%, reduce heat related mortality up to 35% and improve the survivability levels of vulnerable urban population considerably. Finally, the main future challenges related to urban overheating and proposes a specific research agenda to alleviate and counterbalance its impact on human life are presented.

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M. Santamouris is a Scientia, Distinguished, Professor of High Performance Architecture at UNSW, and past Professor in the University of Athens, Greece. Visiting Professor: Cyprus Institute, Metropolitan University London, Tokyo Polytechnic University, Bolzano University, Brunnel University, Seoul University National University of Singapore, and UITM Univ Malaysia. Past President of the National Center of Renewable and Energy Savings of Greece. Editor in Chief of the Energy and Buildings Journal, Past Editor in Chief of the Advances Building Energy Research, Associate Editor of the Solar Energy Journal, E- Prime, Journal of Low Carbon and Sustainable Energy, and Member of the Editorial Board of 24 Journals. Editor of the Series of Book on Buildings, published by Earthscan Science Publishers. Editor and author of 20 international books published by Elsevier, Earthscan, Springer, etc. Author of 412 scientific articles published in journals. Reviewer of research projects in 29 countries including USA, UK, France, Germany, Canada, Sweden, etc. Ranked as the top world cited researcher in the field of Building and Construction by the Stanford University ranking system, for 2019-2022. Highly Cited Researcher in the Clarivate ranking for 4 continuous years. Ranked as no 538 researcher in the world in all scientific disciplines in the list prepared by Stanford University in 2021 for the 200000 more influential researchers. He has received many international awards.

From destruction to regeneration. An integrative approach creating ecosystemic living spaces in architecture and urbanism

Joachim Eble
Eble Messerschmidt Partner,
Tubinga, Germany

Healthy living spaces in our built environment depend on the harmonious interdependence of nature within us (Building Biology) and nature surrounding us (Building Ecology). Achieving this goal requires a holistic, integrative and interdisciplinary planning approach. Not only traditional disciplines such as urban planning, architectural engineering, and landscaping must be involved, but the wisdom and knowledge of users, including future residents, also must be incorporated through participatory planning processes. In light of the present discussion and demand for sustainable, climate-neutral solutions, we recognize the necessity of moving towards climate-positive outcomes. This necessitates a shift towards regenerative development and systems. Beyond goals of limiting CO_2 emissions, reducing waste, and improving material flow circularity, we must increasingly view our built environment as an ecosystem in partnership with nature – both within us and around us. This entails inviting nature with all its cycles, to be a guiding principle in all our planning activities and decisions. With this philosophy, our practice has long embraced these principles:

Genious Loci: Reading the site, integrating the topography, geology and morphology, experiencing history and energy of the space geomantically, healing disharmonies.

Urban-rural ecosystem: Reconnecting the city in its region, integrating agro-urban biomass material flows in a circular manner, integrating water cycles as blue-green infrastructure, producing local food by permaculture.

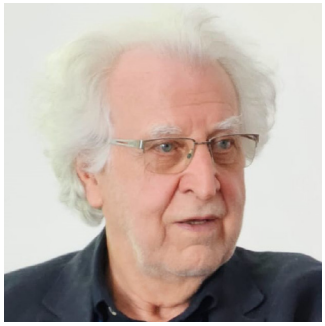
Bioclimatic city: Promoting outdoor comfort by blue-green infrastructures, stimulating natural ventilation and adiabatic cooling by reselection of nature in the city, designing resilient water shapes.

Healthy city: Integrating the healing power of nature by the means of biophilia, inviting the vital elements of air, water, light and plants.

City of short distances: Structuring the city as a decentralised network of sustainable neighbourhoods, promoting mixed uses in the neighbourhood like residential, commercial, working, services, etc. for a 'Walkable City'.

Regenerative-postfossil city: Understanding the city as a smart grid of renewable energies and changing the individual mobility to a post-fossil structured mobility.

Participative city: Inviting the wisdom and knowledge of users and residents by partecipation planning processes, creating a communing feeling for We-Houses, We-Neighbourhoods, We-Cities.



Joachim Eble
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Joachim Eble is the founder of Eble Messerschmidt Partner, renowned across Europe for pioneering, eco architecture and sustainable urbanism. With 40 years of experience, he excels in leading urban planning projects globally, integrating exceptional sustainable design approaches and supervising high-quality urban planning. As sustainability consultant, he specializes in climate-responsive urban design, renewable energies, and water cycle strategies, demonstrated through numerous model projects. He emphasizes linking urban structures with reconstructed landscapes to create outdoor comfort, healthy living environments, and garden city characteristics. He teaches the master-course CasaClima-Bioarchitettura at LUMSA University of Rome and postgraduate master-courses in urban ecology at the University of Wismar (WINGS). He is a co-founder of B.A.U. "Bund Architektur und Baubiologie" focusing on healthy building, and the Foundation "Lebensraum" with the Future Village Initiative. He holds leading roles in European research projects like "Ecocity." His accolades include the FIABICI prix d'excellence 2015 for Townhouses Ludwigsburg, Green Dot Award 2011 for Arkadien Winnenden, LivCom Award 2011 for eco-quartier Pfaffenhofen, and nominations for international honors like the MIPIM Award 2004.

A_CONSTRUCTION AND CONSERVATION HISTORY

Metal construction from laws. The evolution of technical standards in the twentieth century

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Abstract
Architectural design and construction always reflect the conformity with technical standards regarding specific technologies, which makes their knowledge highly relevant for comprehending the evolution of the building's arrangement and appearance over time. In this perspective, the use of metal construction in Italy is a unique instance as it was characterized for a considerable period during the twentieth century by the lack of mandatory technical regulations. Indeed, the first law that established compulsory procedures for the structural calculation of steel frames was only introduced in the Seventies.
This framework, largely due to the backwardness of the national steel industry and the lack of affirmation of metal structures in the building sector, gave to designers the possibility to choose different operational addresses for structural verifications and also to follow provisions developed by foreign experts and regulations. The understanding of the evolution of technical standards is not only crucial for elucidating all the elements of an old architectural design, but it's also relevant today, especially for building circularity, for which it's crucial to know the features and procedures applied to structural components of the past, to know how they could be reused and to unleash all their current potential.
The article examines the development of national technical guidelines for the use of iron and steel in construction and identifies critical issues regarding steel classification and structural calculation procedures in the twentieth century.

Keywords
Steel, technical standards, structural calculation, twentieth century

Design experimentation and scientific research in the 70s and 80s industrialized construction in Palermo

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Abstract
In the period from the II World War to the mid-1980s, Italy witnessed growing attention towards the industrialization of the construction sector with different territorial specificities.
The paper analyses some 70s and 80s public housing districts in Palermo, retracing the history of industrialization in Sicily. The contribution of prof. Benedetto Colajanni and his disciples studying the typological, structural and figurative aspects of buildings created according to this new system, is highlighted.
These are mainly systems for the industrialization of concrete casting with couffrage-tunnels or banches et tables developed in Sicily, thanks to the design contest and the activities carried out by the building cooperatives adhering to the Ravennate Consortium which, at the end of the 1960s, had acquired the patents and machinery for the industrialization of concrete casting of load-bearing structures with couffrage-tunnel and banches et tables systems. These systems allowed the creation of a significant number of rooms in a short time and at low costs.
The first example of the application of industrialization in Palermo was the Sperone district, a testing ground for both the companies and the design group, headed by Benedetto Colajanni. In these buildings, the completion of the industrialized structures was carried out with traditional materials and systems. It was necessary to wait about a decade, with the PEEP districts and the law 25/80, to test the completion on site with modular and standardized elements, both for the closures of the facades and the internal partitions.
The paper provides a contribution to the knowledge of a specific construction typology that has characterized a wide range of residential buildings both in Palermo and in the rest of Italy and which requires maintenance and recovery interventions that can guarantee the performance standards required by current regulations, maintaining the original identity.

Keywords
Building industrialization, public housing, couffrage-tunnel, banche et table systems, typological and structural research

The active conservation of an Andalusian Patio House: a project experience between Italy and Spain

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Abstract
The research falls within the context of the recovery and regeneration of the predominantly residential building tissue in consolidated urban contexts which, subject to a continuous process of modification, are characterized in terms of a palimpsest. The goal is to re-read this transformative process and identify the codes that have regulated it in order to ensure its continuity through active conservation interventions on the building tissue that ensure its protection on the one hand and regenerative recovery on the other. The relationship between type, technique and project is assumed as the operational key of a methodology that seeks the definition not only of the qualitative parameters attributable to the recognition of the peculiarities and the complex of values of the historical building heritage and to their translation in a critical-interpretative key in the levels of transformability, but also of those of a quantitative type, referable to the performance levels connected to a necessary adaptation to new needs.
The paper intends to report the results of the experimentation of the research work, conducted in the framework of collaborative relationships between the University of L'Aquila and the University of Seville, on an old traditional Andalusian patio house located in the historic center of Seville, in Calle San Vicente 24. The building has its first testimony in the Sevillian Municipal Archives in 1929; it is then the subject of various interventions up to that of 1952 by the Regionalist architect Antonio Delgado y Roig, through which the patio house finds its own precise conformation. In the nineties this was transformed into a sort of convent and later definitively abandoned. The project experimentation, starting from the framework of the needs posed by the new owner, the Cultural Foundation "Centros de Estudios Andaluces", seeks a model of use compatible with the characteristics of the type, investigated in the complex of its functional, formal and constructive aspects and defines congruent intervention strategies. The design intentions are finally translated into technical-construction choices that find precise and punctual detailed solutions within the building schedule according to technical codes referable to a form of advanced craftsmanship, both in the use of traditional and innovative materials.

Keywords
Traditional architecture, Seville, Typology, Patio house, Active conservation

Critical analysis of restoration practices: the case of San Pietro Barisano's church in Matera

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Abstract
The city of Matera has an ancient connection with the calcarenitic rock, a fundamental material for understanding its architectural history. This limestone rock is easily workable but vulnerable to various types of degradation so it has often been subjected to conservative interventions that have not always achieved the desired results. Instead, they have sometimes worsened the initial conditions by altering the building's surfaces.
Starting from the 1990s, the ancient district named "Sassi" has been undergoing restoration works and on-site experimentations of new products and techniques. Configuring itself as a laboratory of experimental restoration practices, it is well suited for an analysis aimed at identifying the best practices currently available in the field of architectural heritage conservation.
Despite all the interventions were carried out in a uncoordinated manner by intervening "for emergencies" or on individual issues, the analysis of the interventions, products and techniques used to counteract different types of degradation and preserve the conservation status of the building has made it possible to gather valuable information to identify a broader standard for planned and preventive maintenance of the architectural heritage.
The paper is focused on the critical analysis of interventions carried out on the Church of San Pietro Barisano, an important historical and architectural landmark of the city, founded in the 12th century and characterized by several construction phases. After a long period of abandonment, it has suffered significant surface deterioration due to environmental and construction factors, as well as the presence of rising damp in the walls. This analysis is part of a research project that aims at developing a digital protocol of good practices for architectural heritage conservation by promoting preventive and predictive maintenance. The results of the investigation underlines the key-role of pre and post intervention diagnostics..

Keywords
Restoration process, best practices, conservation sustainability, monitoring of interventions, planned preventive maintenance

Philological HBIM for knowledge, management, and valorisation of the industrialized building: the case of prefabricated large panels systems (1950-80)

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Abstract
The paper presents the results of an ongoing research relating to the application of HBIM for the knowledge and management of industrialized buildings of the second half of the Twentieth century. The goal is to advance on the HBIM approaches dedicated to the heritage of contemporary buildings, applying a methodology that allows the collection, systematization, and classification of the archival documents-derived building data, supporting the technical knowledge and the planning of the retrofit interventions (architectural, energy and structural). The methodology concerns three phases, corresponding to the different roles that the HBIM assumes-as a knowledge, systematization, and representation tool, within the historical-technical analyses: 1) design of the CDE and classification of the documentary sources; 2) 3D cross-reference and verifications of the documents-derived data; 3) production of open-data and interactive visualizations. The process is applied to the digitalization of the noteworthy Camus system, of French origin and used in the Gratosoglio district (Milan) in the 1960s, considered as benchmark of reinforced concrete large panels industrialized systems and applied to wide and international building stock. The methodology relied on modelling strategies for an effective exploitation of the native functionalities of the BIM Authoring commercial platforms and the IFC open standards, with the aim to extend the process to the professional communities for the management, maintenance and enhancement of the building heritage of the Twentieth century.

Keywords
Prefabrication, Construction History, Camus Patent, BIM, Building management

The Climate Issue in Modern Architecture: Eileen Gray's Tempe à Pailla Villa (1931-1935)

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Abstract

The paper delves into the relationship between modern architecture and climate issue, with a specific focus on a bioclimatic reinterpretation of the architectural endeavors of Eileen Gray (1879-1976), an Irish designer active in early 20th-century France.

In contrast to the prevalent architectural research of the early 1900s, marked by the pursuit of universally applicable codes driven by the futuristic enthusiasm for the Machine Age, Gray establishes an original design trajectory notable for both its theoretical thinking and practical application. Considering the contextual conditions in which she operates, Gray develops a design philosophy grounded in environmental principles that incorporates external natural elements as integral components of her architectural identity. Light and air, conceptualized by Gray as construction "materials", harmonize with her architectures through meticulously designed systems of solar shading and natural ventilation. Despite the significance of the designer's interest in environmental factors and climatic mediation devices, this aspect remains relatively underexplored in the literature, which is surprising given its clear role as a generative element for various technological and morphological design choices.

Building upon the premise that attention to climatic issues is a constant in Gray's research, the study extends its exploration to her lesser-known second villa, Tempe à Pailla in Castellar (1931-1935). After providing essential context about the intervention site and architectural conception, the paper delves into the environmental and typological principles governing the villa's design, enriched by a critical examination of archival documentation. The considerations presented, partially derived from the outcomes of a doctoral research, aim to contribute an additional dimension to the diverse array of studies on Gray's work, proposing a new interpretive framework with a focus on climatic aspects.

Keywords

Modern architecture, climate design, passive techniques, Eileen Gray, Tempe à Pailla

Architectural engineering for rehabilitation of historical architecture. A tool for safeguard and revitalization of Palermo's historical center

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Abstract
The contemporary rehabilitation of historical buildings, characterized by a high monumental value, which are integral to the historical center of an urban area, represents a significant instrument for urban renewal, revitalization, and economic development of an entire city. Within the framework of such interventions, this paper examines an ongoing building restoration project in the historical center of Palermo, aimed at highlighting the pivotal role of knowledge in the design of these interventions.
The objective is to preserve and enhance the building while adhering to the materials and construction techniques characteristic of the local architecture. The comprehensive examination of this structure, grounded in the principles of applied research on rehabilitation interventions, in compliance with historical architectural norms and technical regulations, is not merely focused on the original intervention but is contextualized within a broader vision of rehabilitation. This vision, albeit perhaps progressing at a slow pace, is crucial for the growth of the entire city, fostering continuous engagement and repopulation by the residents of Palermo and beyond.
The historical center, once neglected for many years, now represents an urban space housing an artistic and cultural heritage of significant international importance, with substantial growth potential for the entire metropolitan area.

Keywords
Compatible architectural & engineering rehabilitation, historical architecture, Palermo, historical palace typology

Velasca Tower: an Italian-style structure unveiled in a new light through the BBPR archive

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Abstract
This paper expands on the study of the relationship between the construction and architecture of Torre Velasca in Milan, concerning the solutions adopted for the supporting structure. It evaluates records from the BBPR architects, presently kept at Rome's MAXXI Museo Nazionale delle Arti del XXI secolo, loaned by the Belgiojoso family in 2022 and now accessible to researchers for the first time. The research delves into unpublished documents related to the project's execution, particularly emphasizing the interactions between various participants involved in the building's construction. This study scrutinizes BBPR's drawings, project papers, meeting reports, and communication with the SGI - Società Generale Immobiliare technical office. The paper elucidates the key factors influencing structural decisions by comparing the new data with information from previous research. Furthermore, it sheds light on the underlying rationale behind the design choices implemented throughout the tower's construction. It illustrates how the structural framework was strategically utilized to redefine its architectural identity, distinct from the conventional North American skyscraper model. Additionally, the study uncovered the unique contributions of individuals who played pivotal roles in shaping this globally acclaimed architectural masterpiece.

Keywords
Italian engineering, BBPR architects, reinforced concrete, skyscrapers, structure and architecture

The narrative capacity of spaces for living. Le Corbusier's *appartement-atelier* in Paris

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Abstract
The restoration of the interior spaces of a house and their transformation into a museum allows us to observe themes related to the culture of living and to study the relationships between society, people, objects and spaces.
Although rooted in Western culture, opening interiors to the public has only gained attention from international bodies and institutions, such as ICOM, and national bodies, such as the French *Ministère de la Culture*, in the last two decades. This has contributed to establishing the scientific foundations for this topic, gaining increasing interest. Thus, the institutionalisation of the domestic space allows the monument to be reused and experienced through dialogue with the public.
Conserving the fragility of modern interiors seems like an impossible challenge. However, the selected case study takes exciting reflections regarding protecting, restoring, and conserving the material and immaterial values that its opening to the public has allowed the contemporary world to learn.
As a space intended for daily life, the cultural value of Le Corbusier's *appartement-atelier* does not only concern issues linked to the legislative national context but is profoundly determined by its ability to place itself in continuity with the contemporaneity through its narrative capacity tells us about its author, an illustrious man as an architect of evident fame; of his substance, an architecture child of the Modern Movement; and the social context in which it was generated.
An iconic architectural work par excellence, this example describes how modern architecture has radically transformed spaces in response to the new lifestyles of the 20th century. These changes, which concern aesthetic and functional aspects, are the direct consequence of the political and social transformations of the time and a new conception of internal space governed mainly by attention to the user's needs.

Keywords
Heritage, House Museum, Le Corbusier's appartement-atelier, DEMHIST, label "Maison des illustres"

Unveiling the water built heritage: preliminary results towards a systematic cataloguing of Italian port

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Abstract
Since ancient times, Italian ports served as fundamental landing places for travellers and played a crucial role in trade and tourist routes. Between the end of the 19th and the beginning of the 20th century, industrial development caused progressive physical and functional obsolescence of port areas, due to the overcoming of the production models, which they were conceived for. While some structures and infrastructures were upgraded to support the new maritime traffic, others were inadequate for the modern requirements and, thus, dismissed and abandoned, resulting nowadays in assets with a poor state of conservation. From recognizing the value of such built environments related to the maritime culture and processes of cultural stratification, the definition of methods and tools to support recovery and reuse plans is paramount. The present work proposes a cognitive framework to define heritage features of port environments and set up a systematic categorisation process.
To this aim, a cataloguing card was proposed and validated on 63 Italian port areas, including their relationship with the territorial surroundings, particularly the urban context, and the functions hosted within. The most recurrent types of heritage assets (over 300 items) were then evaluated, with the support of two national platforms, following a classification among modern, historical, industrial, archaeological, infrastructural and artistic heritage. At the end of the survey, it was found that the available platforms are lacking in data and non-properly meeting the specific research goals. In fact, even when heritage structures and infrastructures are catalogued, relevant information, such as the chronology of historical evolution and graphic-descriptive contents, are missed. The results of this work provide some preliminary insights and a starting point for detailed analysis aimed at developing systematic cataloguing systems for the benefit of technicians, administrators and safeguard entities.

Keywords
Port area, cultural heritage, cataloguing, preservation and enhancement

Resilient and sustainable development of inland areas: the RI.P.R.O.VA.RE Project between co-planning and multidisciplinary approach

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Abstract
The RI.P.R.O.VA.RE Project, winner of the national competitive call promoted by the former Ministry of Environment, Land and Sea Protection, involved professors and researchers from three Departments, belonging to three different Southern Italian Universities. The shared goal was to deepen the issue of inland areas and their sustainable and resilient development. Starting from the analysis of the state of the art - based on several studies and researches at national and international level - the Project provided support tools for the construction of integrated policies in order to improve and increase the territories' resilience. This is very important since inland areas - which are distinguished from cities by a greater capacity to react to shocks and sudden events - while experiencing a strong demographic and settlement disadvantage, are also highly significant for their environmental and cultural heritage.
With these premises, the paper presents the work carried out during the RI.P.R.O.VA.RE Project, in its main and general aspects, first describing its goals and methodological steps and then, with the application to a focus area, presenting its results. These results, translated into research products, summarise what was achieved at the end of the project, i.e.: the setting up of criteria and methods for the delimitation of inland areas, the assessment of their resilience degree and the definition of integrated area strategies through participative and co-planning approaches. Finally, the strategy drawn up for one of the investigated focus areas, the Ufita Valley in Campania, is concisely outlined.

Keywords
RI.P.R.O.VA.RE Project, co-planning, land resilience, Integrated Area Strategies, sustainable development of inland areas

Recovery and sustainable regeneration: architectural and environmental perspectives for urban and building reuse

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Abstract
The increasing interest in sustainability in the field of cultural heritage has focused on the objectives of sustainable use, but the application of its principles to restoration is still evolving and requires methodological consistency and operational expertise, involving civil society, institutions and academia in an ongoing process of reflection.
Agenda 2030 highlights the importance of conscious action towards existing built environment, with targets related to clean water, sustainable energy. cities and communities.
The practice of urban recycling, adding new architectural elements to existing spaces to limit urban expansion and enhance brownfield sites, is growing as a response to the overconsumption of land. Similar to 'grafting', the practice aims to densify cities rethinking the use of existing space and experimenting innovative solutions. Successful examples can be found in Germany, Netherlands, Belgium and Spain. In Italy, however, the parasitic approach has only been adopted to a limited extent, and there is still a tendency to choose between conservative restoration and demolition and new construction.
Since the 1980s, the term 'parasitic' has been used in architecture to describe projects and installations that reuse existing structures to create new urban and architectural spaces. This practice, which relies on a symbiotic relationship between host and guest, offers new opportunities for urban densification and encourages reflection on the value of the territory and the city. The parasite's taxonomy categorises projects based on their relationship with the existing system, distinguishing between system reconfiguration, host body subversion, and alterations.
The article presents an application to an international case study in which the evolution of the restoration concept towards sustainability and urban recycling offers new perspectives for the conservation of cultural heritage and the creation of more resilient and sustainable cities and communities.

Keywords
Restoration, sustainability, urban sprawl, parasite architecture

Industrial archaeologies of complex palimpsests. Application of semantic web technologies to digitalise the knowledge path from data to interpretation

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Abstract
Semantic web technologies are today widely used across the Architecture, Engineering and Construction (AEC) sector for different scopes and activities during the building life cycle and the operation and maintenance phase. In the heritage field, the development of several methods to facilitate information exchange and interoperability between stakeholders represents a crucial issue in the current research scenario. Building information modelling and related technologies can address some of these challenges and limitations through relational database structure. However, there are still some open questions related to knowledge representation and management of complex heritage sites. This paper outlines the use of semantic web technologies and standards, such as Web Ontology Language and existing domain ontologies, to digitalize the knowledge path from data collection to interpretation for the documentation of heritage assets. Firstly, it briefly defines the methodologies, data structure, exchange formats, and relations of the different technology databases with their application in the digital interpretative processes. Then, the proposed framework is evaluated through an example of industrial archaeology application in a multi-layered historical site. The aim is to propose a framework to manage different information classes, inconsistencies and uncertainties, from preliminary data gathering and structuring to ontologies instantiation activity by representing the logical levels of connection. The final intent is to highlight the possibility of overcoming the limitations in the different heritage study and management approaches to give proper support during the decision-making process performed by multiple stakeholders.

Keywords
Heritage assets, Industrial archaeology, Semantic Web Technologies, Ontologies, Information exchange and interoperability

How many fragilities for how many architectures: the Taormina stadium of P.L. Nervi

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Abstract
This study addresses a relevant topic for Italy: protecting 20th-century football stadiums. Italian art. 55bis of D.L. 76/2020, the "sblocca-stadi" amendment, allows sports facilities to be exempt from cultural asset protection protocols. Dealing with this type of heritage is complicated. Sports stadiums are especially vulnerable to Modern architecture's fragility. Their fragility makes integrating them into cultural heritage difficult because their constant need for regulatory and performance changes conflicts with the building's history. Functional adaptation and conservation require communicating these architectural structures' cultural, technical, and scientific significance. This is essential to create interventions that balance architectural innovation and heritage preservation.
The analysis focuses on three football stadiums in Italy that were designed and constructed by Pier Luigi Nervi during the 1950s and 1960s. These architectures embody the essence of Italian architectural culture and are distinguished by the unique "Nervi style". However, each structure also possesses distinct characteristics influenced by the context in which it was constructed. The study centres on the Taormina stadium, by conducting research in the archives and carrying out field investigations, we have identified the distinctive features of this architecture and assessed its current state of conservation. This has revealed additional vulnerabilities that are specific to the case study. Intervening in the conservation project requires a thorough understanding of the asset and the reconstruction of its history, which serves as a valuable tool. The scientific community in this sector plays a crucial role by possessing a wide range of skills that can collectively contribute to safeguarding these heritages.

Keywords
Pier Luigi Nervi, football stadium, Taormina stadium, Modern architectural heritage, architectural fragility

Formworks in thin shell construction: past and present

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Abstract
In Architectural Engineering, thin shells represent two-dimensional structures in which the third dimension, the thickness, is significantly smaller than the others, which are thus prevailing. The thin-shell construction technique has its roots in Spanish bóvedas tabicadas (dating back to at least the 12th century), the construction of which has continued to the present day. The Spanish technique, in the different countries of the Mediterranean area to which it was exported (Portugal, France, Italy) has remained almost unchanged over time. However, the introduction of new building materials such as cement and steel at the end of the 19th century inevitably led to the experimentation of thin-shell structures characterised by greater slenderness and more complex shapes. Starting with Rafael Guastavino Moreno -who began to make improvements to the traditional technique-, and moving on to Eladio Dieste -who succeeded in fusing the qualities of bricks with those of reinforced concrete-, and Heinz Isler and Felix Candela -who, working in two different contexts, managed to improve the use of reinforced concrete-, we arrive to current constructions and experiments, in which the economy and ecological compatibility of the process are essential factors to be taken into account in the construction of modern shells.
After making a general overview on thin shells, the aim of this paper is to provide an analysis of some of the ribbing and formwork technologies used over time to build thin shells. Similarities and differences among the various types of shells will be highlighted, having been used shape, size, and materials as variables for the analyses. A brief analysis of the current experiments carried out to determine alternative formwork systems to those usually used also is described at the end of this paper.

Keywords
Thin shells, Thin vaults, Concrete shells, Formwork, Ribbing

Transformability indicators for the evaluation and definition of public housing regeneration strategies: the “Palazzoni” case study in Latina

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Abstract
Exploring the transformative potential of large-scale public housing complexes stands as a pivotal issue in formulating sustainable regenerative initiatives. The research introduces the concept of transformability, defined as the inherent capacity of buildings and apartments to undergo changes in their original layout while respecting their typological and constructive set-up. This concept is instrumental in defining the regenerative potential of buildings. The paper delves into the multifaced challenges faced by existing public residential buildings, including outdated design choices, management shortcomings, and a lack of responsiveness to contemporary needs. It underscores the imperative to develop well-suited regeneration projects to address these challenges effectively. The methodology involves the development of indicators at various scales, from individual apartments to the entire building, aiming to comprehensively assess the transformability. The study focuses on the Italian context and, specifically, on the large-scale case study of the “Palazzoni” complex in Latina. Here, a detailed analysis is conducted on the elements within the residential complex that possess the potential for transformation, coupled with an evaluation of how well the PINQuA project (a regenerative initiative funded by the National Recovery and Resilience Plan, ongoing on the building) aligns with the proposed indicators. The research substantially contributes to bridging the existing gap in the literature regarding evaluation tools for assessing building readiness for transformation, providing insights that can inform the development of effective regeneration strategies tailored to the challenges presented by large-scale public housing.

Keywords
Transformability, Large-scale housing, Sustainable regeneration, Assessment tool, Existing buildings

Sine glossa: the coded drawing for the recovery with the help of the IPDB

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Abstract
The use of Descriptive Geometry constituted the modus operandi referred to the scientific unit for the development of the representation of multiscale building models relating to the investigation concerning the theme of the recovery of listed and unlisted historic buildings. The procedure used and necessary to implement the comparison useful for digitally reconstructing the artefacts involved the different classes of manuals, treatises and professional practice also inherent to the organization for the descriptions of the techniques essential to the recognisability of the building. With the definition of sine glossa we intend to consider the codified drawing as a regulated practice; that is, without alterations and ambiguities for the purpose of understanding models drawn according to graphic and geometric rules aimed at the recovery of a building organism. In this way, the lexical debate that has involved scholars, researchers and established thinkers over the last forty years in relation to the terminological question relating to the definitions of recovery, reuse, redevelopment, and restoration. At the same time, a specific and qualified observation report was introduced on a part of the architectural, building and engineering heritage considered to be very complex and articulated in both its diachronic and synchronic phases. In fact, the research study exposed in this essay is articulated through the technical aid of the Integrad Project Database, the acronym for BIM, and a comparison with building recovery. These aspects investigate, together with the exercise of redesigning the morphological models of the codified representation, the theme that concerns the housing of the Bolognese villa in the garden city between the years 1920 - 1950. The outcome reveals how the codified drawing first determines questions, then resolutions which tend to keep the theoretical basis of the research positively connected in terms and meanings in a specific and hinged context such as building recovery.

Keywords
Building recovery and drawing, Drawing and BIM, Draw building recovery, IPDB - BIM building recovery and drawing

Information Systems and automated census using Object Detection for the management and valuation of built Cultural Heritage

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Abstract
The contribution concerns the development of methods and protocols for the monitoring of historical built Cultural Heritage with an integrated multidisciplinary approach consisting of documentation activities and analysis procedures. In particular, the latter concern the state of the art, morphology, construction technologies, and the conservation state of materials and construction packages, to structure the corpus of knowledge of the asset under examination. The analysis procedures aim to understand the spatial components of the structure in relation to construction, technological, and material aspects, and to define the digitization actions to be activated on the artifact based on the observed condition. Understanding and monitoring of the cultural asset is achieved through the construction of synthesis frameworks, functional for describing its complexity, which culminate in the use of semi-automated and automated censusing systems of Information Systems for the formulation of monitoring protocols and programmatic frameworks for management. The methodology for automating the monitoring and the architectural census using Object Detection algorithms on georeferenced orthoimages is tested on the follow-up of the AICS co-funded cooperation and research project "Management and control of urban growth for the development of heritage and improvement of life in the city of Bethlehem" (3D Bethlehem), in which the University of Pavia had scientific responsibility and the research laboratories STEP and PLAY of the Department of Civil Engineering and Architecture were involved.

Keywords
Historical building heritage, urban management, building census, object detection, information systems

The engineering approach to the study of Roman thermal buildings: the case study of the Rotonda Roman baths at Catania

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Abstract
Roman architecture is one of the most advanced forms of historical architectures because of the several innovations that have contributed to the progress of the art of construction. The ability of the Romans consisted in creating monumental architectures by experimenting with innovative materials and construction techniques, and combining traditional building elements in an effective way, thus achieving formal and technological solutions of great relevance. Therefore, research activities on Roman buildings are essential for the reconstruction of their historical development, and for their protection, conservation and promotion, with the aim to preserve the cultural memory of the ancient cities. In this framework, this paper reports the preliminary results of an ongoing research activity on the Roman thermal complex "Terme della Rotonda" in the city of Catania. This activity aims at achieving a three-dimensional digital model of the thermal complex and characterizing it at architectural and construction level to provide information on the mutual connections between the architectural solutions and the adopted materials and construction techniques. The study here reported is part of the interdisciplinary research project SAMOTHRACE that aims at bridging the knowledge gap on the dating and diachronic development of the thermal complex.

Keywords
Roman architecture, Roman bath-buildings, historical construction techniques, integrated survey, 3D modelling

City of Water. The Water Heritage as the core of the Urban Identity of Salerno city: don Tullio's 18th century fountain

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Abstract
Investigating the complexity of a historical urban context, the evolution of its forms and the role of its tangible and intangible heritage requires an analysis of the architectural, artistic and constructional events strongly linked to cultural, social and environmental dynamics.
This study proposes a key that considers the relationship between the built environmental and water resources, to recognize the evolutionary phases of the urban environment and the role of the historical hydraulic heritage in the current contemporary context, through the architectural vicissitude of an artefact symbolic of the complex city-patrimony-water relationship in the city of Salerno: the eighteenth-century don Tullio's fountain.
The paper focuses on the role of water-related works and highlights the strategic importance of the conservation and recovery of hydraulic architectures in the context of sustainable development, promoting a holistic approach that integrates environmental, historical and social aspects. Using the city of Salerno as a case study, the paper analyses fountains as examples of engineering and architectural works that bear witness to the history and culture of a place and proposes strategies for their enhancement and protection.

Keywords
Water resource management, Historical Hydraulic Heritage Recovery, Sustainable Development Process, Holistic approach, Salerno's fountains

From patented prefabricated panels to energy requalification strategies. The case of nursery schools in Emilia Romagna region

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Abstract
Since the 1960s, prefabrication has become an increasingly popular technique for building construction. Prefabricated building components are preferred because they can save costs, expedite construction schedules, increase quality control, and provide safer working environments. Despite the initial extensive use of prefabricated buildings for residential purposes, the acknowledged advantages were also applied to the construction of new schools. The urgent need to quickly establish a network of new schools at all levels led the main manufacturers of prefabricated components to file numerous patents for prefabricated panels and floors. These were widely used in all regions until the early 1980s. Today, most of these buildings, constructed using compositional schemes that involved the assembly of prefabricated cells, require energy and functional retrofit interventions. Understanding the patents and technologies used is essential for optimizing the redevelopment intervention in terms of costs and fully leveraging the replicability of the project to be applied to schools of the same historical era and prefabrication type. Regarding prefabricated school buildings, particularly nursery schools, there are several opportunities to support energy and environmental retrofit projects and optimize the inherent opportunities in prefabricated panels. The paper aims to present a retrofit project workflow for single-story prefab nursery schools. The case studies are in Carpi, in northern Italy.

Keywords
Prefabrication, patented elements, nursery schools, retrofit workflow, historical assessment

Historical-constructive investigations and digital modelling for knowledge and requalification of the architecture of the second half of the twentieth century. The case of the University of Calabria in Cosenza (1972-1986)

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Abstract
The analysis of the heritage of the second half of the twentieth century offers useful lines of study to understand the evolution of building industrialization in Italy, both in the more advanced areas of Northen Italy, and in the Central and Southern regions, where the spread of these practices was more challenging. This paper presents the first results of the analysis conducted on a portion of the University of Calabria campus, located in Arcavacata, near Cosenza, and designed by a group guided by Vittorio Gregotti. This study is part of the research project "Light prefabrication: knowledge, monitoring and requalification of the architectural heritage of the second half of the twentieth century in the regions of Calabria and Lazio", funded by the European Union Next Generation EU, concerning the requalification of buildings of the second half of the twentieth century, built with prefabricated components, also in combination with structures realised on site. The case study presented in this paper belongs to the first phase of the realization of the campus. The ongoing research aims to associate the historical investigation with the survey of the actual building to develop a digital model of the complex in which to summarize the results of the archival analysis with the data concerning the state of conservation and any technological criticalities observed. The archival analysis carried out to date has highlighted some features of the case study useful to relate the local experience to the national Italian construction context. The transfer from the national framework to the Calabrian case of industrialization faced difficulties and delays. The presence and possible effects of these contextual inertias will be verified, in the subsequent phases of the ongoing research, through other Calabrian realizations of the period such as, for example, the Martensson student residences, the new railway station and the Gescal public housing district of Vaglio Lise in Cosenza.

Keywords
Construction History, Light prefabrication, Requalification of building heritage, University of Calabria, 1970s-80s

University buildings as an opportunity for urban regeneration: sustainable and innovative teaching and research spaces

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Abstract
The Italian architectural heritage, in particular that linked to education, learning and research, is rather dated since in some cases schools and universities are set up into historical buildings that have been adapted and reused (mostly former convents and barracks) or new buildings specially created, that largely date back to the last century, according to typology distribution and construction technologies that are difficult suitable with the needs of digital and computerized teaching and with the dynamism of research activities.
It follows that spaces for education and research often demonstrate poor functionality compared to current requirements and inadequacy with respect to the needs of both energy-environmental and economic-management sustainability. Fortunately, since 2019 a season of modernization of university structures has opened thanks to two MUR tenders which have made over 1,900 million euros available to universities for redevelopment, modernization and renewal projects of spaces to be allocated to institutional activities.
This contribution aims to underline the role that universities can play as drivers of urban regeneration and building redevelopment thanks to the projects that these fundings (absent for too long) will guarantee in the coming years. New buildings for learning and research can be the starting point for a new sustainable future because they can support the establishment of a sustainable culture due to their impact on next generation.
Referring to a specific case study (the urban regeneration of the Scientific Institutes area of the University of Pavia) the paper highlights approaches and methods that can also be exported to other similar contexts (in terms of size, functions and organization) through a cognitive analysis, sustainability-oriented planning and programming followed by participatory and multidisciplinary planning, essential to achieve the objectives of quality education (SDG 4) and sustainable cities and communities (SDG 11) as also required by the 2030 Agenda for sustainable development.

Keywords
Building for learning, University, Urban Regeneration, Sustainability, Innovation

Former Eridania of Forlì. A path of knowledge for the purposes of recovery

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Abstract
The former Eridania complex in Forlì is part of a series of disused sugar factories of the same company, comparable from a typological point of view, which characterize the Po Valley. The recovery of this complex, which like its peers maintains a certain architectural value, has received great interest over the years from private investors, local cultural associations, the Municipality, owner of the buildings since 2023, and from the Universities. There are many ideas proposed to date, but all are limited to hypothesizing the uses of the industrial area, without ever investigating the consistency and real state of conservation of the site. An accurate and in-depth study of them is of fundamental importance for the implementation of a good recovery project, or at least for the purposes of maintaining an acceptable state of maintenance. A step to take is that of the architectural survey and the critical study of the history and consequently of the construction phases, in order to fully under-stand the characteristics of the object of study. Only by following this process will it be possible to conceive adequate maintenance interventions with a view to recovery, avoiding unwanted demolitions. The first phases of this study involved the systematization of archive documents and a first geometrical survey and building evaluation. The preliminary analysis of the metal roofing includes a proposal for making the conditions safe.

Keywords
Construction history, Sugar factory, Industrial site recovery, Building knowledge, Architectural survey

Spontaneous architecture and construction. Typological analysis of vernacular buildings from Italy to Morocco

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Abstract
At a time when environmental awareness and the need to preserve our planet are at the centre of global debates, it is crucial to explore innovative approaches that can combine our social and economic growth with respect for the environment. Often, when talking about sustainability in construction, we turn to advanced technologies and cutting-edge solutions, sometimes forgetting that the answer may lie in our culture and history. Vernacular architecture, with its deep roots in local traditions and intelligent adaptation to the surrounding environment, offers us a good example in this context, as it was born as a direct response to people's needs and perfectly combines the needs of a community with the available environmental resources. The following work, a synthesis of an international research project that is still in progress, aims to analyse, from a typological-functional point of view, two rural architectural typologies in comparison: the eighteenth-century Tuscan rural farmhouse and the typical Moroccan rural dwelling known as the douar. The main goal in to highlight how two realities, although geographically distant, shared the vision of integrating the building with the environment and the needs of the community and how, even today, these buildings, which have remained intact over time, continue to fulfil their function perfectly, projected into the future.

Keywords
Vernacular architecture, sustainable architecture, moroccan architecture, tuscan architecture, local materials

Sustainable Guéliz District: a Data-Driven Methodology for Preserving Architectural Heritage and Achieving Sustainable Development in Marrakech

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Abstract
Guéliz is a district of Marrakech built during the French Protectorate in Morocco. It was designed with a focus on tourism, enhancing the landscape features and the architecture of the Medina. Characterized by a blend of architectural styles –Rationalism, Art Decò, Art Nouveau, and Academia – Guéliz's buildings are emerging as a part of the city's recent heritage alongside those in the Medina. However, recent years have seen substantial changes altering the district's form and many of its buildings. Some heritage sites are abandoned or in dire need of renovation, while others have been refurbished without consideration for their historical significance. In response, local authorities are striving to raise awareness of Guéliz's recent heritage importance. This effort involves establishing design guidelines to regulate renovations and conservation pursuing sustainable development. This paper seeks to address this context by developing a comprehensive repository of information about Guéliz's recent heritage using a multi-scale, multi-level methodology. The multi-scale approach delves into the history and urban design of the district to understand the relevance of each building. Meanwhile, the multi-level analysis entails examining cadastral sheets, floor plans, and documents while conducting historical, architectural, structural, and decay analyses. Digital technologies are used to conduct the analysis, in particular photogrammetry and HBIM. The first supports the survey of buildings and the decay analysis. HBIM models of the buildings are used as a repository of the results of the different analyses. The methodology was tested on many Guéliz buildings, with three presented in this paper. As a result, the methodology showcases the relevance of providing local administration with a digital repository, aiding informed interventions for preserving Guéliz's recent heritage. Some important topics to consider in the drafting of intervention guidelines were addressed.

Keywords
Sustainable development, hbim, colonial architecture, preservation, Marrakech

From abandoned architectures to smart ecovillages. Rehabilitation of traditional dwellings in the Madonie inner rural area of Sicily

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Abstract
The inner rural areas of Sicily face depopulation and unemployment, particularly evident in the Madonie region, centrally located on the island and comprising 21 interconnected municipalities. Within this area, numerous abandoned residential structures accentuate the prevailing challenges. The objective of this study is to demonstrate how technological and sustainable design, and a compatible architectural rehabilitation through eco-design, especially focusing on mountain hotels such as the Milocca Hotel in Castelbuono, can serve as a key catalyst in revitalizing the area. Emphasis is placed on utilizing these spaces for social housing, along with adaptive reuse and rehabilitation of existing structures, following the principles of green building. Contrary to perceiving tourism solely as a stimulus, a paradigm shift is proposed, considering ecovillages as catalysts for repopulating these rural areas with new residents. The strategy involves offering new services, as well as promoting community value and the rehabilitation of housing structures. A comprehensive exploration of ecovillage models globally, in Europe and Italy, underscores the relevance of this innovative approach to communal living. Moreover, the potential to align with global trends makes these villages intelligent hubs, exploring and experimenting with new forms of habitation to stimulate local economies and facilitate repopulation. Through the implementation of sustainable technological solutions and the rehabilitation/reuse of existing structures, socially competitive housing structures can be developed, even in comparison to modern dwellings in major cities. The widespread adoption of technological innovation across the Madonie district generate a network of "smart villages," transforming vulnerabilities into strengths. This approach not only introduces a series of best practices but also preserves the rich tradition and culture embedded in the material and immaterial heritage of Sicily.

Keywords
Smart Villages, Ecovillages, Inner rural areas, Madonie district, Abandoned architectures

Interdisciplinary Approaches to the Contextual Study of Multi-Layered Industrial Archaeology Sites: The Case of the Tabarca Building in Genoa

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Abstract
The regeneration of abandoned industrial warehouses within modern urban landscapes is of considerable scientific interest. These structures document the productive history of cities and the architectural and technological innovation. The Tabarca Building in Genoa is a prime example of industrial archaeological significance, embodying the commercial heritage of an area within the historic urban fabric. In particular, it was the first site in Italy to use refrigeration technology to preserve goods. The introduction of cold storage was a revolutionary development at the beginning of the 20th century that transformed world trade and led to the creation of new building typologies. Despite its historical importance, the potential of the Tabarca building remains underestimated today. Its conservation requires a multifaceted approach that addresses different aspects of the building, i.e., archaeological, functional, stratigraphic, conservation and geometric considerations. An interdisciplinary strategy, including a broad overview and a detailed focus on the individual building, is essential to delineate its temporal evolution.
This paper aims to reconstruct the historical and technical context of the Tabarca building and its surroundings through a multidisciplinary lens. Here, the authors integrate the analysis of the current state of the building with its historical, typological, and urban features. The initial results presented lay the groundwork for future rehabilitation and valorisation efforts for similar structures, demonstrating the need for an integrated approach to understanding and preserving industrial heritage in contemporary urban environments.

Keywords
Construction and conservation history, industrial archaeology, multidisciplinary approach, refrigeration technology, historical construction techniques

The reuse of abandoned buildings between potential and opportunities. The Minerva cinema in Catania

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Abstract
In the context of the ongoing debate on the sustainable development of cities, the theme of the recovery and reuse of disused assets is inserted. The presence of large disused building containers unites many Italian cities, affecting buildings with different uses.
Within the urban fabric of the city of Catania, there are numerous cinemas that are no longer in operation and in a state of abandonment. This paper documents the recovery and reuse of the Minerva cinema, located near the historic center of the city, and decommissioned since 1984. The analysis of the urban context in which it is inserted has suggested its conversion into a multipurpose center that can act as a driving force for the redevelopment of the entire area.
After carrying out an in-depth analysis of the historical events and the morphological, distributive and technological characteristics of the building, as well as its state of conservation, the required performance in terms of safety, use, comfort and accessibility was identified. All the design choices adopted aimed at the minimum impact on the external perception of the building, which maintains its morphological-compositional characteristics. Using the box-within-a-box strategy makes it possible to adopt interventions capable of determining the least impact on the structure, in terms of transformations and acting loads. The use of reversible technological solutions and maximum functional flexibility were the guiding principles in the definition of the project. The study also focuses on the energy performance of the building and the economic evaluation of the intervention.

Keywords
Building renovation, reuse, built heritage, energy efficiency

Recovery, valorization and reuse of a characteristic architecture of the Italian building heritage: the roadman's house. A case study

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Abstract
Among the cultural assets there are some considered "minor" due to their typological, formal, material and construction characteristics. Among these can be included the "Casa Cantoniera", the home of the 'Cantoniere', i.e. the roadman, the road inspector, person who had to look after his own canton (3-4 kilometer stretch of road). A service architecture typical of the Italian territorial context of which it constitutes a peculiar element and distinctive of the landscape. Iconic architecture, easily recognizable by typology and Pompeian red colour, network of small infrastructures serving large and structured road infrastructures, capable of designing the anthropized landscape and ensuring that it dialogues with the natural landscape, characterizing it and making it somehow unique. As a result of the redefinition of the tasks assigned to the operators in charge of the surveillance and maintenance of roads throughout the country, as well as new methods and practices of intervention, the roadmen's houses are almost completely disused and for several decades have been undergoing a process of slow abandonment resulting in inexorable degradation. At the end of 2015, an agreement was signed between ANAS, the Ministry of Cultural Heritage and Activities and Tourism, the Ministry of Infrastructure and Transport and the State Property Agency, in order to define the Guidelines for the sustainable reuse of roadman's houses, which was followed in 2016 by a call for tender for realization of a pilot project for their recovery and valorization; and, in 2021, by a new call for tenders aimed at promoting concession requests. Within this context, the objective of this work, still in progress, is to contribute to the historical knowledge of these small buildings and to provide typical intervention solutions for their recovery and valorization, so as to be able to insert them into a new circuit of tourist use and slow mobility.

Keywords
Recovery, valorization, reuse, preservation, roadman's house

Conservation and safeguard of colour in historic building surfaces

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Abstract
In the context of the culture of recovery, conservation and maintenance of buildings, the study of techniques, materials, colours and surface finishes of historic buildings plays an important role. The conservation of these elements is important for both architectural and environmental aspects. The colours of the wall surfaces depend on the use of sands and peculiar pigments, mostly local ones used in plasters, as well as on the use of stones or other covering materials deriving from a consolidated historical and technical tradition. The Italian vernacular architecture of historic centers has always been characterized by peculiar shapes and colours in the different regional areas, in the same way the courtly or monumental architecture is characterized by colours deriving from the use of specific materials present in the places. Even the signs and patinas found on the surfaces allow us to better understand the construction events of the artefact over time. It is therefore of extreme interest to preserve the surfaces of historical artefacts as much as possible, respecting their authenticity and avoiding altering, with inappropriate repair interventions, the perception of the image of the building in its environmental context. What and how to preserve the integrity of architectural surfaces, due to their material value and evidence of a consolidated construction tradition, requires adequate cultural and technical tools. Among the latter, colour plans can allow to monitor and control interventions on the surfaces of historic buildings. On the other hand, however, there is a risk of considering the colour plans as projects finalized in themselves, thus losing sight of the transformations linked to the life history of the buildings, the vicissitudes and mutations engraved in the skin and colour of their surfaces in search of an ideal and often utopic original philological identity.

Keywords
Colour, historic buildings, surfaces, conservation, color plans

Modernism denied. Recovery and regeneration of the Cinema - Theatre “Mastrogiacomo” in Gravina in Puglia

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Abstract
At the end of the 1920s, the affirmation of sound and the advent of the rationalist lexicon favoured the evolution of cinema from a traditional typology to a functional typology, heralding avant-garde constructive experiments. This evolution coincides with a simplification process already in place in the architectural language that will result in the gradual disappearance of ornamental elements leaving room for elementary surfaces, increasingly clear and enhanced using new materials. The rationalist code will set, for this type, a new architectural and regulatory standard, reaching almost unchanged to the present day. The designers, called to confront the new typology, will refer extensively to theatrical models, not only because the questions to be solved are similar, but because in most cases the construction of multi-purpose halls continues, in which animated projections will alternate with theatrical performances. The definition of the typological and functional evolution of cinema-theatre is analysed in the case study “Mastrogiacomo” in Gravina in Puglia (Bari), avant-garde cinema-theatre, made by architect Francesco De Martino. Cinema-theatre is part of a series of works that from the beginning of the 1930s will be subject to a constant process of upheaval, involving a substantial transformation of both compositional and technological character. The economic sanctions of 1936 and the autarchic economic model, will involve the introduction of new materials and components within the building, improving the conditions of well-being, safety, and liveability. Through examination of this study, highlights the need to recover and enhance the architecture and technological systems of cinema through a multi-scale approach capable of analysing a plurality of information, to preserve the identity of this heritage.

Keywords
Modern Architecture, Recovery intervention, Building construction systems, Cinematografi, Cinema-Theatre

High-altitude architecture beyond constructive limits: the Fürggen cableway arrival station

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Abstract
The experimentation of technological systems, developed during the 20th century, emancipated the characteristic ingenuity of the professionals of the time, engineers and architects, sometimes challenging the landscape context they were confronted with. High-altitude architecture, although of recent conception, has represented a dilemma in the design debate. Not identifiable with Alpine architecture, but from which it draws its essential aspects (relationship with nature, boundary-space, extreme environment), high-altitude architecture is part of the extensive built heritage of the last century. Of particular artistic relevance, this particular way of 'making architecture' fully embraced the 'sentiment' of innovation and experimentation initiated at the turn of the century, leading to the birth of architectural masterpieces in an 'uncontaminated' place. The arrival station of the Fürggen cableway, designed by the Turinese architect Carlo Mollino, has become an emblem of modern architecture at high altitudes. The use of traditional materials, such as stone and wood, relate harmoniously with innovative materials for the Alpine environment. The building, constructed on the crest of the mountain like a continuation of it, conceals a pumice concrete skeleton in its inner core according to an all-Italian construction solution: the Eliobeton-Pinottini system. Formulated with perforated pumice concrete blocks and stiffened with steel reinforcement, this system, patented in 1948, has a multifaceted use thanks to its technical and technological characteristics. The objective of the research is the knowledge of the elements that make up the artefact, through a methodological process that systematises all the useful information by means of archive and bibliographic analyses, with the aim of outlining a line of intervention for the conservation of the modern architectural heritage, which is not adequately valued.

Keywords
High Altitude Architecture; Furggen Cableway; Carlo Mollino; Eliobeton-Pinottini system

From digital survey to stability assessment in San Tomè, Almenno

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Abstract
The San Tomè Rotunda in Almenno San Bartolomeo (Bergamo, Italy) is an emblematic example of the originality of Lombard Romanesque architecture. Built during the mid-12th century, it appears as a cylindrical structure with an apse that extends in the northeast direction, surmounted by two smaller cylindrical volumes. The first contains the dome, and the second houses the lantern. Inside, a double-level row of eight columns surrounds the central space, concluding with a hemispherical dome topped with an oculus. Since the 19th century, the growing interest in the unique configuration of the temple led to a series of restoration efforts. These efforts resulted in a well-preserved building, with but also in the overlay of materials, making the interpretation of the palimpsest a challenge. On the other hand, this left room for new research to clarify the evolution of architecture. The most recent intervention, which occurred a decade ago, involved inserting metal hoops to contain cracks in the vaults and walls of the church. To combine advancements in historical and archaeological knowledge with safety monitoring, an integrated survey campaign was conducted. The results shed light on several issues, including the lantern. Drawings from the 18th and 19th centuries depict the lantern as not being connected to the hall, and F. de Dartein, an engineer and expert on medieval architecture, did not even report it. It was likely reconstructed during the 19th century renovation by E. Fornoni. This project may have involved opening the summit oculus, which appears eccentric with respect to the dome axis in the current survey. The surveys also allowed the detection of the slight deformation of the dome, whose deviations from a supposed perfectly hemispherical geometry can be taken as indicators of the displacements suffered by the walls. These findings demonstrate how the information provided by an accurate survey can be used to understand the structural behaviour of a historical building and its deformations over time, becoming essential for a coherent and effective consolidation project.

Keywords
Romanesque church, Rotunda, dome, deformation, survey

Recovery, enhancement and reuse of existing building assets: towards a new reuse for students

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Abstract
The paper proposes a reflection on the theme of residences for university students in Italy, with a focus on recovery, enhancement and reuse of existing buildings. Sustainable development has assumed a key role in current and future projects due, among the other factors, to the significant mobility flows generated within a territorial area by the presence of a university. Among the critical issues that currently characterize this subject are the under-sizing of residential services for students and the territorial asymmetry of the educational offer, both in the private and public sector. This problem is thus leading to the creation of flows from south to north: 36% of the structures for university education are in the north, 31.5% in the center and 32.5% in the south. Furthermore, at regional level there is the highest concentration in Lombardy, Lazio and Campania due mainly to the presence of private universities. Another critical factor is the maintenance condition of the Italian building stock, as a quarter of its total consists of buildings realized before 1949, with 4.1% of them in poor condition. According to the latest ISTAT census, in Italy there are more than 7 million unused, abandoned or confiscated buildings among residences, factories, industrial sheds, schools etc. The WWF, at the same time reports that in the last 50 years the urbanized area has increased by 600 thousand hectares compared to a population growth of only 27%. The comparison of these data shows how the business of student housing can be an opportunity for urban regeneration for the "student cities" that today face the problem of high rents due to high demand. The research aims to demonstrate the opportunity of the recovery of buildings to accommodate university students.

Keywords
Student accommodation, sustainability, reuse, urban

The Architecture of the Bridges

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Abstract
The 1949 exhibition at MoMA "The Architecture of Bridges" curated by Elizabeth Mock inaugurated a fresh view to the field of collaboration between engineers and architects. Among other reasons, the appearance of new technologies and materials as steel in XIX century and concrete in XX provoked a gap that the architects of modern movement detected without really solving the distance between the beauty of honesty and the "intellectual swindle" of certain architectures. Second half of last century deployed technology for massive reconstruction and exponential urban growth and therefore a context of obliged reunion of the two disciplines. The MoMA's exhibition followed by others in Pompidou centre illustrated the new collaboration between engineers and architects, from Utzon and Arup to Ishigami and Sato, from the mechanical to the green paradigm.
This paper aims to analyse those contributions in both directions through an analysis of the history of the construction of bridges as a specific and pure example of the positive interaction between architects and engineers, beyond any kind of controversy. First, by a prospection of engineering technology transferred to architecture that silently by with no interruption has taken place from the construction of bridges to edification with brilliant examples from Freyssinet to Vierendeel. Secondly putting an eye to their architecture where we will describe some of the most relevant examples designed by architects, from Palladio to Plecnick. Both views, with central examples as Peter Rice or Jean Prouvé, show how those collaborations go beyond the specific to build an intermediate field that today is central for a balanced a sustainable development.

Keywords
Bridges, Architecture, structure, collaboration, research by design

Parametric deconstruction of the technological elements of the Sassi of Matera. Towards digital heritage management

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Abstract
The use of digital technologies in heritage conservation is radically changing the way how people interact with our cultural past, proposing new and current ways of exploring, understanding and preserving the historical-architectural cultural heritage.
The research is part of a segment that connects the history of the city of Matera with contemporary trends. The blend of existing architectural heritage, digitalisation and new and innovative digital tools, finds a primordial application in the present research, because of a shortage in the state of the art of validated research in the scientific field, in order to define an innovative smart prevention approach on the UNESCO heritage.
Underlining how the process of intervention on a cultural heritage asset involves the phase of direct and indirect knowledge as a decisive moment for the definition of all subsequent activities, a fundamental step is the creation of a semantic model, developed according to HBIM methodology, including the components of the historical architecture of the Sassi of Matera, designed from the complex phase of technological decomposition of the elements and subsequent digital reconstruction, in order to define a process that includes the modelling of the first elements of the architecture of the Sassi historicized in the research.
The creation of a catalogue and thus a computerised digital library of components characterised by non-regular and complex geometries is followed by the creation of a new manual that can become a reference point in the design phase, for interventions and good practices on the UNESCO heritage of the Sassi of Matera. The research aims to convey the concept that HBIM is considered, as defined by the UNI 11337:2017 standard, an essential support, control and management tool useful for understanding and interpreting the complexity of the existing architectural heritage.

Keywords
Hbim, cultural heritage, manual restoration, parametric object, unesco

Rainwater harvesting and reuse: a preliminary review

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Abstract
Today, available water resources are under severe pressure on a global scale due to demographic, economic, and social demands, environmental and climate changes, and technological challenges. It is well known that rainwater harvesting (RWH), a simple and ancient method, has the potential to integrate surface and groundwater resources in areas with inadequate water supplies. Since their inception, the temporal and partial availability of water resources, particularly in southern regions, has triggered the development of various water systems for RWH and storage. Since then, technologies for the construction and operation of multiple types of cisterns and other relevant hydraulic structures have evolved. Significant achievements in RWH and use from the dawn of humankind to the present are analyzed. The Indo-European and Roman periods are highlighted as examples of outstanding achievements. The primary need for water justifies not only the innovations found throughout history but also the most advanced level of engineering of each era used in these constructions. In addition, the significance of this hydraulic technology and understanding the value of water conservation in the present and future are considered. Hygienic precautions to ensure the purity of the water collected and stored is another aspect that deserves further study. This preliminary research will provide a systematic overview of the state of the art.
In recent decades, many countries have supported the updated implementation of this practice to cope with increasing water demand and to reduce the frequency, peak, and volume of urban runoff. These considerations motivate an interest in examining the current situation and prospects for further development of this method worldwide. This paper aims to analyze the current situation of RWH as an alternative water source to address water scarcity in various countries.

Keywords
Rainwater harvesting techniques, Rainwater reuse, Historical water storage, RWH Best Practices, RWH regulations

Material-constructive features of the roofs in the Basilica of San Francesco D'Assisi in Palermo. Decay, instability, hypotheses of intervention and monitoring

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Abstract
The paper shows the results of the analyses carried out on the roofs of Pontifical Basilica of San Francesco d'Assisi in Palermo, within the framework of a *Scientific and didactic collaboration agreement with the Ministry of Infrastructures and Sustainable Mobility (MISM)-Interregional Superintendency of Public Works for Sicily and Calabria*. The typological, morphological, material and construction analyses have been carried out to allow the provision of appropriate maintenance and restoration actions on the different roofs, able to eliminate the causes of the decay due to the frequent infiltration of water inside the building. In particular, the analyses illustrated in the paper are focused on the decay and possible instability of the wooden roof of the apsidal area and the flat roofs reconstructed after the war damage due to the bombs of the Second World War, along the sides of the Tribune and the nave of the *Basilica*. The apse of the Basilica is defined by a masonry vault overlaid with a double-pitched wooden roof with trusses. After a brief description of the evolution of the building, the results of the geometric and textural survey carried out to identify the crack pattern and the areas most affected by damage will be presented. The mechanical characterization of the materials and the analysis of the load-bearing structure under the loads provided by the current Italian legislation for existing buildings are presented with a finite element modelling of the section of the Tribune as well as the results of the safety checks. After having identified the main structural problems affecting the building, the possible interventions accompanied by an associated monitoring plan are proposed.

Keywords
Masonry, damage mapping, FEM, decay, architectural engineering

Small Thickness Brick Vaults. Experimental Study of Single-Leaf and Lined Alentejo Tile Vaults

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Abstract
This article describes the tests carried out to assess the structural strength of traditional thin brick vaults in the Alentejo region of Portugal, commonly known as "abobadilhas alentejanas". This type of traditional construction extends throughout the Mediterranean basin, where it takes on different names depending on the country and region. For example, this particular type of vault in Spain is called bóveda tabicada (volta catalana in Catalonia and bóveda extremeña in Extremadura), and in Italy it is called volta in folio (realina in folio in Sicily).
The slenderness of these vaults and the fact that they can be built without centering, using gypsum mortar and taking advantage of the arch effect, are characteristics that distinguish them from other masonry vault solutions. The single-leaf execution technology, using few labourers and with no need temporary support structures, is one of the reasons for their presence in the traditional constructions of south-east Portugal and other regions of the Mediterranean basin.
One of the ways that ancient builders used to increase the strength of Alentejo tile vaults was by superimposing a second layer of brick over the intradorso layer, thus doubling the thickness of the tile vault. Typically, the intradorso layer was made without centering, using gypsum mortars, and the supplementary layer was built on top of it, sometimes with lime mortars, without the use of gypsum.
However, despite the interest that this solution continues to arouse, the structural study of this solution is still scarce and the particularities of its operation have not yet been fully reproduced in structural models. In order to provide more information on this issue, a campaign of experimental tests was carried out on prototypes of single-leaf and lined tile vaults, replicating traditional construction. This article presents the experimental work carried out, describing its procedures, results and main conclusions. Other experimental campaigns were carried out as part of ongoing research, the results of which will be presented in upcoming publications.

Keywords
Alentejo tile vault, Loading tests, Structural strength

Delving into the research and experimentation on the patented underground tanks by Pier Luigi Nervi

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Abstract
Pier Luigi Nervi, renowned for his groundbreaking contributions to engineering and architecture, left an enduring legacy in the realm of structural innovation and design. Among his remarkable achievements are the underground tanks that Nervi conceptualized for the Royal Italian Navy and the Royal Italian Air Force, which stand as testaments to his ingenuity and technical prowess. These tanks, conceived between 1936 and 1940, represent a convergence of Nervi's engineering expertise and his commitment to addressing practical challenges in construction and infrastructure. With a focus on durability, functionality, and aesthetic appeal, Nervi's underground tanks epitomize his visionary approach to structural engineering. This paper aims to delve into the intricate design principles, construction techniques, and historical significance of these remarkable structures, shedding light on their enduring relevance in contemporary engineering discourse.

Keywords
Heritage, patents, archive, Pier Luigi Nervi, underground tanks

Patrimonio, Identidad y Nacionalidad. The Italian Club in Rosario, Santa Fe: an international research experience Italy-Argentina

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Abstract

The contribution summarizes the preliminary results of a training and research project Italy-Argentina, stemming from the collaboration between the Department of Civil Engineering at the University of Salerno and the Faculty of Arquitectura, Planeamiento y Diseño of the National University of Rosario, on the knowledge, protection, and recovery of Argentine heritage linked to the presence of Italian immigrants in South America in the early Twentieth century. Starting from an understanding of the construction and evolution of the concept of "heritage", strongly linked in recent years to the construction of the social identity of a nation, the contribution focuses on the issue of the conservation and enhancement of Argentine cultural heritage and its role in relation to the definition of the national cultural identity. This is done through the case study of the Italian Club in Rosario, an emblematic work in the construction of the city's identity in relation to Italian influences.

Keywords

Heritage, recovery, conservation, Argentina, international

Turning rails into trails: inspiring cases of railway conversion around the world

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Abstract
This research paper delves into the multifaceted significance of preserving railway heritage, most precisely railway lines, expanding beyond traditional considerations of material and architectural heritage. Those networks stand as historical witnesses to crucial events like the industrial revolution, colonization, and globalization, contributing to the shaping of historical landscapes, global demography, and communities.
The study explores the history of the Rails-to-Trails movement, originally aimed at promoting a healthy lifestyle but evolving into a global phenomenon that preserves historical landscapes, reconnects rail towns, and fosters slow tourism. Examining the reuse of abandoned urban rails into linear parks, the paper focuses on well-known examples like New York's High Line, addressing both its successes and limitations. Alternative ideas, such as those along the Petite Ceinture, highlight diverse approaches to repurposing urban rails and emphasize the importance of community involvement in decision-making processes. The paper underscores the challenge of balancing conservation, sustainability, and economical interests, emphasizing that well-integrated greenways present an eclectic solution for the future of railway heritage, harmonizing history, landscape, and contemporary needs.

Keywords
Railway Heritage, Rail to Trail, Industrial Archeology, Greenway, Linear parks, Railbanking system

Digital tools for the study of the industrial building heritage: from data acquisition to parametric modeling and interactive visualization

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Abstract
During the Twentieth Century, the industrial buildings represented an "ideal laboratory" for the development of architectural techniques and languages of Modernity. For the study, conservation, and valorization of the industrial building heritage, advanced digital tools and processes can play a crucial role. This paper presents a workflow based on data acquisition – documental analysis – parametric and informative modeling, and interactive visualization of the building details and the related documental sources. The workflow is conceived to support the study of buildings featuring non-standard structures and construction solutions, based on complex geometries. Specifically, an Application Programming Interface (API) has been defined combining the use of the parametric modeling platform Grasshopper©, enriched by the Geometry Gym© tool kit, the structural analysis software FEM Sap 2000©, the open standard IFC 4, and the cloud-based Shape Diver© platform for AR. The workflow is presented via the case study of the so-called "Silberkuhl system" – consisting of hyperbolic paraboloid (HP) thin shell elements – which was worldwide applied for industrial building roofing between the 1960s and 1970s.

Keywords
Industrial heritage, thin shells, digital archives, HBIM, open standards, Augmented Reality (AR)

Prefabrication of structural components for medium-span roofs: Italian manufacturing of the Hyperbolit Silberkuhl system (HPV)

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Abstract
This work is part of a research project conducted by the author on industrial construction in Italy between the 1950s and 1970s. It refers to the contribution made to construction history by building companies through the study of the methods they used. In particular, it explores the topic of so called 'medium-span roofs' for factories (within 20 meters).
Starting from the years of the so-called 'Italian economic miracle', factory construction intensified in a large part of the country. Compared to the years preceding the Second World War, this type of building had evolved. The main experiments focused on solutions aimed at limiting the use of columns; consequently, the roof span increased. Construction of particularly prestigious factories – influenced by the so-called Milanese structural design – also pertains to this topic.
This study focuses on a serial construction method for industrial building roofs. It was patented by engineer Wilhelm Johannes Silberkuhl in Germany (the Hyperbolit Silberkuhl system, HPV) and it was used by Sogene (the construction company of Società Generale Immobiliare, SGI) for construction of some factories in Italy during the 1960s. The HPV method was based on prefabricated concrete thin vaults with double curvatures: particular geometry and prestressed reinforcement allowed creation of light elements, easy to transport and to assemble.
Moreover, this study provides a further contribution to a reconstruction of Sogene's overall enterprises, a construction company particularly involved in industrialization processes in the construction field.
Bibliography, technical magazines and original archive sources are taken as a reference.

Keywords
Medium-span roofs, HPV system, Factories, Sogene, 1960s

Interpretation of the Protection of the Garisenda Tower in Bologna: a Study of Critical Success Factors Incorporating Local Community Viewpoints

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Abstract
The conservation of building heritage in danger (BHID) has been a longstanding and intricate matter, garnering widespread global attention. Although there has been much research conducted on monitoring, evaluation, restoration, and management in this subject, there is a lack of studies focusing on the perspective of heritage site communities and their possible negative implications. Thus, this study examines UNESCO and ICOMOS publications on building heritage preservation and Web of Science secondary substances on protecting at-risk heritage. The aim is to identify 24 success factors that significantly impact the protection of BHID. Subsequently, surveys were carried out among residents, merchants, visitors, and architectural specialists in the surrounding community, utilizing the leaning tower of Garisenda in Bologna, Italy, as a case study. The aim was to identify and analyze the crucial aspects that contribute to the success of BHID protection, considering the viewpoint of the community. The research findings identified twelve critical success factors. The community generally agrees that the most important factors for successful BHID protection are financial support, safety and risk assessment, government policy support, project organization and management, as well as the adoption of technologies and methodologies. However, there is also a recognized lack of awareness regarding the importance of community involvement and cooperation in BHID preservation efforts. Therefore, the study proposes enhancing community involvement in the Garisenda tower protection project to promote a balance between public and private interests. This will help minimize the adverse effects of conservation efforts on the community and achieve a more sustainable preservation of building heritage. These research outcomes not only apply to the protection of the Garisenda tower but also provide valuable insights and references for the practice and study of protecting other BHIDs.

Keywords
Building Heritage, Garisenda Tower, Heritage in Danger, Identified Dangers, Community Engagement

Towards the Healthy City. Urban Regeneration in the Île-de-France Region: 3 Case-Studies

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Abstract
Since 2005 the Ile-de-France Region has witnessed an impressive series of Urban Interventions inspired by the Loi Borloo on Urban Regeneration. Thousands of residential units in obsolete buildings have been demolished and new Urban Centres, Urban Neighborhoods and Garden Cities have been built.
The most famous examples are the 3 huge building bars at La Courneuve each one accommodating 4.000 inhabitants and demolished in les than 10 seconds. However, more interventions have been implemented at Maison Alfort, Neuilly sur Seine, Clamart, etc.
This paper illustrates 3 Case-Studies: the new 80.000 inhabitants Garden City at Val d'Europe, the new Urban Centre and Garden City at Le Plessis Robinson, and the New Urban Centre for the Garden City at Yerres.
These interventions can be regarded as the follow-up of 1970s process of construction of the first 5 Villes Nouvelles around Paris.
All these 3 Case-Studies show an important presence of Social Housing integrated into the Mixed-Use Urban Structure for around 35%.

Keywords
Urban Regeneration, Building Type, Mixed-Use, Social Housing, Garden Healthy City

Earthquake-resistant timber frame techniques in the Calabrian valleys of Gallico and Catona after the 1908 Messina earthquake: analysis and typological classification

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Abstract
The catastrophic earthquake that hit the area of the Strait of Messina on 28 December 1908 stimulated an immediate re-evaluation of historical anti-seismic construction techniques, the memory of which had been gradually lost following the experiences of the late 18th century. The adoption in seismic contexts of the *baraccata* system, based on the use of timber framing embedded in the masonry, was in fact already regulated in 1784, but the absence of subsequent major earthquakes disincentivised its use in southern Calabria over the following century.
The effects of the earthquakes in Palmi in 1894, southern Calabria in 1905 and, lastly, that of 1908, however, highlighted the vulnerability of masonry buildings in the Reggio Calabria area, thus representing the spur for a reconstruction marked by the extensive use of timber as a structural material. In the fifteen years following the earthquake, there was a constant and diversified use of anti-seismic timber frame construction techniques: from slender *intelaiata* structures without masonry cladding to baraccata buildings built in accordance with regulatory requirements, including different typological variants depending on the form and position of the frame and the type of masonry used.
The survey of the buildings in the settlements along the Gallico and Catona valleys to the north of Reggio Calabria – in particular, an analysis of the numerous ruined buildings scattered throughout the territory and of some recent restoration works – highlights the widespread use of these building systems. Regulated by building codes but resulting from an often spontaneous and emergency constructive practice, it constitutes a cultural heritage of considerable importance; its knowledge, also aimed at a greater understanding of its conservation features, is therefore an essential condition for the valorisation of the entire territory.

Keywords
Timber framed structure, 1908 Messina earthquake, post-seismic reconstruction, anti-seismic constructive system, casa baraccata

The archival document in support of architectural heritage enhancement: comparing approaches and purposes in Messina and Ticino

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Abstract
Knowledge and preservation of documentation relating to existing architecture are necessary condition for its enhancement. Firstly, through the study of archival material, it is possible to reconstruct the genesis of an architectural project. Consultation of drawings, technical reports, site photographs and other documents provides an excellent opportunity to conduct in-depth historical studies of specific architectural heritage. Bibliographic sources can help to complete the research. Secondly, because through new documentation, the result of research and studies carried out directly on the studied heritage, can initiate practices for the conservation, enhancement and renovation of existing architecture. In this sense, a digital approach facilitates the acquisition of information from the paper and simplifies the link with subsequent dissemination and/or operational stages.
This article presents a research experience conducted by the *Laboratorio di Studi doCme 1908 - Centro di Documentazione per Messina* - of the Department of Engineering of the University of Messina and the work of the *Archivio del Moderno* of the *Accademia di Architettura in Mendrisio* (*Università della Svizzera Italiana*). The article analyses the themes of researching historical sources, filing, and systematising archival documentation. Reading these two experiences in parallel made it possible to juxtapose research approaches aimed at the protection of historical material and its dissemination. It was also an opportunity to rethink a possible model for the inventory of archival documentation, suitable for the narration of the phenomenon of urban stratification and, at the same time, for the enhancement of the architectural heritage resulting from this slow phenomenon, both in the context of Messina and Ticino.

Keywords
Archival Documentation, Inventory, Digitization, Messina, Ticino

Small towns' heritage: resilient strategies and projects for their regeneration. The case study of Tocco da Casauria in the Abruzzo region

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Abstract

The large number of studies concerning the small towns mainly focused on the recognition and conservation of their values, especially ranging from morphological and settlement arrangement to typological and construction features: they are indeed representative of a multilayered and widespread heritage which is relevant in the national framework for its quantity and quality. Unfortunately, the strategies and practices applied so far weren't able to effectively counterbalance the dynamics of depopulation and socio-economic crisis, also connected to disaster events, which are typical of this particular heritage. However, the recent health emergency of Covid-19 demonstrated the critical issues of high-density settlement models and that small towns can still represent an available resource: they can trigger regeneration processes whose suitability engages a reflection about the effective implementation of new housing and use models, also related to cultural and production activities. These considerations were reported in the projects of the "Integrated workshop for graduation thesis of the courses Building Reuse and Conservation - Materials and Techniques for Building Reuse", that especially concerned the settlement models and the architectural heritage that characterize the threshold landscape of the piedmont areas of the Abruzzo region. The hypothesis of recovery of the small town named Tocco da Casauria and of its Caracciolo Castle is included into this framework of experimentation activities, with the aim of proposing the regeneration of the fortified settlement through strategies of cultural improvement and promotion of local resources. The architectural project foresees to newly shape the building set of the town and its edges with a technical language that fits the historical surrounding and to highlight the new system of relationships between the castle and the small town.

Keywords

Small villages, resilient palimpsest, regenerative processes, design methodology, capacity building

B_BUILDING CONSTRUCTION AND PERFORMANCE

Assessing Dispersion and Deposition Patterns of Particulate Matter within Deep Urban Canyons: Implications on UGI Design

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Abstract

Urban air pollution poses a significant threat to both human health and the integrity of built environments. Given their substantial potential in mitigating and managing vulnerabilities and risks, architectural engineering and urban planning represent vital disciplines whose scientific research plays a pivotal role in the preservation of the built environment. Given the complex relationship between urban layout, meteorological conditions, greenery parameters, and atmospheric pollutant concentrations, several studies have established frameworks and guidelines around the urban canopy axioms. However, the previous research methodologies revealed certain gaps in our comprehension of this intricate dynamic, hindering the comprehensive assessment of urban air pollution. Specifically, the intricate dynamics of dispersion and deposition of Particulate Matter (PM) with the presence of urban green infrastructure (UGI) constitute significant challenges within the confines of narrow urban spaces. This poses a significant obstacle for policymakers and urban planners, despite the array of available scientific methodologies, as UGI intervention is mostly tailored to specific contexts. This paper synthesizes an analytical methodology for assessing the dispersion and deposition patterns of particulate matter within deep urban canyons. Through an empirical investigation of different vegetation interventions within a prototypical setting in Alexandria, Egypt, the study dissects the intricate interplay of variables influencing dispersion and deposition indicators. The findings reveals that, even within a narrow and low-porosity canyon, dispersion remains a highly influential factor in PM concentration, surpassing the deposition impact, while the latest exhibits minimal impact primarily affecting lower heights. The research underscore the imperative to address these two distinct aerodynamic mechanisms separately, as each holds potential implications for air quality at different heights within the urban canyon environment.

Keywords

Urban Canyon, Particulate Matter, Deposition, Dispersion, Urban Green Infrastructure

Energy refurbishment of hotels in Greece and Italy. The validation of S.O.L.E.H. expeditive tool

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Abstract
The target of the "Road Map of Efficient Europe" is to refurbish the buildings stock in 1945-2000 that is responsible of the 41% of energy consumption – the 2/3 of this consumption are spent for heating and cooling – with the reduction of greenhouse gas emissions and consumption of raw materials.
The hotels building stock allows to investigate many operative features to improve the effectiveness of energy refurbishment process. S.O.L.E.H. (Sustainable Operation Low-cost Energy for Hotels) project proposed an expeditive tool to facilitate the refurbishment process of hotels in Mediterranean countries, making the hotel building stock more efficient and the tourism industry more competitive.
The project's goals were: to identify innovative solutions by stimulating the targeted use of technological tools, to take care of communication for the stakeholder; to make the hotel building stock more efficient and the tourism industry more competitive; to refurbish existing buildings with a view to sustainability and circular economy. The project is a collaboration between Universities of Padua, Venice and Thessaly and it was funded by POR-FSE Regione Veneto (2014-20).
As every simplified energy tool, it must be checked about the consumption and energy saving data, both concerning the in-put and out-put, to validate the tool itself. The paper presents one of the calculation checks carried out by a real case study in Alexandroupolis (Evros, Greece) underling the gap between the data of tool's simulation and the complete one done with EnergyPlus+®. The work is part of an ongoing research between Italy and Greece aiming to set shared practices and tool to improve the refurbishment process in Mediterranean countries.

Keywords
Energy refurbishment, hotels, Greece, S.O.L.E.H., expeditive tools

Unveiling User Actions: a novel framework for decision-making in design and operation of healthy, responsive, and sustainable buildings

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Abstract
The impact of user behaviour on the building's operational model is one of the key research topics in recent years, given the vulnerability of buildings linked to user behaviour (i.e., energy use variance) and their safety and health risks (e.g., sick building syndrome). Available solution strategies and optimization approaches, such as behavioural and people-centred aspects, yet require high economical and computing costs (e.g., facilities, sensor deployment, maintenance, data collection, processing, and storage), high data accuracy and communication stability. In addition, remain closely tied to assess domains individually and with low system interoperability, resulting in limited system responsiveness worsened by inadequate privacy management policies. This work introduces a pivoting new approach to building design and operation by understanding the complex interactions between users and the built environment, encompassing physical, visual, and sensory dimensions. Unlike conventional methodologies relying on survey-based behavioural sampling or sensor data analysis, this proposal employs direct observation of behaviours, associating them with environmental and perception triggers, based on the assumption that no interventions imply acceptance of the surroundings (tacitly assessing adaptation and tolerance). The study structures and weights the associations between user action/interactions with diverse building elements/objects (e.g., windows, shading devices, doors), facilitates the promotion of pro-environmental behaviours by enabling a rapid identification and evaluation of the distributed impacts on different domains (i.e., health, well-being, safety, energy efficiency, privacy, accessibility), and enables data management cost reductions in smart buildings (i.e., fosters lower data storage needs and data-driven model complexities).

Keywords
Behavioural design, multi-objective approach, comfort, wellbeing, health, building science

Implementing Circular Economy strategies for applications in construction: optimizing cellulose-based waste in building materials

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Abstract
Integrating wastes in construction and building materials represents a promising possibility to implement circular economy (CE) in construction. This approach, conceived to solve the waste production issue, is recognized for its sustainability and efficiency as it exploits unused materials as valuable resources for the production of novel building materials. In this context, special attention is given to cellulose fibres, used for their lightweight nature and mechanical strength that can be exploited to improve materials performance for applications in construction. This paper offers an overview cellulose-based wastes use in construction, exploring characteristics and potential applications. As some relevant examples, cellulose fibers can serve as lightening elements in building blocks and reinforcements for cementitious composites. Moreover, cellulose fibres show a high-energy performance with reduced environmental impact compared to other insulating materials. This significantly contributes to the energy efficiency in buildings. In order to decrease reliance on virgin fibres, three types of cellulose-based wastes are discussed: olive stones (as agricultural waste), waste-paper (as municipal waste), and paper industry by-products (as industrial waste). The analysed wastes, that integrate technological innovation and environmental awareness, outline a prospective scenario in which the development of novel construction materials is in line with the environmental standards, following the principles of the CE and energy efficiency strategies. This study is component of two PhD theses focusing on the reutilisation of wastes from various sectors in the field of building materials. More particularly, one of these is developed under the National Recovery and Resilience Plan (PNRR) and is aimed at investigating green solutions to improve the energy efficiency in buildings by valorising and reusing secondary raw materials.

Keywords
Circular economy, building materials, cellulose waste, olive waste, paper waste

Climate change impact assessment and evaluation of retrofit measures of a representative school in Southern Italy

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Abstract

The ongoing climate policies offer good opportunities for school renovation, aiming at minimizing Greenhouse Gases emissions by retrofitting the existing building stock, both residential and not. Moreover, mandatory upgrading of the performance of existing buildings in compliance with energy standards is an increasingly real possibility. For these opportunities to be properly pursued, further studies at the building-level are required to explore the school energy performance not only in the current but also in the future climate, as well as to identify effective retrofit solutions which could improve school resilience to climate change. Accordingly, the present study aims to evaluate the climate change impact on energy performance of a representative school of the Apulian school building stock. For this purpose, the building was modelled in a Building Performance Simulation (BPS) software, calibrated, and its performance analysed in both the present and future climate scenarios generated through the Future Weather Generator tool, based on the new AR6 Socioeconomic Pathways (SSPs) scenarios. Then, assuming that climate policies require existing buildings to be retrofitted to specific targets, the effectiveness of different retrofit solutions was compared with an energy retrofit in compliance with the reference building required by the Italian law, through a life-cycle cost analysis, in which also the changing climate conditions were taken into account. Finally, the most effective combinations of retrofit measures were evaluated by means of an optimisation problem aimed at maximizing benefits compared with the base case. Surprisingly, from a cost-benefit point of view, the reference building already appeared to be an optimal solution, although from a mere energy perspective, better performance can be achieved.

Keywords

Architectural engineering, school building, climate change, energy performance, optimisation

An IT Tool for Managing Seismic Risk and Energy Performance of the Building Stock in Southern Italy

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Abstract
The effective management of seismic risk in Italian historic centres is paramount to preserving the cultural heritage and ensuring the safety and resilience of the built environment. In this context, analysing seismic risk with the support of modern data acquisition methods is crucial for defining the interventions at different scales, from the urban to the single-building levels. However, there is still a lack of integrated digital methodologies and tools for evaluating risks, damage scenarios and the impact of interventions with a multi-scale approach. This paper introduces the early phase of creating GENESIS, an open-source computational web platform. It aims to facilitate the efficient management and mindful utilization of built cultural heritage by prioritizing cost-effective interventions and optimising the allocation of resources for long-term heritage preservation. In particular, GENESIS proposes a multi-scale combined structural and energy risk analysis, suggesting interventions to enhance the resilience of the built environment. The system not only supports structural rehabilitation but also proposes measures to preserve energy consumption while respecting the cultural value of the built assets. The input data are processed at different levels of increasing accuracy, enabling analysis at the urban level, district level, and aggregate/building level. The platform is developed for the historic centres of cities in southern Italy in their current state, but the scalability of the proposed approach allows for applicability to any historic centre. It will also be updatable over time and space.

Keywords
Multi-scale risk analysis, web-platform, historic built environment, structural rehabilitation, energy efficiency

Behavioral-based multi-risk mitigation in historic squares: applying the BE S²ECURe approach to Piazza dell'Odegitria, Bari

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Abstract

Risks due to air pollution and heatwaves are increasing in historic city centers, slowly affecting communities' behaviors in normal use of outdoor spaces. In this context, historic squares are the most relevant scenarios, due to users' attraction according to cultural, social and leisure activities, and to morphology. Squares are also prone to sudden events implying evacuation, like terrorist acts, being ideal targets for perpetrators. The design of mitigation strategies should jointly consider all these risks and include users' behaviors as a fundamental driver to assess strategies effectiveness. The BE S²ECURe project developed a behavioral-based method to evaluate mitigation strategies effectiveness in squares, from single and multi-risk standpoints, demonstrating their capabilities in idealized scenarios. This study hence aims at showcasing this method on Piazza dell'Odegitria (Bari), for heatwaves, air pollution and terrorist acts. Starting from an inventory assessed in typological scenarios, mitigation strategies are selected depending on their compatibility with heritage features and square uses. Behavioral simulations in single and combined events (i.e. heatwaves altering users' exposure to terrorist acts) are performed using validated BE S²ECURe tools, in pre and post-retrofit scenarios. Comparisons are then performed organizing simulation outputs into BE S²ECURe indicators. Results show that, considering single strategies, engineered planters can reduce multi-risk up to about 13%, mainly acting on terrorist act evacuation and users' protection. If overlapping these effects to cool pavement implementation, multi-risk reduction slightly improves (-14%) but effects to SLODs can be achieved, thus suggesting the advantages of redundancy solutions. The showcase demonstration of method capabilities confirms how decision makers could exploit the approach for preliminary mitigation strategies analysis.

Keywords

Historic squares, multi-risk, mitigation strategy, BE S2ECURe, sustainable built environment

Building sustainability with volcanic ash: a green roof system innovation

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Abstract
This research introduces a novel approach to urban sustainability through the application of volcanic ash in green roof systems. Addressing the ecological challenges of urban heat islands and biodiversity loss, the study explores the potential of volcanic ash as a sustainable and efficient alternative to traditional green roof materials. Its unique properties, including superior water retention, effective drainage capabilities, and beneficial minerals, are thoroughly investigated. The methodology involves the systematic collection and processing of volcanic ash samples, followed by a series of comprehensive analyses. These include particle size distribution, compaction characteristics, and hydraulic properties. The study provides a comparative evaluation of volcanic ash in green roof applications, highlighting its advantages such as lower energy requirements for processing, reduced structural load, and potential for decreased long-term maintenance costs. Furthermore, the environmental impact, cost-effectiveness, and alignment of volcanic ash use with global sustainability goals are critically assessed. Moreover, building energy simulation is implemented to simulate the energy performance of a building equipped with a volcanic ash-based green roof system in comparison to commercial substrates and estimate the possible real efficacy of the proposed solution. The research concludes that volcanic ash significantly enhances the sustainability and resilience of urban environments, offering a scalable and environmentally friendly solution for green infrastructure development. It paves the way for further exploration and application in urban settings, promoting ecological balance and advancing sustainable urban planning.

Keywords
Volcanic Material Applications, Urban Ecological Balance, Green Roof Technology, Virtual Energy Simulation, Circular Economy

Smart locks for sustainable spaces: implementing sufficiency principles to building management for carbon saving

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Abstract

The present work introduces a new strategy for the reduction of building energy needs through the use of smart locking systems. The alternative approach focuses on enhancing energy efficiency and operational resource utilization, exploring their application as management systems to improve building use through strategies such as partitioning, schedule optimization, and on-demand occupancy, aligning with the evolving landscape of smart workplaces. By offering not only insights but also a test case study and detailed recommendations, this document advocates for the adoption of these systems as a strategic approach to reduce energy consumption, optimize resource allocation, and enhance overall building management across diverse settings. An LCA analysis is conducted to compare mechanical and electronic devices, as well as to evaluate the anticipated environmental impact of system production and installation. The analysis demonstrates how the initial environmental footprint, related to the system installation, can be effectively mitigated over the system's service life through the efficiencies gained from optimized building management practices.

Keywords

Locking systems, occupancy profiles, energy saving, LCA, resource optimization

Damage to technical elements of the building envelope in the typical multi-risk scenario of the Campi Flegrei area

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Abstract
Damage to technical elements of the building envelope can have unacceptable consequences for the functionality and safety of a building. Recent interest in such damage is mostly linked to intensive events, neglecting the study of extensive events. Despite the known connection between technical envelope vulnerability and building functionality and safety, systematic vulnerability studies are missing. This study proposes investigation sheets for damaged technical elements as preliminary tools for assessing envelope vulnerability and hazardous events, related to this vulnerability, in urban areas. The study focuses on frequent but non-catastrophic hazards, typical of the Campi Flegrei area, where recent bradyseismic activity has renewed national interest and necessitated risk prevention measures. The research methodology involves three phases: identification of the most vulnerable technical elements, comparison with bibliographic data, and direct application in a multi-risk scenario, specifically bradyseismic activity combined with different environmental exposures. Analysis reveals balconies and cornices as the most frequently damaged elements, particularly vulnerable to bradyseismic activity and environmental exposure. Associations between observed damage and hazard characteristics will support the identification of the degradation pattern of technical elements which is needed to analyse their vulnerability and to assess the risk onto the urban system associate with it.

Keywords
Building risk, building envelope, bradyseism, multi-risk, damage

Recent advancements of semi-transparent photovoltaic technologies for innovative BIPV products

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Abstract
In 2022, buildings accounted for about 37% of CO_2 emissions. In order to meet the Paris Agreement requirements within the 2030, reducing CO_2 emissions in the building sector is mandatory. By using building envelopes with adequate insulation and transparency to let natural light and solar heat gain into the indoor environment, heating, cooling, and artificial light consumption and CO_2 emissions related may be reduced. Since BIPV systems are part of the building envelope, advancements in their application can provide technical, technological, and financial answers to environmental problems. Moreover, BIPV systems also have an aesthetic impact on the formal characterization of building envelope. Latest development in 3D glass components coupled with emerging photovoltaic technology is shown in this paper. This work shows the results of the simulations (in terms of thermal transmittance, solar heat gain coefficient, and visual transmittance) carried out on 3D glass elements integrated with Luminescent Solar Concentrators (LSC) and Semi-Transparent Perovskite Solar Cells (STPSC). In accordance with EN 50583 Photovoltaics in Buildings simulations have been carried out for understanding the performance behaviour of these innovative BIPV components for translucent façades. 20 hypotheses -including Dye-Sensitized Solar Cells (DSSC), already analysed in previous research activities-, LSC devices, and STPSC, were analysed during the ongoing research and are synthesized in this paper. Visible transmittance (VT) results are interesting since this increase the aesthetic potential of 3D glass components compared with opaque BIPV technology that are more widely used, and furthermore the effect of the novel product into the indoor comfort is remarkable, meanwhile thermal parameters did not report significant variations in comparison with previous tested hypotheses.

Keywords
BIPV, Façades, Dye-Sensitized Solar Cells (DSSC), Semi-transparent Perovskite Solar Cells (STPSC), Luminescent Solar Concentrators (LSC)

Strategies to face overheating in industrial buildings located in Mediterranean climate area

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Abstract

Most of the Italian industrial buildings are outdated, mainly built in the 70s and 80s and characterized by several energy-related issues during both winter and summer seasons. As for the latter, in most industrial facilities a cooling system is not installed. Consequently, the thermal comfort of employees within the working space might be not guaranteed during the hottest days when the peak indoor air temperature can also reach very high values. Moreover, the value of cooling degree days is constantly increasing (25% more with respect to 1979) following the current climate change. The rise in external air temperature negatively affects both the energy performance of buildings and the internal thermal comfort of users. Considering this context, the research aims to evaluate some strategies to be applied to existing industrial buildings to face summer overheating. The measures proposed are related to the external envelope, passive natural ventilation, and lighting system. The different analysed alternatives are compared through energy simulations in Design Builder by assessing the internal air temperature value, the energy demand for cooling and the overall energy balance through the external envelope. In general, strategies focusing on the enhancement of the external envelope proved to be more effective in reducing summer overheating than the ones related to natural ventilation. The combination of the reduction of the skylight area and the cool roof strategy results in a peak reduction in the internal air temperature equal to 3°C. Considering the occupancy time the reduction in the average indoor air temperature is instead equal to 2.5°C. Natural ventilation in terms of night cooling is particularly effective during the first hours of working time while the installation of LED lighting affects overheating to a lesser extent.

Keywords

Overheating, industrial buildings, passive strategies, natural ventilation, cool roof

Indoor Air Quality in Apulian school buildings: the case of J. F. Kennedy pre-school in Bari

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Abstract

The importance of air quality in indoor environments has gained significant attention due to the Coronavirus pandemic: the risk of airborne transmission of the virus has made it imperative to reconsider many aspects of building design. Among the various categories of buildings, it is crucial to pay attention to schools' buildings. This paper presents a detailed summary of the research conducted to analyse the indoor air quality inside a kindergarten in the province of Bari. Among school buildings, kindergartens represent a particular exception because they host children aged 3-6 years, who are extremely sensitive to indoor air quality. To analyse the comfort inside the classrooms, a monitoring campaign of indoor air quality parameters was conducted in two classrooms of the school used as a sample for this investigation. The data analysis provided interesting findings regarding the classroom temperature variations, the levels of relative humidity, and users' behaviour. The temperature variations detected during the monitoring are significant and can be attributed to infiltrations due to obsolete window frames, while the levels of relative humidity do not fall within the ranges indicated by regulations for many of the monitored days. The data obtained from the temperatures and regarding ventilation were implemented within the energy model of the kindergarten; the energy model was subsequently calibrated according to the ASHRAE 14:2014 Guidelines. Starting from the size of the classroom, occupancy, and the age of the users, simulations of the accumulated CO_2 levels were carried out; to perform these simulations, ventilation scenarios reflecting both summer and winter ventilation practices were hypothesized. The results demonstrate how CO_2 concentrations tend to reach significantly higher levels in the winter seasons: this factor represents a problem for users' comfort and shows the need to reconsider the design strategies of school buildings.

Keywords

School Buildings, Indoor Air Quality, ventilation strategies, carbon dioxide levels, Sustainable design

The fire vulnerability of insulating materials for residential building energy efficiency: from unawareness of early applications to desirable formulation of certification protocols

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Abstract
Governments are implementing regulatory adjustments, performance standards, and economic incentives to increase the efficiency of existing buildings. Special attention is being given to improving the energy efficiency of the opaque envelope. This involves using insulation materials with high thermal performance, which may not be as safe in the event of fire. The use of external thermal insulation systems in building construction over the last 20 years has resulted in a significant reduction in safety. This is due to the potential for dangerous consequences, both structurally and for the safety of people, in the event of a fire.
Evidence of these serious effects can be found in many buildings that have undergone envelope upgrading. It has been discovered that the placement of new products on building facades can contribute to the rapid spread of fire, regardless of the location of ignition inside or outside the building.
This contribution aims to analyse the supranational regulatory system to understand its evolution, identify gaps, and highlight good fire safety practices for upgrading the performance of existing buildings. A survey was conducted to determine the causes of fires worldwide and to evaluate the contribution of certified and non-certified insulation systems. The aim was to assess the adequacy of EU fire safety thresholds and to identify production chains that have shown greater sensitivity to the identified issues. We considered environmental sustainability protocols aimed at improving the quality of the built environment. We questioned the scientific landscape to understand the actions being taken to extend certification to fire safety, an aspect that is still too often overlooked. Professional training to deal with fire risks in interventions on the building heritage is encouraged in all EU countries to varying degrees. Good disciplinary practices summarise this issue.

Keywords
Energy requalification, Thermal insulators, Fire risk building, Fire Regulatory, Fire protocols

BIM and code checking for school buildings: standard checks for IAQ

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Abstract
The use of code checking within Building Information Modeling (BIM) process is constantly growing due to the automation of some verification steps, both in research and in construction practice. These applications, in the context of existing buildings, allow to consider design and management critical issues in order to improve the quality of life of users, as well as the Indoor Environmental Quality (IEQ). The school building heritage is particularly significant, in terms of consistency, construction value and population involved, necessitating rules for rapid assessment for a vast quantity of buildings managed by public entities.
This research aims to assess BIM's effectiveness in streamlining regulatory checks for school buildings, focusing on dimensional accuracy and indoor air quality compliance. Dimensional checks ensure adherence to design and safety standards, facilitated by BIM's creation of accurate 3D models for real-time assessments. Among the domains of IEQ, the Indoor air quality is another critical aspect of school buildings, directly impacting the health and well-being of occupants. BIM can facilitate the integration of relevant data and can help optimize ventilation systems to ensuring compliance with indoor air quality regulations or evaluate critical issues of technical elements in the quantification of natural air exchanges, and provide management application indications. The study evaluates the challenges, successes, and lessons learned from the implementation, providing insights into the broader applicability of BIM for regulatory compliance in school building heritage. The paper focuses on the practical application of these digital tools, using the Rizzo Institute in Rome as a case study. By implementing BIM for building management, it was possible to guarantee that the school building meets the rigorous regulatory requirements and verify any critical issues, providing the administration with useful application feedback on how to control the spaces used and guarantee effective air exchanges in the classrooms.

Keywords
BIM, code checking, IEQ, IAQ, regulatory checks, built heritage

GIS and UBEM: analysing the buildings stock open data for urban energy modelling

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Abstract
Geographic Information Systems (GIS) can effectively support Urban Building Energy Modelling (UBEM) approaches, which are increasingly implemented and adopted to assess the energy performance of the existing built environment. GIS data may provide a suitable input base to perform building energy analysis at an urban scale. In this context, this manuscript first analyses geospatial open data both quantitatively and qualitatively, as they may supply useful input data sets to enable UBEM-based simulations. Moreover, this contribution also proposes a methodological workflow to effectively cross-check and pre-process geospatial open data, by also providing a GIS tool specifically implemented through the QGIS (Quantum GIS) graphical model designer. The proposed tool allows a user to automatically pre-process georeferenced open data and generate a suitable input file for UBEM simulations inside QGIS environment. It is also worth specifying that the herein advanced method is conceived to provide the georeferenced input data set required to perform UBEM simulations through the open-source EUReCA tool, freely released by the BETALAB research group of the University of Padova (Padova, Italy). The presented methodological workflow is a preliminary outcome of the ongoing research conducted withing the scope of the NEST (Network for Energy Sustainable Technologies) Task 8.4.7 project concerning "Urban Building Energy Modelling (UBEM) and urban green infrastructures modelling for Renewable Energy Communities (REC) and Positive Energy Districts (PED)", financed by the European Union –NextGenerationEU– and coordinated by the University of Padova.
At the end of the paper, the main findings and results derived from the application of the proposed tool to a case study area in Cagliari (Italy) are discussed to point out strengths and weaknesses of the method, by also bringing to light some relevant gaps affecting open geospatial data sets.

Keywords
Geographic information system (GIS), urban building energy modelling (UBEM), open data, geospatial data

Greening intervention strategies for the enhancement of urban resilience of public buildings and open spaces

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Abstract
Densely built-up urban areas, such as historic centres or adjacent and peripheral areas, often exhibit a deficiency of public green spaces and poor environmental qualities. Urgent regenerations of these areas are imperative to enhance the overall quality of life for inhabitants. Considering these aspects, this paper documents ongoing research aiming to propose integrated interventions on extensive public buildings or complexes including health facilities, schools, administrative buildings, and public social housing, often occupying entire blocks or extensive portions of urban fabric. Courtyards, cloisters, and nearby open spaces, coupled with substantial roof areas, provide opportunities for large-scale actions to augment permeable surfaces, expand public green spaces, and thereby facilitate adaptation and mitigation to climate change.
The research aims to establish a multi-criteria methodology suitable for selecting suitable buildings and open spaces to undergo greening interventions. Following mapping, filing and classification phases, the evaluation of public buildings in this analysis considers typological, constructive, urban, and environmental characteristics to identify their readiness to undergo greening interventions and to define the most effective strategies to increase permeable surfaces, enhance microclimate, optimize botanical and hydraulic behaviour, and ensure economic and durable solutions. Furthermore, such interventions, integrated into comprehensive urban regeneration strategies, transform indoor open spaces into public green areas, creating a "network of public greenways" in neighbourhoods lacking such spaces. This approach contributes to human and urban health perspectives. Finally, the results of this study aim to provide robust support for decision-makers in defining effective greening interventions, both at building and urban scales.

Keywords
Human health, Urban green spaces, Green building envelope, Urban resilience, Nature-based Solutions (NBSs)

Early detection of facing-masonry surface biodeterioration through convolutional neural networks

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Abstract

Preventive conservation is the proposed and recommended approach to preserve historic building heritage from deterioration problems caused by several types of actions. It is based on data collection, steady monitoring, inspections, and control of environmental agents. Architectural heritage is subjected to many deterioration issues caused by different types of pathologies, among which attention must certainly be paid to the growth of living microorganisms (bio-colonization). Monitoring actions able to represent the evolution of buildings' deterioration state have been proposed and implemented towards the creation of predictive models based on machine learning methods with the aim to reduce the need for major interventions. In this paper is proposed a method for the early detection of microalgae growth on facing-masonry surfaces. Images representing the microalgae growth process on facing-masonry facades, collected during experimental activities in controlled conditions, were used for training and testing a convolutional neural network. The trained model can ensure an accuracy of 83% and is able to recognize the starts of the bio-colonization process on different types of clay bricks. The work shows that, by processing these images with the trained convolutional neural network, it is possible to disclose the first stage of bio-deterioration phenomena. This work is part of a more extensive research for the early detection of different types of building facade damages and could be implemented for real cases monitoring.

Keywords

Biodeterioration, historical buildings, convolutional neural network, machine learning, monitoring

User-centric Design Approaches: Understanding Preferences for Indoor Environmental Quality in Educational Spaces

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Abstract

Indoor environmental quality (IEQ) within buildings significantly affects occupants' health, well-being, satisfaction, and productivity. Understanding how spaces can be designed to meet individuals' needs is crucial. This study conducted three surveys to explore the relationship between comfort parameters and occupants' perceptions and preferences of space. The questionnaires aimed to investigate this correlation and extract insights into how environmental conditions shape seating arrangements. The research seeks to provide a comprehensive understanding of the dynamics between daylight exposure, thermal comfort, external views, visual privacy, and seating choices in a shared study space. The findings will contribute to inform architectural and design practices on behavioural variations.

In total 384 students were surveyed. Results from the surveys underscored the importance of thermal and daylight parameters within indoor environmental conditions, as they strongly impact students' efficiency and productivity. Other results revealed how visual comfort preferences and neutrality assessment could vary from the standardized prescription depending on daylight availability. Illuminance values from 0.5 to 3 times more than the standard requirement (500 lux) were considered acceptable. At last, the answers demonstrated that under homogeneous thermal and visual comfort conditions, participants favoured seats less visually exposed. Throughout all the surveys, outdoor view was consistently the least influential parameter in seat selection. The findings suggest the potentiality for design approaches implementing user feedback to align with students' preferences for enhanced comfort in educational environments.

Keywords

User-centred design, indoor environmental quality, personalized human comfort, seat preference, daylight perception

Accessibility beyond architectural barriers: how to broaden perspective and elevate design culture in Italy

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Abstract
Accessibility arises at the confluence of three domains: the person, society, and the environment, and depends on a plurality of indicators and the quality of their interactions. In design disciplines, accessibility aspires to realize the same opportunities for the widest possible range of people. Each environmental element is a link in a chain of relationships, and if one of these links has access problems, the accessibility of the whole system is compromised. The responsibility of designers is therefore strong. The paper focuses on the initiative promoted by Friuli Venezia Giulia Autonomous Region (RAFVG), which through the project FVGAccessibile intends to contribute to the elevation of the design culture of professionals and leveraging the importance of embracing the approach related to Universal Design (UD) starting from the theme of elimination of architectural barriers. With Regional Law 10/2018 and the launch of the project, RAFVG intervene to make up for a deficiency that distinguishes most Italian public administrations: nearly 40 years after the introduction of a national law for the predisposition of PEBAs (Law 41/1986), most of the municipalities have never adopted one. The partnership working on the project, including the two Universities to which the authors belong, enabled the implementation of a series of steps aimed at improving the accessibility of the regional territory and at increasing the quality of designing. The paper presents specific actions and tools set up to guide designers to correctly interpret the meaning of accessibility in line with UD. In addition, FVG is the only italian region to have invested in a digitalized system for the management of PEBAs, granting free access to specific software to the technicians in charge and supporting them with trainings to correctly interpret what a PEBA should mean.

Keywords
Accessibility, universal design, architectural barriers, ontology, training tools

Self-sufficient and responsive textile component

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Abstract
The goal of the present research is the development of an innovative textile component for architecture, which could be an adaptive envelope. In particular, this architectural component will be able to perform both the function of a shading element, in case of application in existing buildings, and of protective and finishing casing, for application to innovative components or, finally, as an autonomous casing, for temporary pavilions or roofing of multifunctional spaces. The casing will be adaptive, as it is capable of taking on different features through a set of actuators, controlled according to the inputs recorded by a specific network of sensors. This will ensure that the shape and position of the enclosure can be adapted according to external climatic factors or user needs, to optimize its performance. The basic textile material will incorporate a photovoltaic production system, so as to be able to produce the energy necessary for its automation. This paper describes the first results of the research, that are the state of the art and the aim of this study.

Keywords
Responsive, textile, envelopes, photovoltaics, textile architecture

Innovative building envelopes with fibre-reinforced composite materials: state of art and possible integrations into ventilated façade systems

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Abstract
The building envelope plays an important role in meeting complex functional requirements and stringent green energy standards. The global energy demand is increasing and most of it is consumed in the building sector. The building envelope, which is responsible for the energy balance of the building, plays the most important role in achieving nearly Zero Energy Buildings (nZEB). In this study, innovative fibre-reinforced composite materials are integrated into certified building envelope system technologies. Variables associated with the production of fibre-reinforced composites are discussed, covering aspects of design, installation, and potential applications such as innovative ventilated façade and BIPV systems. Identification of tools, regulations, and test methods will be essential for evaluating design solutions in specific environments. Long-term performance includes maintenance and durability aspects. Based on a scientific approach and integrated design, the use of new technologies can significantly improve the overall behavior of the building envelope. New strategies to scale up the many discoveries of green recycling through prevention, repair, and ideal reuse, contribute to cost-effective and sustainable practices of this material. This interdisciplinary approach addresses the multifaceted challenges of modern façade systems and paves the way for sustainable and energy-efficient building solutions.

Keywords
Building façade system, pultruded technology, cladding systems, energy efficiency, sustainability

Building automation for passive cooling of office buildings: a case study in Madrid

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Abstract
Office buildings characterized by open-space offices and large windows generally have thermal comfort problems. In the summer period, the amount of thermal discomfort depends mainly on overheating due to thermal loads, such as electrical devices, occupation, and solar radiation entering through the windows. In Mediterranean climate, summer thermal gains are extremely high in these types of buildings, and to achieve the conditions of indoor thermal comfort, air conditioning systems are used excessively and waste a large amount of electrical energy. Efficient solutions to define optimal comfort conditions include passive design strategies such as window shading, and natural ventilation operated by a Building Energy Management Systems (BEMS). The objectives of this paper are to evaluate the conditions of users' comfort in an office building located in Madrid (Spain) and to design a new operational strategy by using the existing solar shadings to control the solar radiation and by using hopper windows to increase natural ventilation. The results of numerical simulations in DesignBuilder highlight an average internal temperature reduction of one degree and an improvement of comfort conditions in the occupied period.

Keywords
Thermal comfort, Building Automation, Office Building, Passive Design, Mediterranean Climate

Future-proofing the existing building stock: a multi-hazard scenario for the Lombardy Region

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Abstract
In recent years the frequency and intensity of natural and meteorological disasters have grown and with it their impacts on the built environment on both the urban scale and the individual building scale. Upon observing these events it becomes evident that the expected performances from buildings have increased and endeavors must be made to ensure their resilience towards a rapidly changing future scenario. In this context, the topic of building resilience is discussed in a comprehensive state-of-the art focusing on the existing building stock and its findings are hereby summarized. This paper begins with a summary of the systematic bibliometric literature review conducted to recognize research trends and keywords to better define the scope of the research. Relevant studies were retrieved and categorized to help formulate the research question. It was understood early on that resilience and sustainability are intertwined and that a truly sustainable building must be resilient towards hazards and disasters, and as a consequence, an important question presented itself: what the best approaches are for achieving an overall building resilience and what improvements can be made, especially considering the challenges for the existing building stock. This paper presents the preliminary results of a literature review finalized to understand the typical damage mechanisms of the different hazards in the Lombardy Region identifying the most vulnerable building typologies and components as well as potential technical solutions (i.e. retrofit techniques) and mitigation strategies. The aim is to identify the main parameters that have to be integrated in a multi-hazard resilient building design framework that consider the long-term impact of climate change on a building and its occupants in addition to structural integrity aspects due to natural disasters that are currently covered by many studies.

Keywords
Building resilience, building refurbishment, hazards, existing building stock, Lombardy Region

Cluster analysis as a basis for local masonry typology

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Abstract
Detailed knowledge of local construction features plays a remarkable role in examining and modelling historic buildings, both in the field of mechanical and energy performances. This study proposes a standard procedure for local masonry typology and explores the use of a statistical tool – cluster analysis – to define historic masonry types in local areas.
The purpose of using cluster analysis as a tool for local masonry typology is to reduce the subjective influence of the observer. Consequently, the accuracy of local context analysis can be maintained, but using a homogeneous typology structure, intended as a general instrument for the detailed thermal and mechanical analysis of historic buildings.
The proposed method was applied to four local contexts, namely the historic centers of four small cities in Sicily: Castel di Lucio, Patti, Santo Stefano di Camastra, and Tusa. All masonry walls with visible arrangement were examined in the case studies, thus collecting a dataset of 157 walls.
Cluster analysis was carried out through the R software, considering each examined wall as an observation. Gower distance was selected as the distance metric. Partitioning Around Medoids algorithm (PAM) and the average silhouette width were used.
Clusters have been identified both analyzing each case study and the entire dataset. In the latter, the analysis resulted in three homogeneous clusters, with average silhouette width equal to 0.46. Distribution of relevant construction features (average dimensions of masonry units and mortar joints, MQI) in the three clusters of the overall dataset suggest classification based on cluster analysis is appropriate to the technical examination of masonry.

Keywords
Masonry typology, Local context, Cluster analysis, MQI, Historic building

A clustering method for identifying energy-related behaviour: the case-study of LIFE SUPERHERO project

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Abstract
Understanding Indoor Environmental Quality (IEQ) in residential buildings is often oversimplified due to the complexity of occupant behaviour in correlation with the variability of contextual factors like building characteristics and outdoor conditions. The Internet of Things has facilitated access to a substantial amount of real-time IEQ data through smart devices. Data mining techniques can support the analysis of such wide available databases. In this sense, clustering and classification algorithms offer advantages in identifying complex relationships and revealing hidden structures. They efficiently extract daily patterns from extensive raw data compared to conventional statistical methods. However, the literature on the application of these processes for IEQ seems to be still limited, mostly focusing on energy consumption. Indeed, this work aims at using these techniques in the context of energy-related behaviours, moving towards multidimensional identification of occupant patterns depending on dynamic factors.
To this end, a room-level monitoring campaign was conducted in 10 rooms of 4 flats, chosen from two multistorey residential social housing buildings in Reggio Emilia, Italy. Monitoring took place throughout the entire summer period in 2022, capturing data on IEQ, outdoor climatic conditions, and building occupant behaviour. The analysis first involved extracting meaningful daily indoor temperature patterns through cluster analysis applied to 128 time-series data curves. Then, post-clustering analyses using classification trees were performed to enhance interpretability, examining the connection between influencing factors and IEQ patterns. Findings suggest that the proposed clustering method effectively detects daily patterns in the IEQ domain and that the post-clustering analysis outcomes provide valuable insights for a better understanding of the factors influencing IEQ (e.g., the importance of occupants' behaviour over other characteristics).

Keywords
Residential buildings, Indoor Environmental Quality, Clustering, Classification, Occupant's behaviour

Wood industry wastes valorisation and reuse for a greener architecture

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Abstract
This study is part of a PhD research supported by PNRR aimed to provide concrete actions to implement greener constructive practices in response to the EU Green Deal and the demand of sustainability in construction. The paper analyses how wastes from the wood industry can be reused for applications in construction, in light of the circular economy (CE) and the industrial symbiosis. The analysed wastes derive from various processes and their heterogeneous nature often makes their incorporation into novel products complex. Also, they may contain contaminants that may limit the reuse options or require special handling procedures. Though, by addressing these issues wood waste reuse can offer significant environmental benefits, such as reducing wastes quantity and saving natural resources, or technological benefits by bringing innovation and sustainability to the sector. Once wood assortments' manufacture was briefly outlined, the various types of waste resultant from each processing phase are analysed to explore possible recycling opportunities and identify challenges and prospects for more efficient, rational, and sustainable management. The study proposed here, focuses on the analysis of materials, products and systems that reuse wastes from the wood industry and the possible applications in construction. Among these, for example, thermoacoustic panels, polymer-based biocomposites, wood-cement panels and blocks are discussed. Furthermore, attention is given to microlaminated wood technology, currently considered a technological implementation to traditional laminated wood. Finally, the crucial role of wood waste recycling as a CE approach is underlined, emphasizing the fundamental contribution to environmental sustainability, the mitigation of climate change, and the creation of new markets and jobs in the construction context.

Keywords
Wood waste, Circular economy, Industrial symbiosis, Environmental sustainability, Innovative materials

Key theoretical lenses for climate equity and resilience in the built environment - a conceptual article

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Abstract

As per the Sustainable Development Goals and the European Climate Action, enhancing the resilience, livability, and sustainability of cities may be achieved primarily through mitigation and adaptation to climate change. Cities are a major worry, especially for those who are more vulnerable, as the effects of climate change are escalating problems for urban regions, such as harsher and more frequent heat waves and urban flooding. One of the planning paradigms that helps engineers, architects, and urban planners create resilient communities and lessen the effects of climate change is known as regenerative design, or RD.

Nevertheless, a number of restrictions currently impede the RD's advancement in light of climate change. By connecting various spatial scales, from the urban/neighborhood to the building scale, and incorporating techniques and tools from different perspectives, such as Decision Making Under Deep Uncertainty (DMDU), this conceptual contribution seeks to overcome the constraints of RD by forging a novel and comprehensive outline and framework for just and equitable, climate-proof, cities. The amalgamation of diverse disciplines and scales will provide an all-encompassing array of instruments and methodologies to facilitate the following: (i) address the complexity deriving from the many interrelated factors composing the built environment; (ii) tackling numerous environmental, equity, and justice concerns; (iii) formulating a framework for implementing a flexible plan for future-proofing urban areas.

This conceptual research is innovative since it attempts to overcome the operational limitations of consolidated paradigms and opens up a new field of application for the DMDU in the urban context.

Keywords

Built environment, Just and equitable cities, Multi-Objective Optimization, DMDU, Regenerative Design

A novel software tool for automated and integrated Building Energy Model calibration

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Abstract
In the EU, the building sector significantly impacts energy consumption and greenhouse gas emissions, accounting for 40% of the total energy use and 35% of emissions, mainly due to the energy inefficiency of the building stock. With energy demand expected to increase over the next decade, improving building energy efficiency is essential for meeting EU sustainability goals. Building Energy Models (BEMs) are crucial for evaluating and enhancing building performance throughout their lifecycle. However, a notable "energy performance gap" usually exists between predicted and actual energy use, exacerbated by challenges in accurately inputting numerous variables and the simplifications inherent in modeling. BEM calibration (BC) approaches are often adopted to reduce these discrepancies, aimed at adjusting model inputs to match output with the observed data. Yet, there is not a universal consensus on which is the best calibration method, with manual and automated approaches offering different benefits. Automated methods, especially those using optimization algorithms, have gained prominence for their efficiency and ability to handle uncertainties. However, BC still significantly depends on the energy modelers' expertise. This paper introduces a novel software tool for automated BC, aiming to simplify the process by integrating expert knowledge, sensitivity analysis, and optimization algorithms techniques in a unique workflow. This tool reduces the dependence of BC success on modeler expertise, representing a significant step towards more accessible automated BC in the research field and engineering practice, thence allowing a more effective design of energy conservation measures.

Keywords
Building Energy Model, Model calibration, Optimization algorithm, Sensitivity analysis, Software

Digital Decision Support System Prototyping for Building Performance Analysis and Management

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Abstract
The ongoing transformation of the AECO sector towards digitalization has led to a growing need for digital decision support systems (DDSS) to aid in managing built heritage. While there have been many technological improvements in this area, creating these digital tools still demands substantial technical and financial investments and highly specialized IT competencies. To respond to this challenge, this paper presents BTwin, a toolkit developed to facilitate the prototyping processes of DDSSs for performance-oriented building management. This open-source software, implemented in Python, allows for integrating building data from multiple sources into graph networks, such as building information models and building performance simulations, meters, and sensors. This integration capability, supported by specific semantic and ontological rules, is complemented by the possibility of quickly displaying the data on interactive dashboards accessible to non-expert users. After explaining the theoretical framework behind the toolkit, the paper showcases its practical application in a university building, focusing on energy- and occupancy-related topics.

Keywords
Built Heritage, Decision Support Systems, Knowledge Graph, Digital Twin, Building Information Modelling

Decay detection and classification on architectural heritage through machine learning methods based on hyperspectral images: an overview on the procedural workflow

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Abstract

Imaging spectroscopy is a well-established technology that allows non-destructive remote analysis of objects in order to detect defects or imperfections in a wide range of the electromagnetic spectrum. In the field of cultural heritage, and especially in the architectural one, the interest for its application is increasing, since it allows to carry out decay assessment surveys in a more accurate way. In combination with machine learning (ML) techniques, hyperspectral imaging (HSI) allows semi-automatic evaluations, overcoming time-consuming operations. In this article we present a general framework for the acquisition and processing of hyperspectral images in order to obtain semi-automatically generated decay maps of historical buildings. Starting from the presentation of basic concepts of spectral imaging, we discuss capturing tools and methods for data collection campaigns. Likewise pre-processing operations and classification algorithms are illustrated, along with datasets, which are usually required for the execution of such elaborations. This work aims to become a reference for those are intended to improve research in the field of conservation of architectural heritage with the application of HSI, presenting a typical workflow to follow for surveys and analysis.

Keywords

Hyperspectral imaging, Machine learning, Architectural heritage, Remote sensing

Technologies of façade systems. Studies for the proposal of a new support system for timber claddings

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Abstract
The essay outlines the initial results of a research project developed within the DPIA (Polytechnic Department of Engineering and Architecture) of the University of Udine. This research laid the foundations for the conception and subsequent experimentation of a new support system for facades timber finishes. Following a brief introduction highlighting the current potential and values of using wood in the context of contemporary construction, the new system for fixing timber elements is described. This includes a substructure that aligns double-framed configurations with vertical posts and horizontal beams into a single plane, using a single base element that can be customized in various dimensional ranges. This results in the formation of regular quadrilateral elements that can extend both horizontally and vertically, thanks to the variability offered by a telescopic movement. The lateral junction of multiple quadrilateral elements is achieved thanks to a cavity on the surface facing the cladding elements, near the corner joint between the two "arms" of a base element. The research is therefore ongoing and it is considering a possible redefinition of the base elements to allow the use of stainless steel open-section profiles, instead of aluminum as initially hypothesized. Laser cutting technologies are being considered for defining the necessary openings and holes.

Keywords
Building Technology, Timber, Façade fixing systems, external cladding, Façade systems

Smart Materials in Construction Sector Decarbonisation: Few-layer graphene based Radiant Heating

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Abstract

In the current era, the European Union (EU) is significantly transitioning towards reducing its carbon footprint, specifically by moving away from fossil fuel-based energy sources within its economic framework. This shift, particularly pronounced within the construction industry, is motivated by environmental concerns, economic imperatives, and geopolitical tensions. A key strategy in this energy transition involves enhancing and modernising heating systems to diminish reliance on natural gas. Within the realm of radiant heating solutions, innovative smart materials are being explored for their ability to convert electrical energy into thermal energy through the Joule heating effect (e.g., self-heating materials). This study focuses on developing and analysing electrically conductive self-heating coatings incorporating pristine few-layer graphene (FLG) as the active component. These coatings, formulated with an acrylic-based binder in a water-based dispersion, demonstrate significantly low electrical resistivity, reaching 0.026 Ω cm. Biasing 12 V DC, the FLG-based coating can achieve a surface temperature of 115 °C within fifteen minutes. Furthermore, the research introduces a novel electric heating panel designed to attain an operational surface temperature of 35 °C within an hour using Extra-Low Voltage (24 V DC). The system also considers the integration of Phase Change Materials (PCMs) to sustain an optimal surface temperature for extended heating applications.

Keywords

Electric heating system, Few-layer Graphene, Smart materials system, Construction sector decarbonization, Innovative building techniques

Assessing the spatiotemporal impact of SLODs in urban square, considering user's exposure and vulnerability

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Abstract
Slow-onset disasters (SLODs), such as increasing temperatures and air pollution, impact the microclimate, health and habits of users in the built environment (BE), especially in outdoor spaces such as squares. While numerous risk assessment methodologies are available for the BE at a macroscopic level, methodologies focused on local analysis of mesoscale elements, are still limited. These spaces play a crucial role in the public life of cities, influencing the activities and behaviours of inhabitants. The SLODs risk in the squares depends primarily on the interaction of various factors, including specific hazards, square characteristics (e.g., morphology, activities, and type of activities and services available), exposure and user characteristics (e.g., health, age, mobility). There is a requirement for methodologies to effectively incorporate all these factors, specifically to enhance the implementation of risk reduction strategies. This work introduces an innovative approach to formulate a user-oriented risk index using a Risk Matrix (RMA), which combines the different factors involved. The proposed method ensures rapid applicability while integrating quantitative analyses (from large datasets, accessible online) and qualitative assessments (from experience and knowledge). It allows for the representation of assessed risk levels through mesoscale maps that show the risk variation as specific local conditions change. The simplicity and versatility of the method facilitate its use by non-experts and local authorities to obtain a quick risk assessment and support the definition of targeted mitigation strategies. The study assessed and mapped local risks in both a real scenario and a project scenario where green areas are implemented, and traffic is reduced. Results highlight the influence of localized features, such as greenery and specific attractions on risk levels (e.g., shops, universities, railway stations).

Keywords
Risk assessment, user behaviour, square, SLODs, user exposure and vulnerability

Simulation-based effectiveness evaluation of typological "best strategies" for single and multi-risk mitigation in historic squares

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Abstract

Squares in historical city centres are challenging scenarios for disaster risk mitigation. Besides their physical vulnerability, they are "hot spots" in both terms of morphology and human factors, being also characterized by overcrowding and the presence of vulnerable users. Thus, mitigation strategies should be designed to be effective in various single-risk and multi-risk scenarios, depending on hosted users' emergency needs and behaviours. This paper aims at determining optimal mitigation strategies against rising temperatures, air pollution, terrorist acts and earthquakes and their combination, using a behavioural simulation-driven methodology. Single risk Key Performance Indicators are defined to combine users' exposure and vulnerability to square features (i.e. morphology, physical vulnerability, climatic attributes, hazard probabilities, and damage levels). Multi-risk metrics are then developed combining these indicators. Input data for indicators and metrics are calculated through validated simulation models, and applications to relevant typological configurations of Italian historic squares are performed considering the scenarios before and after the implementation of literature-based strategies affecting users' behaviours. Results show how implementing greenery and engineered planters can be selected as "best strategies" to face the given risks, since they can both decrease effects on users' health and support evacuation flows in emergency conditions. Being tested in typological (idealized) conditions, this study provides an initial strategies inventory that can be further customized in real-world squares. Decision-makers can evaluate their specific impact using the proposed simulation-based methodology and the proposed indicators and metrics.

Keywords

Historic squares, multi-risk assessment, risk mitigation, behavioural-based design

Residential Building Restoration from the second half of the 20th century. Energy performance improvement methodology: comparison between application in Italy and Spain

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Abstract
In Italy and Spain, almost all Europe, in the second half of the 20th century under the influence of the international style (modern style), several million homes have been built. Something that happened in general throughout Europe. Most of these buildings have been built with cavity wall exterior enclosures, with an air gap inside and without thermal insulation. Starting in the 80s, thermal insulation began to be widely used in both countries but in very small thicknesses (2-4 cm plus air chamber inside), which will have to wait for the European EPBD directives, already in the 21st century, and their transposition to the member states, to be increased to average thicknesses of 8-16 cm (depending on the climatic zone where the building is located, the conductivity of the insulating material, as well as the rest of the envelope). This article addresses, on two different case studies located one in Italy and the other in Spain, the privilege of the reduction of energy demand, passive conditioning, the energy behaviour of the envelope, compared to other measures on active systems (conditioning systems). For this, two energy performance evaluations will be used in two different states, one before and one after the energy restoration, which will be non-invasive and acting on the air gap. The results highlight the energetic privilege of the envelope, what we can call the prerogative of building well, above the dimensioning of thermal conditioning systems and the need for research into new insulation materials to intervene in these types of buildings; within these types of envelopes, safeguarding the architectural heritage of the constructions.

Keywords
Energy efficiency, energy restoration, thermal insulation, energy rating software

Extend and certify the concept of comfort within built spaces

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Abstract
Sustainable environmental development is now recognized as imperative for the survival of our planet. On the other hand, the concept of well-being is evolving, which must be understood as an indispensable sustainability requirement for human beings. Therefore, for a true "sustainable building", it is necessary not only to expand the range of requirements that a building must guarantee but also to find a way to concretely assess the compliance of the built space with the new demand framework. The greater attention to the user implies a broadening of the parameters to be considered and the evaluation of performance becomes the improvement strategy to design (in a new building) or modify the conditions of the internal environment (in an existing building) for the benefit of the well-being of the occupants. Certification tools capable of considering the extended needs of user comfort, applicable on different types of buildings and in various geographical contexts, are therefore indispensable. In the case of pre-existing buildings (in Europe 35% of the total are over 50 years old), a further difficulty for certification derives from the lack of technical and construction information. Among the available certifications, in this work it was chosen to apply the WELL v2 to an existing building intended for offices, which the International Well Building Institute redefined in 2018 for the assessment of human health, well-being in the broadest sense and global sustainability in buildings, through the concepts of air, water, nourishment, light, movement, thermal comfort, sound, materials, mind, community and innovation. Starting from a study already carried out on an existing and already renovated office building, we tried to apply it, compiling in the form of tables the results obtained in the current situation and those that could be obtained with the adjustments hypothesized in the study, thanks to which a good score can be achieved in the certification.

Keywords
Healthy building certification, WELL building standard, Occupant satisfaction, Occupant perceived health and well-being, Healthy building

Effects of different adhesions and solar radiation shieldings on surface temperature sensors measurements for low-budget applications

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Abstract

In the field of architectural engineering, it is often needed to perform building envelope monitoring campaign which may also involve reading temperatures of external surfaces, possibly exposed to solar radiation. Also, it is often necessary to develop cheap setups due to budget issues. Therefore, small size low-cost temperature probes are usually preferred. The present study aims to better investigate low-cost temperature sensors response and transient behaviour for surface temperature measuring by using different types of adhesion and/or gluing and different means of shielding against solar (IR) radiation, among those suitable to be used in building thermal monitoring considering issues like quick installation, low profile, etc. In this respect, two different tests were performed using DS18B20, common digital IC thermometers, to read the surface temperature of a 0.5 mm aluminium-magnesium alloy sheet heated up by IR emitters. For what concerns contact thermal effectiveness, results show that the epoxy resin is the adhesion type that performs best, likely due to a better thermal conductivity and an optimum bonding between the sensor and the support compared to alternative glues. The second test case showed a strong influence of the surface emissivity in the temperature results. Based on the evidences collected, the best option results to be providing probes with shields that have emissivity similar to the surface of the material tested

Keywords

Temperature sensor, low-cost sensor, building envelope, surface temperature, solar shielding

Green and architecture: environmental problems and performance requirements

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Abstract
Urban greenery is currently universally recognized as a mitigator against environmental problems. It's indeed in the cities - where there is the highest concentration of anthropogenic activities - that the effects of pollution and uncontrolled urbanization have caused more damage, with the known phenomenon of "heat islands", especially in the metropolises, undermining the quality of life of its inhabitants.
Numerous data collection on urban dimensions and specific indicators reveal the significant paucity of green spaces in urban realities. So how could greenery be implemented, especially in contexts where sealing and paving of outdoor spaces (squares, parking lots, etc.) have reduced the availability of natural soil?
A simple but effective solution can be offered by the verticalization of green spaces, where the green areas are not only capable of purifying the environment through the retention of CO_2 and particulate matter, but also of improving the building energy performance: the design proposal of the 'Living Wall' on the facade of a public building serves exactly this scope. An analysis of the perimeter surface has been carried out in order to identify and measure the comparison energy efficiency parameters before and after the proposed intervention. The following simulation has confirmed the improvement of the building energy performance: the transmittance values, other than complying with the verification procedure as stated in the Italian decree DM 26.06.2015, show a significant reduction with those of the actual state and are decreased by almost half if compared to the case when only the insulation has been applied.
The model has shown beneficial effects even on the thermal phase shift, a key parameter for both summer comfort and energy savings. Much of the heat affecting the building in the daytime is absorbed in the daytime (retaining it but keeping it out of the internal rooms) and then gradually released in the nighttime when the external heat has subsided.

Keywords
Sustainability, green wall, facade

Artificial Intelligence and Lean Construction: where are we and where are we going?

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Abstract
Lean construction (LC) is nowadays a key management approach for construction projects. Although lean principles and methodologies have progressively been introduced in the Architectural Engineering and Construction (AEC) field since the early nineties, digitalization, Building Information Modeling (BIM) and artificial intelligence are increasing opportunities and potentialities of lean construction, as well as providing construction managers with new methods to control and optimize the building process. Within this scope, this paper elaborates on the multiple digitation levels of lean construction and discusses the application of different Artificial Intelligence (AI) techniques to construction project monitoring and management. Among them, conversational AI represents the real novelty in digital construction processes, allowing a new interaction with construction data based on direct interrogation of datasets and their immediate comprehension, as well as the automation of repetitive tasks such as data entry, document generation, and report creation, or support tasks such as project scheduling, inventory tracking, and identifying data patterns and trends. In the last section of the paper, two AI applications for lean construction, one focused on automatic monitoring of construction works and the other dedicated to material handling and transportation planning, are then presented and discussed.

Keywords
Lean construction, artificial intelligence, building process, generative AI

Nature-based Solutions as climate change adaptation measures: lessons and best-practices from European cities

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Abstract

Climate change is the greatest challenge facing our planet. Heavy overbuilding and the associated sealing of soils in recent decades have limited the availability of green spaces in cities, the fundamental importance of which is now recognised. The urgent need to create more green spaces and areas in the built environment draws attention to nature-based solutions configured as preferred adaptation solutions that enable the built environment to cope with the effects of climate change. The focus of this study is on the impact of climate change on urban areas, which are recognised as a major contributor to greenhouse gas emissions and a significant proportion of energy consumption. After analysing the concept of Nature-based Solutions (NbS) with particular reference to green and blue strategies, this study proposes an investigation of the application of NbS in different European cities in order to define a framework that outlines the phases for the implementation of NbS in urban areas and promotes climate adaptation. This framework consists of five phases, ranging from the definition of the challenge to the monitoring of the proposed solutions, to the phases in which the application circuits, the scale of application and the associated measures to be implemented are defined.

Although cities are defined as complex systems responsible for high energy consumption, this study highlights the key role of nature-based solutions from an environmental, social, and economic perspective, configured as best practices and preferred solutions to test and outline city-level adaptation strategies whose replicability is essential for orienting urban environments towards a sustainable ecological transition. The inclusion of NbS in planning enables the creation of sustainable cities and communities in line with current European policies to achieve climate neutrality and sustainable development goals.

Keywords

Climate risk, climate resilience, urban health, blue and green infrastructures, best-practices, built environment

Building characteristics of the residential asset in Bologna after World War II

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Abstract
Renovation of unlisted built heritage is a topical issue at the European level. In countries such as Italy, there are more than 12 million residential buildings; 86% of them were realized before 1990, thus before the adoption of stringent regulatory standards. In Bologna, many residential buildings in the first suburbs date back to the post-World War II period. These constructions were often built quickly to respond to the growing need for housing due to a relevant population increase, often to the detriment of their construction quality. Through deep archival research, 191 buildings realized within the Municipality between 1947 and 1961 with the adoption of State funds were analysed. These buildings, consisting of 2,260 housing units and 9,335 inhabitants, represent 2% of the city population in 1961. The rich documentation, consisting of working drawings, metric calculations, reports, and photographs, made it possible to determine the following information for each building: general data, typological characteristics, housing unit characteristics, construction characteristics, finishes and facilities. The collected data were implemented in a database and a geographical information system to offer an insight into the ways of the building practice adopted at the time, providing indications both on the ways of living and on the performance in terms of structural, energy and functional distribution.

Keywords
Residential construction, construction characteristics, second post-war period, Municipality of Bologna, subsidised building

Decision Criteria for the Assessment of Building Retrofit integrating Innovative Façade Solutions

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Abstract
In the present environmental and political scenario, energy and carbon issues represent both ecological and economic challenges. The individuation of strategies capable to confront these complex circumstances by improving the quality of urban areas and, moreover, of buildings is considered a priority, as well as identifying paths and technical solutions capable to support this transition. A critical approach to building solutions, operating on existing buildings, could allow it to reach higher efficiency targets and possibly lead to a more aware occupancy. In this scope, adaptive façades enable the retrofit of existing buildings characterized by low energy performance and envelope pathologies, also offering a response to the level of comfort to be ensured for the occupants of the internal spaces. The technological unit of vertical closure influences several factors that form the energy consumption of a building, influencing it by more than 50%. The impact of façade systems on the needs for rational use of resources and user well-being and health opens the way to the implementation of advanced solutions, applied to existing buildings. In this contribution, a framework for the evaluation of eligibility of innovative façade solutions in building retrofit is proposed. A strategy considering these façade solutions can benefit from both established and innovative technologies, both in reaching ambitious targets by an effective and wide application and in providing a leverage to the local building sector in design approach and life-cycle management.

Keywords
Adaptive façade solutions, building retrofit, dynamic response, evaluation criteria

Soil consumption: regenerative solutions for vulnerability management and environmental protection

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Abstract
Huge soil consumption is one of the main factors of degradation at a global level: "Land consumption implies its fragmentation with artificial elements that constitute real barriers in terms of connectivity of the ecological network". The term 'land consumption' denotes the 'unsustainable' use of a strategic non-renewable resource that identifies its progressive depletion. Deciding what is meant and what should be classified as 'consumed' soil is crucial both for understanding how to detect and measure the phenomenon and for identifying strategies and actions to govern it. With this in mind, the contribution intends to investigate the reasons and risks of pathological urban sprawl by evaluating new mitigation and compensation tools. In particular, NBS (Nature Based Solutions) must become key resources both to base land governance on soil protection principles and to mitigate the effects of climate change and its impacts on people, such as extreme events and heat waves, and to reduce pollution through reforestation and renaturation of the city. The 'inhabited organisms' will have to orient themselves towards new rules of architecture-nature, to measure themselves against new technologies and new regulations, to find new forms of identity in relation to climate, exposure, the varied vegetation of places, landscape and culture.
Every place, every space, every city will therefore have a forest that is different in shape, height, plants, etc., but also because the inhabitants who inhabit these living organisms will contribute to building it by imbuing it with their own culture and identity. How to do this will be the challenge of our century.

Keywords
Land consumption, regeneration, sustainability, environmental risk, mitigation

C_BUILDING DESIGN AND TECHNOLOGIES

Rural-kit. Integrated spatial devices for multifunctional rural farms and countryside facilities in Sardinia

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Abstract
The article is set within the experiences of Cagliari's DICAAR on the sustainable recovery of Sardinia's inland areas and deals with the definition of guidelines for the design and construction of a prototype for a multifunctional space aimed at rural farms and countryside services. The area of first experimentation is the historic region of Marmilla, in central Sardinia, which is included within the SNAI programs on inland areas of Italy. The Marmilla GAL is the founder of the overall project, which is complemented by a contribution from the PNRR e-INS project involving a multidisciplinary team from the universities of Cagliari and Sassari. The chosen site for the realization of the prototype is in the locality of *Fustiolau*, on the southern slope of Mount Arci, a disused quarry at the center of a process of re-naturalization and landscape reintegration. In this case, the rural-kit project is aimed at accompanying agro-services, configuring itself as a didactic-experimental building for visiting the area's archaeological sites and for environmental education. The spatial articulation of the device is simple, a barycentric classroom intended to accommodate the primary uses, to which are juxtaposed, along the perimeter, accessory spaces obtained with prefabricated cells in the form of flexible plug-ins, which can be integrated with a variable distribution arrangement. The construction principles of the device are the repeatability of the module, the possibility of disassembly of the construction elements, dry construction, recycling of raw materials, and, above all, the reuse of the constituent elements and the possibility of integral reversibility. From these assumptions, the project is distinguished by simple building elements: the basement, the load-bearing cells and the roof, a device for microclimatic regulation and renewable energy production. Digitization, sensing and advanced control will enable monitoring of the prototype's environmental performance during ordinary use to assess its efficiency and degree of overall sustainability.

Keywords
Rural landscape, architectural prototype, prefabrication, sustainable design, architectural engineering

Exploring the potential Role of AI Tools in Automating Design Validation for Building Code Compliance in Design/Construction

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Abstract
The AEC sector is actively requiring innovative solutions to simplify, automate processes, and enhance communication among stakeholders. In the last few years, the rapid development of AI tools has demonstrated their huge potential for revolutionizing used practices, methodologies, and strategies in different construction practices. This research paper explores the possibilities of using chatbots to automate various validation processes within the architecture, engineering, and construction (AEC) industry. Specifically, chatbots can streamline the validation of design plans against building codes, facilitating prompt identification of code compliance issues. By augmenting the efficiency of this validation process, chatbots can enhance collaboration among architects, engineers, and construction professionals, leading to smoother project workflows and improved outcomes. This study investigates the functionalities that can be effectively automated through chatbots. By utilizing AI algorithms, these chatbots can adeptly manage routine tasks, allowing the effort to focus on more intricate and strategic aspects of projects. The paper examines the feasibility and effectiveness of using the most developed chatbots currently available, analyzing the different pros and cons of each. A practical test has been conducted to generate programming codes for assessing the adequacy of building models in compliance with building codes, by analyzing the written text from the building codes using the intelligence of the Chatbots and generating a programming code, particularly crucial during the lengthy redesign process of buildings involving many routine tasks. A thorough examination of the advantages and challenges of integrating chatbots into the AEC industrial sector is presented. The potential benefits include higher productivity, shorter project timelines, and fewer errors. However, concerns about data security and reliability are also acknowledged, and the issues related to the development of AI tools and their effects on the reliability of the results are discussed. This research aims to contribute valuable insights into the transformative role of AI tools in the design/construction industry, offering a balanced assessment of their capabilities and potential challenges.

Keywords
Construction industry, collaborative design, ai tools, chatbots, automation

The Digitisation of the Cultural Heritage: understanding the requirements to define a methodology

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Abstract
The preservation and transmission of knowledge in the digital era is often entrusted to the world of Information and Communications Technology. The advantage of this transition is the increase in the amount of information available via the web, while the disadvantages are mostly represented by the difficulty in accessing to this information or the accuracy and quality of them. In this context, the task of the academic expertise is to gain an intrinsic knowledge of the topic through experience in the field for clarify the best practices in the digitisation process. In the following article we analyse the role of digital technologies in the valorisation of architectural heritage through an analysis of the indications at European level and initiatives in two distinct cultural contexts, Spain, and Italy.
After a comparative analysis of the various superordinate indications, we will investigate the strategies, methodologies and applications used in the two countries to digitise and promote their rich historical and cultural heritage also leveraging the experience of professor L.M. Palmero Iglesias, who has been running a digitization project with European funds since 2019, called PROMETHEUS, which connects the experiences and skills of Italian and Spanish figures and others, to point toward a better understanding of best practices in the digitization process of cultural heritage in order to obtain a holistic digital future that can preserve the authentic values established in the place of origin with the objective of contribute to create a methodology in the field of digitisation, facilitating knowledge sharing and the potential development of international synergies.

Keywords
Digitalizations process, Cultural heritage, Popular identity, Intangible heritage, Digital methodology

Eco-friendly materials and products from the waste derived from the processing of Apricena stone: state of the art and new employment prospects

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Abstract

The stone industry in Italy represents an important reality in the manufacturing production landscape, generating a wide range of stone products, including slabs, blocks, and tiles. In Puglia, there is the Apricena district, known for its production of precious stones, distinguished by varieties such as Fiorito, Biancone, and Serpeggiante.

However, the sector is facing several challenges, including international competition and production of waste. The waste comes from processing activities such as cutting, leading to the generation of slurry stone waste, also known as "marmettola". Currently, there is no homogeneous legislation in Italy, often resulting in waste disposal in landfills. This underscores the need to improve the sustainability of production activities by exploring new solutions for the reuse of these stone wastes.

In this context, the research aims to survey literature experiences pursuing the reuse of waste through the development of new materials and composite elements. The methodology involves screening contributions on various scientific databases such as Scopus, ScienceDirect, Espacenet, etc., using appropriate keywords. Contributions are then categorized by mechanical, chemical, and physical performances, as well as the application fields for these composite materials. This analysis will help in identifying the widest applications capable of effectively absorbing waste volumes.

Keywords

Stone waste, Marble slurry, Cement-based materials, Polymeric-based materials

Methodology for designing adaptive facade components: smart materials and 4D printing for resilient construction

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Abstract
The present work originates from the identification of the concept of resilience and its application to the construction industry. The city, like us, must be able to show resilience in order to respond to the increasingly urgent challenges of our time, such as climate change and pollution, which increasingly expose it to new fragilities.
From an analysis of the existing literature, two trends emerge that could prove to be salvific within such a transitional path. On the one hand, it is worth noting the remarkable strides that are being made in the area of additive manufacturing, especially with regard to 4D printing, an advanced version of 3D printing, differing from its predecessor in its capabilities, such as the shape memory effect, which allows objects made with these techniques to change their conformation depending on the stimuli they receive. Another innovative technology that is well suited to the evolving needs of the construction industry are the so-called kinetic facades, consisting of systems, mechanically operated, that can change the spatial conformation of a facade, to allow better exploitation of solar radiation at different times of the day.
The aim of this work is to integrate the potential of these two technologies through the design of a facade component produced with 4D technologies that is capable of changing its conformation based on external temperatures, with the purpose of modulating the passage of solar radiation inside the building.
The process of elaborating the component will then be defined, initially through the production of PLA printed samples, with different combinations of the main printing parameters, in order to verify the efficiency of the shape memory mechanism and the influence of these parameters. From the results obtained from the experimental phase, it will then be possible to define a mathematical model suitable for simulating the behaviour of the material in different conformations, in order to design the most functional form for the desired purpose.

Keywords
4D printing, smart materials, kinetic façade, passive systems, sustainable design

Multi-criteria approach for assessing the sustainable skin for temporary housing modules

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Abstract
This study delves into the application of multi-criteria analysis to identify sustainable building envelopes for temporary housing, integrating economic, environmental, and social evaluations. In a historical context marked by increasingly severe housing crises and a growing number of individuals deprived of housing, this research aims to address a significant gap in the current academic landscape. Through a critical analysis of the limited existing research on the subject, the article highlights the urgency of developing housing solutions that not only meet immediate needs but also promote long-term sustainability. Multi-criteria analysis emerges as a key methodology for balancing economic, environmental, and social impacts, thereby contributing to the provision of resilient and ecological shelters in response to global housing emergencies. As societies grapple with these challenges, the study calls for a comprehensive and integrated approach to housing design that considers the multifaceted nature of sustainability and its crucial role in meeting the housing needs of vulnerable populations. The critical analysis of existing research reveals the necessity of developing shelter solutions that address not only immediate needs but are also designed to promote sustainability. It represents a methodology for balancing economic, environmental, and social impacts, thus providing an integrated framework for temporary housing design. Navigating through socio-economic and environmental complexities, multi-criteria analysis emerges as an indispensable tool for developing resilient and environmentally respectful solutions capable of meeting the needs of the most vulnerable populations. In this manner, this study proposes an innovative and evidence-based approach to addressing contemporary housing challenges and contributing to a more sustainable future for communities affected by housing emergencies.

Keywords
Postdisaster, emergency, shelter, envelope, MIVES

A comparison of digital procedures to support renovation processes of the built environment

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Abstract
The inefficiency affecting a significant part of our built heritage reveals the urgency of renovating existing buildings and the need for extensive and cost-effective interventions. To achieve a disruptive diffusion of renovations good practices, it is still necessary to increase end-users' awareness and provide a framework for efficient workflows to the professionals involved in these processes (designers, contractors, manufacturers). In this scenario, digital technologies play a key role, since they enable the optimisation of the whole renovation process by saving time and costs, reducing the chances of mistakes, and fostering interoperability. One of the main applications of digital technologies in the Architecture, Engineering and Construction (AEC) sector deals with the organisation of data into digital, informative models that can be useful for the management of many phases of the process, from planning to monitoring. The collection of data on existing buildings is the first crucial step in this workflow and current methodologies for their acquisition and processing still require expensive tools and complex, time-consuming procedures. Despite the growing research interest concerning the trade-off between accuracy and real feasibility of the acquisition and processing phases, an approach that takes into account both the affordability of survey practices and the suitability of acquired data for subsequent modelling steps is still needed. This study contributes to this aim by presenting some tests carried out within a European project with the goal of defining and validating strategies based on digital procedures to support renovation processes. An experimental comparison among three different data acquisition and processing strategies has been conducted. The approach adopted considers, on the one hand, the limits and potential of the acquisition and processing procedures and tools, and, on the other hand, the requirements for digital modelling in BIM environment.

Keywords
Existing building, retrofitting, 3d digital survey, data acquisition, low-cost digitalization

Building Heritage Materials Passports (BHMPs) for resilient communities

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Abstract
The new model of circular economy and digitalization promoted by the recent normative framework of the European Union opens new scenarios of integration between sustainable buildings and built heritage conservation that led to the emergence of a new transversal ethic of sustainability based on knowledge of materials and their circular use in construction with a leading role for the expertise of the scientific-disciplinary sector of Architectural Engineering. The building sustainability requirements and the widespread degradation of the built heritage, in many cases reduced to the state of dilapidated buildings or ruins, give to materials and building components an intrinsic value downgrading the need for the conservation of the building organism or what remains of it. Circular design offers the possibility of a reformulation of the connections between construction and the life of materials and building component that neither begins nor ends with their use in buildings or specific locations. On the contrary, the reuse of heritage materials and building components can transform the loss of construction into a potential gain in a continuous history of use, deconstruction, and re-use. The paper focuses on the study of the state-of-the-art on Materials Passports with the objectives of the development of Building Heritage Materials Passports (BHMPs) for the recovery of materials and building component belonging to dilapidated built heritage in the inner areas of the Basilicata region, the rediscovery of local buildings technologies and their recognition by communities as common goods and inexhaustible resources. By leveraging the sustainability of the ancient ways of building and inhabiting places, the paper promotes "care actions" of tangible and intangible building heritage with the involvement of communities in Living Labs able to strengthen the resilience to abrupt climate change, transforming needs into opportunities for sustainable development.

Keywords
Continuum building design, Building Heritage Materials Passports (BHMPs), building heritage, Livings Labs, open ecosystems of innovation

Reversible building design. Material circularity and life cycle extension in the construction industry

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Abstract
In the last decades, the effects of the climate crisis have become increasingly evident, as demonstrated by the growth in the number and intensity of extreme weather events recorded worldwide. The construction sector is one of the economic and production sectors that contributes most to worse this phenomenon, due to its environmental impact in terms of resource consumption, CO_2 emissions, and waste generated by building construction and demolition processes. Globally, the construction sector produces approximately 40% of global CO_2 emissions, and in only in Europe, construction and demolition waste accounts for about a third of total waste. It is therefore the responsibility of designers to explore new alternative approaches to the traditional way of designing, constructing, and managing buildings, in order to counteract trends and reduce the environmental impact of the construction sector. This study attempts to critically examine a new possible approach to building design and life cycle management through the principles of reversible design. Framed within the strategies of Design for Environment (DfE), reversible design aims to create artifacts designed to be easily assembled and disassembled, allowing for modifications of the construction over time, if the original requirements change, or allowing dismantling and material recovery at the end of the life cycle. Enabling adaptability over time, facilitating conditions for material reuse, and extending the building and its components' life cycle are implementable strategies to achieve the decarbonization goals of the construction sector by 2050, as outlined in the most recent international climate agreements. For the methodological control of reversible design principles, the research intends to present their possible application to a case study: the design of a functional module for post-natural disaster housing emergency.

Keywords
Reversible design, circularity, life cycle, construction and demolition waste, design for disassembly

Valorisation and reuse of cereal wastes for construction applications in a circular economy perspective: a review of the state of the art

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Abstract
Nowadays it is well-known, also by the general public, that the uncontrolled use of non-renewable natural resources, the energy demand increase, and the pollutants emission into the atmosphere have a devastating impact on the environment, on human health, and the society in general. In this scenario, construction is a high concerning sector; hence, there is an urgent need to employ materials with low environmental impact for all those activities connected to the sector, such as construction or redevelopment of buildings, structures and infrastructures according to the required high-performance standards. Moreover, another problem is the generation of enormous quantities of wastes and by-products whose disposal often poses many difficulties, not considering that the usual landfilling causes an additional environmental burden. This study is a part of a doctoral research supported by a PNRR project aimed at the R&D of materials, products and systems for buildings energy improvement, through the valorisation and reuse of secondary raw materials. In particular, this work presents the state of the studies on wastes deriving from the cereal sector, analyzing how they can be reused for the production of more sustainable building materials intended for energy performance improvement as demanded by the current European and national regulations. Cereal wastes reuse, like most of those resulting from the agricultural sector, represents a valid opportunity for a greener construction, also promoting a sustainable approach from the circular economy perspective and in line with the Minimum Environmental Criteria. Therefore, valorisation and reuse of recycled materials in construction would not only reduce their environmental impact, but would also contribute to increase sustainability in construction, a sector that still presents many critical issues connected not only to the actual construction practices, but also to all those activities of production and management that characterize buildings.

Keywords
Bio-waste reuse, buildings materials, energy efficiency, sustainability, circular economy

Innovative cardboard components for architecture: methodologies for performances and durability assessment

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Abstract
The need to make contemporary buildings more sustainable, inclusive and safe has highlighted the possibilities offered by "green" materials. Among these, corrugated cardboard material stands out, given its possibility to be used within innovative prefabricated components for the building envelope, characterized by a low cost and a low environmental impact.
ARCHICART technology is based on the patented PACOTEC panel, an innovative prefabricated corrugated cardboard panel for interior partition walls and envelope applications. The panel, designed to be dry-assembled on site, is made up of corrugated cardboard box-shaped profiles glued together and covered with a continuous double sheet corrugated cardboard. ARCHICART technology has previously been the subject of an experimental campaign focused on its mechanical and thermal performances assessment.
This contribution reports the main objectives and phases of a new project, aimed at the attainment of European Technical Assessment (ETA) document, mandatory for the performances' declaration of products for which there is no harmonized standard.
Indeed, the novelty of the product require an in-depth study of the component performance over time through an experimental evaluation. So, particular attention must be paid to the durability of ARCHICART cardboard components. For this reason, an analysis of the state-of-the-art on the methodologies for accelerated aging tests on building components is herein reported.
In the second part of the manuscript, a tailored aging protocol for ARCHICART panels is defined on the base of multi-year weather data files. The proposed protocol aims to mediate the need to accelerate the aging cycle, therefore increasing the severity of the degradation agents and their frequency over time, with the need to test the hygrothermal behaviour of the components under real operating conditions.

Keywords
Green buildings, corrugated cardboard components, European technical assessment, durability, aging cycle

Sustainable architecture: computational modeling of green roofs through BIM and Dynamo VPL integration

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Abstract
This study explores the fusion of green building practices and Building Information Modeling (BIM), with a focus on green roofs. It highlights the construction industry's shift towards sustainability, emphasizing green roofs as a crucial sustainable technology. Using the Dynamo Visual Programming Language in Autodesk Revit, the research automates the creation of parametric models to assess the thermal and structural properties of green roofs under varying moisture levels.
Key findings indicate that the choice of substrate and drainage materials significantly impacts thermal resistance in dry conditions and stress the need to evaluate structural performance in both dry and saturated states. The research presents a methodological framework that includes material selection, integration of green roof components, and performance analysis. It examines various green roof materials, analyzing their thermal and physical properties in different moisture conditions.
The study showcases how Dynamo in Revit can automate green roof analysis, enabling quick evaluations and informed design choices. This method supports modern eco-friendly design trends, improving building sustainability and performance. However, the research recognizes its limitations, such as a limited focus on specific green roof technologies and performance indicators, and its concentration on the design phase.
Future research directions include exploring a broader range of green roof technologies, additional performance metrics, and expanding the scope to encompass construction and maintenance phases. Incorporating AI and machine learning, establishing standardized guidelines, and examining synergies with other sustainable strategies are also suggested. These advancements will enhance the integration of green buildings with BIM, furthering sustainable development in construction.

Keywords
Eco-Friendly Building Design, Lifecycle Analysis, Autodesk Revit Applications, Thermal and Structural Performance, Digital Automation in Construction

The innovation imagined for the window: international patents in comparison

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Abstract
The window is an element of the building system that has always been a field of stylistic and technological experimentation. By virtue of belonging to the envelope, it assumes a non-secondary role in the formal composition of façades and affects levels of thermal, luminous, and acoustic comfort. Recently, the aim of environmental sustainability has encouraged the offer of more efficient solutions, also responding to the circular economy, for example by providing for the use of recycled materials. To intercept both the direction taken by the research sector and the direction that industrial production may take, the purpose of the study was to understand what the innovative features of the window will be in the near future; this was done by analysing published patent applications.
The methodological approach required prior investigation of patent types and of the territorial extension of their protection. In order to detect current trends on a global scale, interest was directed to international patent applications (PCT - Patent Cooperation Treaty), which allow for the possible protection of the invention in the 157 Treaty countries and which are published in the PATENTSCOPE database of WIPO. In 2023, the chosen year of observation, 195 patent applications were published in the "window" category and 132 were included in the study, selected according to previously defined inclusion and exclusion criteria. The classification was based on the sub-systems identified within the window element (Attachment to the structure; Frame, Sash; Glazing; Screen; Movement and maneuvering; Gasket) and categorised into three innovation areas (A1. Design, A2. Performance, A3. Sustainability), and related sub-areas.
The study showed that the area of Sustainability is still lacking; while greater interest on the part of the researchers concerned the area of Performance, and in particular thermal/luminous comfort, with a significant focus on the integration of the smart component in windows.

Keywords
Window, Patents, Design Innovation, Performance Innovation, Sustainable Innovation

Sustainability Assessment of Refurbishment vs New Construction Systems: a Long-Term LCA Perspective on Durability and Building Lifespan

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Abstract

Two main intervention categories emerge for the renewal of residential building stock: refurbishment and demolition and reconstruction. The Life Cycle Assessment (LCA) currently stands as one of the most widely employed methodologies in the construction industry for evaluating environmental impacts. Nevertheless, a common practice in LCA at the building scale is to consider a default value for their lifespans, regardless of the durability of the construction system and the average longevity observed within the geographical context. Consequently, this common practice involves a significant risk of misinterpretation or partial evaluations of results in long-term assessments deriving from two main factors: (i) the overestimation of environmental impacts associated with heavyweight construction systems, which are characterised by higher embodied energy and carbon, despite their advantages in superior durability and low maintenance compared to lightweight alternatives; (ii) the tendency to overestimate the lifespan of existing buildings after refurbishment, particularly those that have already surpassed 60 years of service. To illustrate this method, a comparative LCA is carried out between refurbishment and demolition and reconstruction of a case study, a 1960s multi-family residential building located in the suburbs of Bologna. In particular, two heavyweight and three lightweight construction systems are evaluated for the new Zero Energy Building (ZEB). The findings highlight a strong dependence between LCA results and building lifespan, significantly influencing the choice when comparing intervention strategies. The results show minor impacts for demolition and reconstruction scenarios compared to refurbishment scenarios after 30 years of analysis and lower impacts of lightweight construction systems in the same period, while in the medium to long term, over 60 years, heavyweight construction systems yield lesser impacts when accounting for their extended lifespan.

Keywords

Life Cycle Assessment, Building Lifespan, Durability, Zero Energy Building, Construction System

Pilot project of a new positive energy timber building for sustainable climate-positive circular communities: challenges, opportunities and innovations

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Abstract

The present and future cities are key players in the ecological and energy transition towards a circular economy thanks to their resource, material and energy potential.

The EU-funded ARV project with its six demonstration projects, aims to contribute to speedy and wide scale implementation of climate positive circular communities where people can thrive for generations to come. The intent of the ARV project is to develop and demonstrate a new paradigm of "integrated circular design", by taking a multidisciplinary approach to (re) design buildings maximizing energy efficiency, minimizing life cycle greenhouse gas emissions and costs, optimizing occupant well-being, and ensuring high architectural quality.

In Italy, the case study is the Destra Adige Piedicastello area, one of the oldest districts of the city of Trento. It was selected because it has the opportunity to become an incubator and demonstrator of a new way of thinking about local communities, oriented towards climate respect in a circular economy and energy self-sufficiency perspective, and through the development of solutions that can be rapidly replicated and exported to other districts and cities.

To this end, it was decided to design an experimental demonstration timber building that systematizes innovative design, construction, and plant engineering solutions for a new culture for positive energy buildings (PEBs).

The challenge was addressed employing methods of integrated and participatory design in a multistakeholder cooperation applying the principles of circular economy and focusing mainly on the use of local bio-based materials, the high energy efficiency with active/passive solutions, the effective integration of renewable energy sources and the off-site prefabrication of the building components.

Keywords

Positive energy building, integration, circularity, timber prefabrication

Energy efficiency strategies in Active House buildings. The case study of the kindergarten and primary school in Alfedena (AQ)

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Abstract
The international Active House protocol is an assessment and design guidance tool for the realisation of so-called "active" buildings, able to ensure low energy consumption and at the same time contribute positively to human health, while respecting the environment through the use of renewable energy and sustainable materials. The protocol involves a self-checking procedure of the project, in which design and construction choices are planned in order to provide a general framework with respect to the expected Energy-Comfort-Environment performance. In this context, the purpose of the study is to identify whether in new buildings located in a mountainous environment with a Mediterranean climate and built in compliance with current Italian energy-saving regulations, there are any shortcomings regarding comfort, energy and respect for the environment. It is also intended to identify procedures and design actions necessary to achieve the compliance with the requirements of the protocol, as an implementation of what has already been carried out in common practice. These objectives were achieved by applying the protocol to a newly built school located in the municipality of Alfedena (AQ).

Keywords
Active House Protocol, Energy Efficiency, Comfort, Environment performance, Alfedena (AQ)

DfD output approach for sustainable deconstruction. A social housing neighbourhood near Naples

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Abstract
EU regulations encourage member countries to a rate of renovation, of the existing building stock, of no less than 3 percent per year. With respect to an Italian landscape strongly characterized by a building stock with reinforced concrete structure, now at the end of its life, this action is realized through a replacement approach. One of the most effective strategies for achieving the construction sector's sustainability goals is to move toward a circular-type process, of the sector. This is achieved by maximizing the reuse of building components to be decommissioned, at the end of their life, through the method of "upcycling", a design of the 'new' aimed at reusing materials from a demolition/reconstruction (C&D) process that avoids their disposal in landfills. This strategy makes it possible to reduce the environmental impact associated with both the disposal of waste materials resulting from the demolition of the building and the extraction of new raw materials, for new design. The study developed an integrated model, called the "Classifying Method", which analyses three end-of-life building complex disposal scenarios: landfill, recycling and reuse. The objective of the method is to determine a "ranking" aimed at identifying the most virtuous scenario, both in terms of environmental impact and economic viability. On the subject of Ecological Transition, this study aims to propose a methodology as a concrete response to the following areas:

- Circular systemic approaches such as Open Building, Life Cycle Thinking, Design for Longevity, Design for Disassembly, Reversible Building Design, Zero Waste, Urban Mining, Upcycling, Recycling, Reuse;
- Optimization and advanced management of process (design, production, product, service, end-of-life, reuse/recycling), non-renewable resources and waste/waste, for the implementation of sustainable and traceable product life cycles and energy efficiency of the built environment.

Keywords
Sustainable Disposal, Zero Waste, Upcycling, Design For Deconstruction, C2C Approach

Marble waste sustainable re-use: future prospect for Custonaci marble basin in Sicily

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Abstract
In Italy, the marble industry is one of the most productive sectors in terms of quality and quantity of material exported. However, after the economic crisis of 2008 and the COVID19 pandemic, production and export numbers have experienced a significant reduction. This is particularly true for Sicily and the area of Custonaci (Trapani, TP). In this area numerous quarries had to temporarily halt mining operations due to the lack of demand from the market and the reluctance of most entrepreneurs to modify and improve their production lines. Nevertheless, the sector's most pressing issue is the massive quantity of waste generated during cutting and processing. These wastes are left to pile up in the land next to the sawmills, even if, according to the current Italian legislation, they should be moved to dedicated landfills. Unfortunately, this operation rarely happens as its cost is prohibitively high. Moreover, the intensive extraction activity has a massive impact on the landscape. As a result, in the past few years, researchers have started to find alternative use to this by-product in a variety of industries including construction, fashion and agriculture. Marble quarry waste is already widely used in construction to manufacture aggregate for cementitious matrixes as well as artificial stone, where marble waste is used as mineral filler within a polymeric matrix. The new challenge is to combine marble waste with either a bio-based or a recyclable material, in order to reduce the use of virgin materials and to ensure a further reuse. This works proposes an overview of the state of the art in terms of current legislation, patents and products with marble waste and it paves the way to an experimentation with marble waste from Custonaci marble basin (namely Perlato and Perlatino di Sicilia) by mixing it with either a biodegradable polymer (PLA or PVA) or a recyclable polymer such as nylon, coming from dismissed fishing nets.

Keywords
Marble, Stone waste, Slurry, Polymer, Reuse

Made in Italy eco-designed products from stone waste: the STONE project

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Abstract

The Italian manufacturing sector is facing the challenge of transforming supply chains with a circular economy perspective, encompassing technological, organizational, and social aspects. In this regard, the scientific and technical communities are conducting research and experiments to enable the recycling of industrial waste, aiming to reduce the consumption of raw materials and environmental impacts. The Italian stone sector, which continues to hold the European primacy in the extraction and processing of natural stone, generates enormous quantities of waste such as "marmettola" (stone slurry/sludge) and "cocciame" (stone chips) each year. These are partially reused for certain low-value purposes, while the majority is disposed of in landfills, causing significant environmental impacts.

In this context, the STONE project aims to propose innovative and eco-friendly materials and components that are Made in Italy, meeting the performance requirements for the design of indoor/outdoor living spaces and temporary housing solutions. Furthermore, a harmonized process for reusing waste from stone processing will be structured to manufacture eco-design products validated in the three reference geoclusters: Sicily, Tuscany and Apulia.

Keywords

Stone waste, Sustainability, Ecodesign, PSS, Italian geoclusters

Digital transformation in construction: cutting-edge strategies in building materials supply chains

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Abstract

Building materials' supply chain is undergoing a significant digital transformation, driven by technological advancements and the need for lean communication among clients, companies, subcontractors, and suppliers, leading to legal disputes, cost overruns, and delays in contract finalization. Moreover, innovative processes and tools must ensure performance quality of building technologies and materials, meeting the requirements of both clients and regulatory standards. In this context, the research seeks to explore the implementation of innovative approaches in the era of digital transition in construction. The goal is to provide comprehensive assistance to all parties involved in the life cycle of building design with several benefits, including remote consultation of technical specifications of materials and technologies, and physical and legal traceability facilitated by a distributed and immutable ledger.

Keywords

Innovative building supply chain, digital transition in construction, technical specifications, residential buildings

Biophilic Architecture and the new paradigm Building-Man-Environment

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Abstract
The concept of biophilic design is based on a wide variety of experiences ranging from physical, sensory, metaphorical, morphological, and material to spiritual. Certain elements (such as air, daylight, plants, and landscapes) offer opportunities to develop design strategies with multiple benefits, particularly to enhance health and well-being, productivity, increase biodiversity, circularity, and resilience of the built environment. Investigating the human-nature relationship is, therefore, the task of biophilic design, which constitutes a new frontier in green building aiming to improve collective well-being in human environments and to restore, through the incorporation of greenery, a general sense of fulfillment to those who inhabit architecture.
Moreover, through the use of passive and active design strategies, an optimal balance between living comfort, energy savings, and environmental respect can be achieved. This contribution aims to present the genesis of biophilic architecture, its principles, and how these are applied in design. To verify the results of this approach, a method for the multiparametric evaluation of the effects of design, based on the principles of biophilic architecture in terms of living comfort and environmental sustainability, is also proposed.
Biophilic architecture not only responds to the immediate and practical needs of creating healthier and more engaging spaces but also aligns with broader environmental and societal goals. By fostering deeper connections between individuals and the natural environment, it encourages a more mindful and sustainable way of living and working. This approach has the potential to transform urban landscapes, making them more resilient to environmental challenges such as climate change and urban heat islands, while also enhancing the mental and physical health of the inhabitants.

Keywords
Biophilic design, environmental integration, user-centred design, comfort, quality living

Experiences of participatory and shared co-design: the Metaplan method for a “possible city” in Calitri (AV), Italy

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Abstract
Participating, in common usage, means taking part in a collective activity, intervening in a specific act or process. Participatory and shared planning involves the collaboration of various stakeholders in a community (citizens or social groups, administrators, technicians, etc.) who, through spaces and moments of discussion and elaboration, are involved in the conceptualization of a project that aims to translate into a proposal what emerges from the workshop activities. This article intends to present the experience of participatory and shared planning through the Metaplan method, carried out as part of the project called “The Possible City”. This experience originated from the proposal of students from the art high school in Calitri (AV), supported by school teachers, to rethink, through a redevelopment project, degraded places in their territory, transforming them into new urban spaces that are aggregative, functional and accessible to all, thanks to a participatory and shared process involving citizens. The phases of the process involved the school community of Calitri, the municipal administration, representatives of local associations, merchants and especially children, the elderly and people with disabilities, expanding forms of participation to entire the entire community through workshops, interviews and surveyes aimed at understanding the history of the places, their function and community expectations. The Metaplan method, based on the visualization and organization of ideas in a structured manner, also lends itself to being enriched and perfected through the integration of new technologies, pedagogical approaches and inclusion strategies.

Keywords
Participatory and shared planning; school community; Metaplan method; co-design

Beyond Generative A.I. to reduce the gap between Architecture and its Techniques

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Abstract
This work explores some methods for integrating Generative Artificial Intelligence (Gen.A.I.) into Technical Architecture processes. After the problem contextualization in AEC sector, including opportunities for enhancement, the paper analyses critically the state of art about A.I. development in the restricted field of study.
In general, we assume that, present and future outcomes both, in research and practice, depend on the pervasive hardware advancement for calculation power, together with the software usability simplification, based on intuitive middleware levels, up to natural language interfaces.
Specifically, this contribution aims to investigate how Gen.A.I. can become a component of project and construction methodology, capable of more efficient results, by reducing the gap between creative solutions and their feasibility.
First, a text-to-image case of study is presented, aimed – rather than to assess the implementation pipeline – to illustrate the ease of the process, even more by using free software widely available online: it shows that the impressive visual result originates from an innovative methodology, produced not only by statistical knowledge, but also by artificial generative abilities.
Follows a critical discussion about the potential of this "new" technology: it concerns not only aesthetic composition and form-finding, that seem to monopolise the attention of the sector, but clearly it involves the whole building process, including technique and technology of architecture.
To this aim, authors select and analyse some A.I. applications properly addressing objectives of the BIM method, namely enhancing technical control on design solution performance.
Conclusions outline the relevant role of Scientific Community, called to guide the transformation of these processes, by addressing structured Technical Architecture knowledge models, instead of letting it being guided by the automatic algorithms.

Keywords
Artificial intelligence, generative artificial intelligence, architecture, innovative techniques, artificial creativity

Scan-vs-BIM approach for construction site monitoring optimization

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Abstract
The monitoring of a construction site is crucial to verify the progress and control its alignment with the defined project schedule phases. An efficient site monitoring ensures there are no delays that could result in losses in terms of efficiency, time, and costs. This study aims to propose an approach to optimize construction site monitoring with BIM models and the comparison between point clouds. The primary goal is to provide a framework for evaluating the progress of construction activities, thereby enhancing the overall project management. The approach is based on comparing point clouds from on-site acquired images and point clouds from BIM models corresponding to the phases defined in the project schedule. The comparison is achieved in terms of distances between points in two different clouds. Specifically, point clouds corresponding to identical and subsequent phases are compared to assess whether the construction site is behind or on schedule. This provides an effective tool for verifying the progress of activities. The effectiveness of this approach is demonstrated through its application to a specific case study involving a three-story reinforced concrete building with a project schedule divided into incremental phases. The comparison between point clouds extracted from on-site images and those generated by a representative BIM model of the building's construction program affords an automatic analysis of work progress.

Keywords
Point clouds, construction site monitoring, BIM

Performance-driven design of a residential unit with the use of genetic algorithms

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Abstract
This study examines and integrates the principles of multi-objective optimization, space syntax, and graph analysis in the context of Artificial Intelligence (AI) applications for architecture and construction, particularly automated space planning. The primary purpose of the study is to determine the efficacy of various advanced strategies for generating a wide range of design options. Building codes, customer requirements, and other architectural constraints must be addressed while developing optimal solutions. After selecting the parameters to deal with, the process aims to thoroughly study design possibilities while balancing features in competing positions.
The process adopts space syntax and graph analysis to visually represent the functional connections between various spaces and users' movements within the building. The analyses are carried out within the Grasshopper platform using the Wallacei and Termite Nest plug-ins. Wallacei employs multi-objective evolutionary optimization methods to tackle conflicting design issues, whereas Termite Nest develops design possibilities combining space syntax and graph analysis. This study aims to demonstrate the limitations and the potential of computerized architectural space planning by showing how these advanced algorithms can generate optimized design solutions that meet particular requirements.

Keywords
Genetic algorithms, Performance-driven design, Space syntax, Multi-objective optimization, Space planning

Italian buildings deep renovation through Off-Site Construction

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Abstract
Despite the recent surge in interest, off-site construction is by no means a new concept Prefabrication began in the 16th century with British colonisation to meet the demand for rapid settlements using elements manufactured off-site and assembled on site. Modern prefabrication can be dated to the mid-19th century with the birth of industrial production, and the first major example of prefabrication was Sir Joseph Paxton's 'Crystal Palace', built in 1851. Since there has been continuous improvement in prefabricated construction, aided by the development of site lifting machinery. This article proposes to the reader a modern and intelligent vision of prefabrication, highlighting the great advantages of off-site construction (OSC), not only in terms of speed of commissioning, but also in terms of energy and structural advantages, as well as those related to a better environmental quality and the reduction of site "nuisances". A "catalogue" of solutions has been studied and drawn up, applicable to the whole national territory, which responds to the above-mentioned requirements and is expressed in a "dynamic matrix" that allows operators in the sector to make targeted choices in cases of building renovation. The solutions developed can be easily replicated in non-housing situations and offer numerous advantages, such as the possibility of integrating the façade with other functions, speed of installation, dust and noise reduction, flexibility in the choice of modules and the possibility of carrying out the renovation while keeping the occupants in their homes during the work.

Keywords
Built environment, energy efficiency, deep renovation, off-site construction, RES integration

Assessing the Environmental Footprint: Recycled Concrete in Prefabricated Walls

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Abstract
This study aimed to evaluate the real environmental impact of using recycled materials in construction, particularly within the context of prefabricated walls in the French construction industry. Our objective was to assess the feasibility and implications of incorporating recycled concrete into prefabricated wall systems, considering both environmental benefits and potential drawbacks.
To achieve this objective, we conducted a comprehensive life cycle assessment (LCA) comparing two scenarios: one utilizing traditional concrete fill and the other integrating recycled concrete. This analysis was carried out in the Parisian region, where a recycling facility is situated, ensuring the consideration of local factors such as transportation distances and recycling infrastructure.
Innovatively, we overcame the challenge of accessing comprehensive life cycle inventory (LCI) data by integrating Environmental and Health Declaration Sheets (FDES) into the OpenLCA software platform. This approach democratized access to high-quality environmental data for construction materials, mitigating the financial barrier associated with proprietary databases like Ecoinvent.
Our analysis revealed a nuanced interplay of trade-offs associated with using recycled concrete. While recycled materials exhibited lower carbon emissions, they also demonstrated a higher degree of soil acidification compared to traditional concrete. This juxtaposition underscored the complexity of sustainability considerations and emphasized the importance of comprehensive evaluations in material selection.
By analyzing the real environmental impact of using recycled materials and evaluating their feasibility in a practical context, our study contributes valuable insights to the ongoing discourse on sustainable construction practices. It underscores the significance of considering local contexts and recycling infrastructure, ultimately aiming to minimize environmental footprints.

Keywords
Recycled concrete, life cycle analysis (lca), prefabrication, sustainable construction

Thermo-active foundation walls for the energy efficiency of Near-Zero Energy residential Buildings

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Abstract
Energy savings in buildings and the focus on efficiency in energy uses become key elements in trying to improve future living conditions. Starting from this point, low-enthalpy geothermal energy is an efficient renewable resource when coupled with a Geothermal Heat Pump (GHP). The study of geothermal heat exchangers through energy geostructures define its interest in terms of reducing consumption, environmental impacts and costs.
This paper investigates the technological system of energy foundations, delving into the case of a geothermal exchanger integrated into foundation walls because they represent under-studied systems and because they are interesting from a performance and construction standpoint. The preliminary step was to evaluate the performances of different kind of foundation walls as geothermal exchanger coupled with a geothermal heat pump using dynamic modelling in the TRNSYS suite. The configuration under study was hypothesised by carrying out preliminary tests and varying the boundary conditions of the retaining walls. The final optimised configuration was subsequently applied and sized on two case studies for two common building types, such as an in-line building and a terraced building. The dimensioning of the geothermal system is based on residential buildings and near-Zero Energy standard. The simulation was performed in an Italian Mediterranean location to evaluate its performance, and then the consumption of these systems was extrapolated and compared to air source heat pumps.
In conclusion, this technology could generate favourable impacts on energy consumption and emissions, proving to be suitable for both the construction of ex novo buildings and the energy refurbishment of existing ones.

Keywords
Energy efficiency, Energy geostructures, Geothermal Heat Pump, Near-Zero Energy Buildings

Architectural Engineering: Engineering Approaches for the Design for Manufacturing and Assembly for the Housing sector

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Abstract
Prefabrication is spreading in the Global North due to the necessity to build, in a short time, a large volume of new housing for an exponentially growing global population, while at the same time achieving high standards in terms of aesthetic, structural safety, and energy performance. Design for manufacturing and assembly is at the base of prefabrication. Among the variety of available prefab technologies, those based on lightweight steel profiles are particularly well suited for low and mid-rise housing. Although this technology is spreading, for it to be applied at a large scale, it still requires to be optimized to reduce the amount of material and fabrication waste, lower fabrication time, and reduce costs. The optimization requires understanding and improvement of the mechanical behaviour. It is worth considering that the structure's cost can reach up to 20% of the total expenditure and its associated embodied carbon can make up as much as 40% of the overall construction's embodied carbon. Therefore, favouring a composite system that can also facilitate achieving good energy performances with lower embodied carbon is paramount. Therefore, this paper presents the results of an interdisciplinary international research project aiming to optimize a housing system's mechanical and environmental performance for mass production. It presents the experimental objectives and results and the impacts that design decisions have made on the environmental impacts of the developed system. The presented interdisciplinary experimental approach, which is characteristic of architectural engineering, could be used in the future for the development of more prefab systems.

Keywords
Prefabrication, embodied carbon, housing, optimization, steel and composite systems

Circling Towards Profit: a Circular Life Cycle Approach to Evaluate the Economic and Environmental Feasibility of Buildings and Construction

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Abstract
The concept of Circular Economy (CE) has undergone a significant evolution, extending beyond the traditional 3R paradigm (reduce, reuse, recycle) to embrace a more holistic perspective that incorporates additional aspects. Previous research indicates the profound impact of circularity on the economic as well as the environmental domains of sustainability. Despite numerous efforts to integrate circularity metrics with established environmental and economic evaluation methods, a comprehensive framework that cohesively synthesizes circularity with both economic and environmental in a single unified framework is notably missing. To address this gap, this paper introduces the Cost of Circularity Assessment Tool (CoCAT), an innovative and integrated framework. CoCAT incorporates the Whole Building Circularity Indicator (WBCI) along with Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) to simultaneously evaluate the economic as well as the environmental feasibility of various circular solutions. WBCI serves as the key metric on which the rest of the analysis is developed. The successful integration of WBCI with LCA has previously been demonstrated, and this study extends the methodology to encompass LCC through a rigorous literature review and critical analysis. The paper methodically explains this unified framework, aligning CE-based methodologies for all three assessments within the CoCAT in line with the existing standards. Additionally, it provides guidance on conducting integrated inventory analysis, combined interpretation, and visual representation of results, with a focus on whole-building level assessment. The research reveals that such integration streamlines the assessment process, saving time and effort. CoCAT can be used by stakeholders, companies and LCA practitioners to identify trade-offs between increased circularity and its impacts on sustainability performance (environmental and economic) for informed decision-making.

Keywords
Cost of circularity, circularity assessment, circular economy, circular life cycle costing, circular buildings

Multi-domain assessment of the impact of Biophilic Design strategies for the design of workplaces in Virtual Reality

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Abstract
A recent interest in implementing Nature-Based Solutions through Biophilic Design (BD) strategies has risen for the creation of comfortable indoor environments. Despite lab studies indicating benefits for work efficiency, the lack of preliminary design assessments has hindered their implementation. Virtual Reality (VR) has emerged as an effective tool for data collection in highly realistic environments, addressing such limitations. While current research on BD has mainly emphasized the visual connection with nature, it is important to note that individual experiences are multisensorial. This paper presents an innovative design approach for the preliminary assessment of BD strategies in VR. A case study compares three office layouts (Indoor Green – IG; Outdoor Green – OG; Non-Biophilic - NB) and three acoustic scenarios (Office – O; Office+Traffic – O+T; Office+Nature – O+N) with 198 participants performing cognitive tasks for each acoustic condition, alongside surveys. Results of sense of presence, immersivity (visual), sensory congruency (acoustic), and cybersickness disorders indicate the effectiveness of VR in the preliminary evaluation of BD interventions (ecological validity). The outcomes of the cognitive test highlight a positive influence of audio-visual connections with nature on working memory, inhibition, and task-switching performance. The most supportive visual*acoustic condition is identified as Natural sound in the IG setting, while O+T in the NB environment proves to be the most disruptive. The findings reveal a significant impact of the acoustic environment on the soundscape assessment: the O+N scenario enhances both pleasantness and eventfulness compared to the O scenario. An interaction between audio-visual stimuli was observed regarding pleasantness, with IG being more effective in the O+N scenario, and OG in the O+T scenario.

Keywords
Virtual Reality, Biophilic Design, Multi-domain, Work-efficiency, Soundscape

Vertical Greenery Systems for building stock

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Abstract
The 2030 UN Agenda for Sustainable Development calls for strategies for climate change mitigation and adaptation. In this sense, greening strategies can help achieve this goal as well as improve the environmental, psychological, and social quality of cities. Nature Based Solutions (NBS) constitute one of the strategies that address both adaptation and mitigation of climate change. In the urban context, NBS are translated into Green Infrastructures (GI) i.e. greening of private and public land with trees and hedges, Green Roofs (GR) and Vertical Greenery System (VGS).
The greening systems when applied on new buildings, for instance Bosco verticale (Stefano Boeri, 2009_2014) or Caixa Forum (Herzog & de Meuron, 2003_2008), just to mention the most famous ones, became one of those requirements which the design in based on; instead, when we deal with urban regeneration and building renovation/retrofitting design it is necessary to choose the greening strategy that accounts the constraints dictated by existing buildings related to geometry, load bearing structure, architectural and technological aspects.
This study aims to evaluate the applicability of VGS on the existing building stock and their role in summer comfort, starting from the classification of building types used in the most recent architectural projects. The study provides a premise for the transfer of this technology as a useful strategy in greening interventions on the building stock.

Keywords
Built Environment, Building Retrofit, Green Façade, Living Wall

Design for disassembly of a modular steel structure: case of study “Dinamizador barrial”

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Abstract
The policy to mitigate climate change necessarily passes through the reduction of the carbon footprint of the construction sector, responsible for 40% of global emissions. With the aim of encouraging circular economy processes, the methodology developed considers a quantitative/qualitative approach aimed at optimising the benefits of applying module ‘D’ of the LCA Building, with reference to the UNI EN 15978 standard. The case study concerns the design of an urban regeneration intervention, in the city of Cordoba, Argentina, consisting of an aggregative system of modular typologies, with a steel structure. Concerning the quantitative thresholds, the disassembly incidences were considered, applying the most restrictive parameter among the international sustainability protocols, including the Italian CAM. As far as qualitative parameters are concerned, the PROGRESS (Provision for Greater Reuse of Steel Structures) method was applied, a tool developed to evaluate the reuse of structural steel components. The validation of the method involves the development of an improvement hypothesis using existing, decommissioned steel components, highlighting both the economic benefits and the environmental impact of the process, through the application of the A1-A3 Building LCA module.

Keywords
Deconstruction, Design for Disassembly, Design for Reuse, Sustainable Design, Steel reuse

Transparent hybrid glass-wood bracing: initial results of an experimental campaign

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Abstract
This paper focuses on the shear behaviour of glass panels used in curtain walls, in particular those with an adhesive joint between the frame and the double glazing units, as described in the Patent No. 102020000025636, entitled "Continuous Facade System for Buildings". The importance of this research lies in the need to understand the response of these panels to seismic and wind forces, particularly through experimental research. Whilst the use of curtain walls with glass panels is becoming more widespread in the building industry, their structural behaviour during seismic events remains poorly understood. Given the complex nature of these systems, a careful study is required, taking into account all relevant variables. Although these structures are designed to effectively resist wind-induced pressures and depressions, their dynamic behaviour during earthquakes may be complex and difficult to predict. During seismic events, the structural components of the façade can be subjected to various stresses induced by horizontal or vertical vibrations, resulting in increased internal stresses that cause damage and permanent deformations. Therefore, our objective is to study the response of these glass panels to shear forces, with the aim of understanding their structural behaviour with different construction solutions, such as monolithic and laminated tempered glass. The interest in assessing their shear performance also extends to exploring their potential application as transparent bracing walls, offering an alternative to conventional solutions such as reinforced concrete, solid masonry (reinforced or not) and similar methods. The present paper illustrates the results of in-plane shear tests on curtain wall panels assembled with structural adhesives. The frame is made of mahogany wood and the glass panels are made of laminated and non-laminated tempered glass. Overall, the experimental results highlighted how the use of adhesive bonding increases the stiffness of the resulting hybrid structural system allowing the application of transparent stiffening partitions in buildings.

Keywords
K Building performances, Transparent hybrid glass-wood bracing, Adhesive technology

Life cycle impact analysis of different intervention scenarios for regenerating the existing building heritage. The case study of the new "Borgo Digani" in Argelato, Bologna

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Abstract

This paper aims to compare different intervention scenarios for the regeneration of the existing building stock based on two opposite paradigms: deep renovation and demolition and reconstruction. In the second case, three different construction technologies for the structure of the new building were investigated, respecting the original volumetric and architectural characteristics: wood, reinforced concrete, and steel. The comparison between the different solutions sought to highlight the potential and criticalities of the two different approaches, with particular attention to aspects related to environmental sustainability. This investigation was carried out on a manor villa built at the beginning of the 1990s, belonging to the "Borgo Digani" complex located in Argelato (Bologna), selected as a pilot case by the European project "DRIVE 0", financed within the Horizon 2020 programme, aiming at promoting the decarbonisation of the existing built heritage. The analysis was carried out by imposing certain fixed conditions for all scenarios: the external shape of the building, the thermal performance of the envelope walls (equal to 0.18 ± 0.02 W/m^{2}K), and the use of the same thermal insulation material for energy efficiency. Analyses of the energy performance of the different technologies adopted and the different building envelope solutions selected were addressed with *Edilclima* software. The assessments of the environmental impact of the various interventions, on the other hand, were carried out through a simplified Life Cycle Assessment (LCA) on the whole life cycle of the building, using *One Click LCA* software. The results of the analyses, expressed in terms of embodied energy and embodied carbon, showed how the final values are highly influenced by the imposed boundary conditions and how crucial it is to interpret critically the data resulting from the calculations carried out, which also consider the expected performance.

Keywords

Deep renovation, demolition with reconstruction, circularity, environmental impact, Life Cycle Assessment (LCA)

A literature review of H-BIM strategy for construction maintenance

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Abstract
Building maintenance planning strategy has always been of capital importance to improve building asset life cycle, and Building Information modelling can improve the efficiency of maintenance processes. The research work under this paper performed a literature review addressing the H-BIM strategy for building maintenance management and planning. Heritage Building Information Modeling H-BIM, is the application of the BIM strategy to the existing building stock, with the aim of creating a method and tools for building information acquisition and management. Actual implementation of H-BIM based strategy for building maintenance management aims at planning and controlling technical maintenance operations, also addressing environmental sustainability. Sustainable building maintenance mainly refers to materials and product re-use. Therefore, in case of existing buildings without cultural value, building maintenance sustainability refers to the Design for Deconstruction problem and H-BIM can be used to improve End of Life sustainability. H-BIM contains all pieces of information available to minimize Construction and Demolition Waste while deconstructing and reusing the building materials in a circular economy perspective. Digital Twin is the virtual replica of a built asset, that can support analysis, control and simulation functions with the objective of creating a Decision Support System for maintenance management. The use of sensor systems distributed within the building will become essential tools in the maintenance process. The owner will always be updated about building functions efficiency, and related maintenance requirements and operations. Even the model of use of the building can be designed and controlled, addressing specific living experiences of the users, the Building-Enabled lifestyle management.

Keywords
H-BIM, construction maintenance, facility management, digital twin, building information modelling

Physical-based reduced-order model for buildings energy efficiency

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Abstract

This research aims to investigate the feasibility and possible benefits of applying Reduced-Order Models (ROMs) to the Architecture, Engineering and Construction sector. The reduced-order model is a methodology for designing complex systems that exploit the synergy of interacting phenomena. Although it can significantly speed up design and run dynamic simulations, this technique is still not widely applied in the AEC field. Other industries often use them to optimize systems performance, create digital twins, and streamline multidisciplinary optimization methodology.

The first section of this paper describes the proposed methodology, followed by the study of the advantages and limitations compared to traditional design systems, including an analysis of current research and applications. Instead of a prescriptive design based on the worst-case scenarios, this kind of simulation enables performance-based design with partial loads and dynamic behaviour. This innovative approach makes it possible to support the designer during the conceptual phase and deal with the design problem more consciously to realize more sustainable and comfortable solutions. ROMs require low computational capacity and thus can handle real-time sensor data during operation and maintenance. A drawback is the difficulty of understand and model the physics underlying a specific system.

The last section presents an operational workflow and the early stage of a test application that explores how physical-based ROM can support the designer in defining energy interventions on an existing building's classroom. Thermal and energy behaviour, heating, ventilation, and air conditioning systems and their interaction have been modelled. The final step consists in incorporating subsystems representing potential active and passive energy improvement interventions to understand how the system improves and minimizes energy consumption improving indoor environmental quality.

Keywords

Reduced order model, Physics based design, 1D model, Architecture-Engineering-Construction, Energy simulation

Notes on technique and innovation

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Abstract
I believe that it is necessary for our discipline (Architectural Technology) to refer to the technology relevant to the construction sector, because the backbone of our research is the development of components or parts of components, as well as the theoretical-experimental evaluation of performance in a process of continuous optimisation. This must translate into a freedom of thought and research that creates a very broad reservoir of knowledge from which the market can draw for the needs of the present or a more or less near future that we do not yet know. I focus my work on a concept of environmental sustainability based on the value of the performance and longevity of the product, but I am convinced that not all research has to follow current trends. Therefore, I thought it appropriate to try to highlight the specifics of technology and innovation with this article as food for thought for the development of research in our field.

Keywords
Technology, Innovation, Invention, Sustainability

Advancing raw earth reinforcement for 3D printed architecture - Durability assessment

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Abstract
The integration of 3D printing technology into earth construction presents an opportunity to reinvent earthen architecture and construction methods. This by revalorizing earth-based materials sourced from excavation works of major infrastructure projects. This article explores the durability aspects of 3D printed earth architecture, focusing on water resistance against drip impact and natural weathering. Additionally, it examines the efficacy of incorporating bacterial cellulose (BC) as an additive for enhanced water resistance.
The study outlines material selection, prototyping techniques, and testing methodologies. Findings reveal that BC addition significantly improves erosion resistance, as demonstrated by drip test analyses. Moreover, observations from the weathering study highlight minimal degradation in BC-stabilized samples compared to unstabilized counterparts, which exhibited notable cracking. Finally, the impact of the implementation techniques has been explored, revealing a fragile behavior of printed samples compared to molded ones. This suggests a correlation between printing parameters and water resistance.
This research contributes to a broader thesis centered “harnessing the advantages of cutting-edge construction technologies and eco-design methodologies to valorize excavated soil as construction wastes”.

Keywords
Earthen material, fabrication additive, biopolymer, drip test, natural weathering

Performance analysis of a steel exoskeleton with double skin façade for energy and structural retrofit of existing ’70s-’80s buildings

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Abstract
In current climatic and social context, energy retrofit of existing buildings plays a really important role thanks to the considerable economic and CO_2 savings connected to the lower building energy demand. This study fits perfectly into this context and aims to evaluate the effects of an energy and structural retrofit intervention on an existing building representative of the pre-1980s Italian period by means of a steel reticular exoskeleton. This exoskeleton was designed in order to improve the dynamic response of the existing structure and to realize a new high-performance double-skin unitized façade. The new façade, designed taking into account fundamental geometrical criteria, creates a floor-by-floor air volume, used as a greenhouse in winter and as a ventilated cavity during summer. Furthermore, the choice of low-emissivity performance glass for the wide glazed surfaces allows to reduce the heat losses during winter, reducing the overall energy demand. During summer, on the other hand, the activation of solar-controlled automated venetian blinds, combined with the control of natural ventilation, allows a significant reduction of the cooling demand. The transition from winter to summer mode is guaranteed thanks to a dedicated schedule that allows the control of solar radiation and natural ventilation from May to September. From a performance point of view, thanks to the control and optimization of the natural ventilation and incident solar radiation in the double skin cavity, the overall energy consumption of the existing building can be reduced by more than half. In conclusion, this study highlights how the proper design of an exoskeleton allows to both improve structural and energy behaviour; in particular, using the exoskeleton to create a glazed double skin façade, significant savings can be achieved, making existing buildings less energy-intensive.

Keywords
Energy retrofit, architectural engineering, sustainability, exoskeleton, double skin façade

The “Filigrana” system for a fair look in façades solar-panel embedded

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Abstract
Solar energy is the most available and easy to use of the renewables available for buildings. Retrofitting the building stock goes through a designed, non-emergency placement of solar panels. In some cases, rooftops are not the best option: for example, in residential buildings they are not equally available to all owners or in commercial centers they are cluttered with chillers, AHUs, and so on. In contrast, the integration of solar collectors into the vertical envelope raises some visual issues related to the image of the urban environment, which has to deal with dark, shiny surfaces that are, moreover, suboptimally oriented with respect to the sun’s rays and therefore inefficient. This paper focuses focused on the new design of a thermal insulation system that incorporates photovoltaic or thermal solar collectors and allows for dimensional flexibility, scalability, and custom finishes. Retracing the development of the optimal shape of thermal insulation cladding, devices that enable the application of photovoltaic strings or solar thermal panels are also illustrated and visual results in different contexts are proposed. The project result, originally named Filigrana and covered by an Italian patent, has been brought to the level of pre-feasibility by Dreamet S.r.l. (Modena, Italy) under the name “Aster”: it allows the free choice of color of cladding, the replacement of all or part of the solar collectors over time depending on their technological evolution, and, most importantly, it is designed to improve the orientation of solar collectors on the vertical walls of buildings. Shopping malls and warehouses may be the main target, but the system also allows for managing access to photovoltaic energy for each of the individual tenants, avoiding impromptu and random additions to facades and improving the passive thermal performance of the building envelope.

Keywords
BIPV, photovoltaic envelope embedded, patented PV façade, green building, envelope refurbishing

Raw earth buildings and Industry 4.0: an overview of the technology and innovation of the MUD-MADE project

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Abstract
Research on digital production technologies for the building sector, although several decades behind other sectors, is beginning to become more and more systematic. The use of natural materials such as raw earth makes the sustainability of such processes even more pronounced than current building solutions. Despite this, many limitations still prevent the use of digital technologies employing raw earth for construction from becoming current. The article investigates the state of research on the topic, identifying the reasons for current limitations. It also describes the MUD-MADE research project that aims to overcome these limitations and make the use of digitally fabricated raw earth components for the building sector a reality. This project proposes a novel artificial intelligence-supported workflow for designing raw earth building components produced with digital manufacturing technology (i.e. 3D printing, robotic arm or laser cutter). The workflow can support the designer in a multi-objective optimization involving different performances (e.g., thermal, structural, acoustic) by saving material and maintaining feasibility. The workflow exploits parametric design to set a predefined visual script able to support the user. Indeed, the predefined script will allow the user to design a building component by selecting (or creating) different possible external shapes and infill geometries (depending by a set of generative algorithms and parameters). The designer can include information about the local material and the available technology to digitally manufacture the component directly in the predefined code. In addition, the predefined script sets the boundary conditions and priorities about the expected performances. Moreover, performance priorities are defined by the user based on the requirements of the component to be achieved.
Finally, artificial intelligence, exploiting the artificial neural network (ANN) will support the designer by automatically identifying the optimal configuration among the possible combinations of parameters and generative algorithms.

Keywords
Digital manufacturing, sustainable design, earth building, artificial neural network

Reuse of façade materials across benefits, challenges and potential opportunities

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Abstract

The construction industry is facing significant challenges in aligning with the circular economy principles, primarily due to the management of Construction and Demolition (C&D) waste. Effectively addressing this issue is pivotal in minimizing the environmental impact of buildings at the end of their life cycle. An essential step towards this goal involves establishing a robust supply chain for the recovery and reuse of waste materials and avoiding those to be landfilled.

In this research a literature review has been carried out to map and analyse the existing challenges which prevent the establishment/implementation of a recovery route for the facades materials and components. These challenges could be transformed in actionable opportunities to tackle the problem. The facade systems are characterised by a relatively short service life compared to other building layers, and they undergo frequent process of refurbishment and renovation. The result is a large waste stream associated with the facades layer. Several issues were found to have consequences among multiple categories, showing the complexity of the End-of-Life (EoL) stages of facade materials. The identified challenges and opportunities in the EoL scenario of the facades can be categorised into technical, economic, logistical, legislative, and cultural domains.

Finally, the paper discusses ongoing trends and research stream in the field of facades and building sustainability, such as the benefits of the design for disassembly approach in creating systems and components with a higher recovery potential and the design for reuse/recovery of materials.

Keywords

Materials reuse, circular actions, design for disassembly, façade system, C&D waste

Making mountain huts future-proof – consistency analysis to improve adaptation and resilience of the mountain hut network

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Abstract
Mountain huts form a continuous network throughout the alps. Originally built as a support for scientific exploration, it continues to serve as a vital resource for mountain visitors, maintaining much of their original form. Over time, the motives driving people to visit huts diversified, encompassing sport activity, tourism and scientific research. This trend has led to an increasing number of people visiting the mountains. Concurrently, aggravating environmental changes in the Alps, with average temperatures increasing almost twice as fast as the rest of the northern hemisphere, increase frequency of natural hazards, such as landslides or avalanches. These developments raise the risk for mountain visitors while threatening these delicate ecosystems and their built environment. Mainly built before 1980s, mountain huts need to adapt to these dynamic social and environmental changes. The characteristics of huts and their surroundings are different from urban settings, requiring a specific renovation framework that considers all these peculiarities. This article explores the state of the art of this architectural typology, investigating a cluster of 749 mountain huts owned by the Italian Alpine Club (CAI), studying their management methods and the most recent approaches on alpine huts renovation. This study aims to analyse the unique architectural typology of mountain huts with an interdisciplinary approach, considering the feasibility of technical aspects while accounting for environmental, economic, and social parameters. This will be the baseline to establish measurable criteria to aggregate existing alpine infrastructure and to finally create a comprehensive guideline for functional sustainable renovation and ultimately to increase the climate adaptation and resilience of the alpine built environment.

Keywords
Alpine huts, alpine build environment, building renovation, renovation guidelines, Italian Alpine Club

Digital Evolution: from BIM to Digital Twin

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Abstract
In recent decades, technological advancements in areas such as the Internet of Things (IoT) and artificial intelligence have facilitated the digitalization of various resources, systems, and processes across various industrial sectors. Progress in virtual modeling and data acquisition technology has contributed to the emergence and development of the Digital Twin, a virtual representation of a physical asset that utilizes technologies such as sensors, IoT, communication networks, and 3D models to collect real-time data useful for monitoring its performance throughout its lifecycle. This work aims to emphasize the importance of applying Digital Twin technology in the construction sector, which helps understand the evolutionary behaviors and performance of a structure over time and space. It considers how the elements (materials, systems, etc.) composing the structure degrade based on various environmental conditions and user occupancy patterns. Simultaneously, through analysis and monitoring of physical assets using the digital twin, it becomes possible to determine the optimal time to intervene and replace worn-out components or systems, thus ensuring the continuous functionality of the structure to maintain performance at optimal levels. In the coming years, technology will enable the integration of artificial intelligence into the construction sector. This will allow the analysis of performance, both pre- and post-construction, to anticipate evolving needs with a high degree of probability. This will be facilitated by the collection of statistical data and the comparison of performance behaviors from buildings that are typologically and morphologically similar.

Keywords
Artificial Intelligence, Digital Twin, Building Information Modeling, Facility Management, Internet of Things

Life Cycle Assessment and datasets development of steel construction products for the Italian LCA Database

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Abstract
Life Cycle Assessments (LCAs) in the building sector, and in particular in the design phase, are becoming more and more widespread as these are used to identify the environmental indicators underlying the criteria of sustainability assessment protocols for buildings such as LEVEL(s), and environmental rating systems such as LEED, BREEAM, ITACA and Envision for infrastructure. In this context, the ARCADIA project (concluded in October 2023) had the main goals of creating a national Life Cycle Assessment database for selected supply chains and strengthening public administration skills in applying Life Cycle Costing in Green Public Procurement. This paper describes the LCA study phases conducted, according to the ISO 14040-44 methodology, by the working group of the steel building construction value chain and the relevant results and datasets implemented in the Italian LCA Database. The work focuses on assessing the environmental impacts of producing two main products for the steel building value chain, selected according to market needs. The methodology comprises a "cradle to gate" approach, grounded in the distinct attributes of the product systems, consequently, it can adequately aid in evaluating sustainability during decision-making for steel products by generating accurate Carbon Footprint assessments. The methodology yielded results in the range of 0.93 - 1.60 $KgCO_2eq/Kg$, depending on case study features, and agreed with the impact value range in previous literature.

Keywords
Life cycle assessment (LCA), construction sector, steel building materials, environmental impact

Biogenic Local Waste for the Refurbishment of Rural Heritage: the Gualtieri Case Study (Lombardy, Italy)

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Abstract
Can rural buildings be refurbished by exploiting natural waste from local productions?
This research aims to achieve implementation and sufficiency objectives by focusing on existing building refurbishment, efficiency improvement, and local natural resources exploitation. The solution being explored is the use of bio-based building materials, which, if well-designed, can offer low or even positive environmental impacts. To avoid land use and ensure not to compete with the food and biofuel sectors, the research focuses on organic waste in a circular approach. The research investigates a replicable workflow for using local bio-based waste in rural refurbishment, from the quantification of waste to the evaluation as building components, to finally assess the impact of their application. The contribution analyzes the state of the art, highlighting the lack of an established methodology for using natural waste in construction. The final goal is to facilitate the integration of these materials into the local construction sector. A case study has been presented to consider a specific geography and government system, starting with examining the Valmalenco Mountain Valley in northern Italy and hypothesizing the refurbishment of the Gualtieri village as a pilot project. The research employed Life Cycle Assessment to investigate the sustainability of different refurbishment scenarios for the case study, employing the semi-static method to determine GWP. Two tiers of study ensued: a primary comparison of biogenic insulation materials based on performance, impact, and cost, and a secondary analysis of three technologies, both conventional and innovative. Finally, a comprehensive examination of impacts was conducted and contrasted with the CasaClima protocol's national performance scale, yielding positive verification.

Keywords
Bio-based materials, Rural settlements, Local organic waste, Refurbishment strategies, Data-driven design

Innovative folded rain-screen cladding prototypes

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Abstract

This paper proposes an innovative self-shading rain-screen cladding module. Various materials and geometries were explored, and the use of a reflective nanotechnology coating was also evaluated. Multidisciplinary research was conducted, which involved the technological definition of the construction details, the mechanical verification of the anchors, the energy optimisation of the panel shape through solar path evaluations, experimental measurements of the thermal performance during the summer period, and the comparison of construction costs. The main results showed that the aluminium-designed module with a flat surface and reflective coating is the best-performing alternative and provides 9°C lower surface temperatures of the wall behind than a traditional white plastered wall.

Keywords

Innovative rain-screen cladding, Shaped self-shading prototype, Thermally reflective finish, Multi-objective Design, Innovative low-cost anchoring system

A new load-bearing stone construction method: digital modeling and construction of two prefabricated freestone walls

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Abstract

This article introduces a construction method that provides solutions capable of promoting the load-bearing use of stone in new buildings. Considering the economic and environmental advantages of natural stone in an international context of seeking reasonable resource use and construction processes with a better environmental impact, this research aims to open new perspectives for the use of natural stone as a structural material in contemporary architecture. The underlying hypothesis of this research is that the use of stone in load-bearing systems, gradually abandoned during the 20th century, could regain significant interest if new design and engineering models were developed more extensively. The article presents the method applied to the design and fabrication of two prefabricated load-bearing freestone walls, which are part of an innovative construction method based on prefabricated masonry elements. After construction, the two prototypes were lifted and transported to a national natural stone exhibition, located 30 km from the manufacturing site, thus demonstrating the feasibility of the process.

Keywords

Stone, Prefabrication, Construction method, Stereotomy, Masonry

A methodological approach for informed design between tradition and innovation

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Abstract
With the rise of environmental concerns and the impact of information technologies, architecture is changing, and so are the methods of design. Thus, new approaches based on principles of information sharing, data, algorithms and collaboration are at the forefront of theoretical and practical architecture debates. This article introduces a collaborative methodological approach to digital design centred around creating a system where relationships between form, structure, and material are informed and interact within it.
The approach proposed operates at the intersection of various disciplines, including mathematics (geometry), mechanics, physics, construction history, and computation. It relies on collaboration among diverse actors, enabling each to contribute their practical and constructive expertise in a comprehensive and integrated manner across multiple dimensions of the architectural project.
Considering innovation as an intrinsic element within a continuous historical context, this research identifies in a past construction technique the potential for developing innovative systems. In order to revalue the connection between tradition and innovation, focusing on the links between form, technique and construction, we present an example application of the methodology for formfinding of a flat vault. This application is based on a topological interlocking system, which draws inspiration from a patent dating back to the 17th century.
We detail the numerical design steps of the stone system as well as the prototyping phase based on the use of traditional stereotomy cutting methods. Finally, we present a prototype built during a workshop with students from École Nationale Supérieure d'Architecture de Paris-Malaquais, in collaboration with Compagnons du Devoir et du Tour de France.

Keywords
Numerical design, collaboration, tradition and innovation, stereotomy

Innovative layouts for the management of production buildings according to the principles of industry 5.0

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Abstract
The design of the layout of logistics spaces represents a fundamental step for the organization and rationalization of industrial production procedures according to an approach that also places sustainability and resilience at the centre of interests within the context of a human-centric approach of the so-called Industry 5.0. The optimization of warehouse flows is strictly connected to the optimal use of space, necessary to guarantee the reduction of operational phases, ease of access and control, and the best efficiency and usability of the spaces. The research work presented in this article aims to define a generally applicable methodology for the design and adaptation of industrial plants, with particular reference to systems intended for warehouse logistics processes. The design guidelines that we want to define will integrate the spatial needs related to practice and business activity with the new research directions that look at digital innovation of companies and energy efficiency. Central to these assumptions is the definition of the structure of the layouts which can determine different performances for the same activities, as they transversally influence multiple aspects such as the health and well-being of workers, the management of spaces, times, energy consumption. The topics covered are the result of an initial research activity carried out at the Solis GreenLog S.r.l. logistics centre, a hub of the Solis S.p.A. group, an integrated temperature-controlled transit point that offers spaces and services for storage, processing, handling and distribution of the goods.

Keywords
Industrial buildings, industry 5.0, warehouse layout, energy efficiency, cold chain logistics

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