

Daniela BESANA, Elisabetta DORIA
Alessandro GRECO, Marco MORANDOTTI

BEYOND THE PROJECT

EXPLORING KNOWLEDGE, COMPLEXITY AND INNOVATION IN BUILDING

BOOK OF ABSTRACTS



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BEYOND THE PROJECT

Exploring knowledge, complexity and
innovation in building

Pavia, 17-19 June 2026

Daniela BESANA, Elisabetta DORIA, Alessandro GRECO,
Marco MORANDOTTI

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BEYOND THE PROJECT

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INTRODUCTION



This publication collects the contributions presented at *Colloqui.AT.e 2026 "Beyond the Project. Exploring Knowledge, Complexity and Innovation in Building"*. In the meanwhile of the final publication of the full contents and contributions of the conference, it stands as a living document of the disciplinary debate that animates our field, whose boundaries are constantly being renegotiated, and whose identity is defined at the intersection of rigorous knowledge, technical innovation, and critical inquiry into the built environment.

The decision to gather these abstracts in a dedicated publication responds to a precise editorial and scientific intention: to make visible, although in a concise and synthetic way, the breadth and depth of the research carried out within the Italian university system in the area of Building Technology, and to offer the scientific community a shared resource for exchange, dialogue, and comparison. The abstracts collected here represent a cross-section of ongoing research, emergent questions and consolidating paradigms; a kind of cartography, necessarily partial and provisional, of where our discipline stands today and where it is headed.

The conference gathers around the theme *"Beyond the Project. Exploring Knowledge, Complexity and Innovation in Building"*, a formulation that deliberately triggers. To go beyond the project does not mean to abandon it, but rather to interrogate its limits, to expand its semantic field, and to recognise

that the act of designing the built environment is never reducible to a technical or formal operation alone. It is, at once, a cultural act, an ethical commitment, and a political gesture embedded in social structures, material constraints, temporal flows, and systemic interdependencies that resist simplification. This assumption has ever been true, but it is even more urgent in the present days.

The conference convened at a moment of acute historical pressure. The acceleration of global transformations, both ecological, technological, demographic, and geopolitical, places unprecedented demands on those who study, teach, and practice building. In this context, the twin transitions that structure contemporary discourse on the built environment, the ecological transition and the digital transformation, are not merely policy frameworks or research horizons: they are structural forces reshaping the very conditions under which architecture and construction operate.

The European Green Deal, the targets set by the Energy Performance of Buildings Directive, the proliferation of digital platforms for design and construction management, the emergence of AI-assisted tools point to a reconfiguration of professional roles, knowledge systems, and educational responsibilities that our discipline cannot afford to observe from a distance. The ecological transition demands a fundamental rethinking of the relationships between buildings, energy, materials, and climate. It calls for a

shift from performance optimisation within existing paradigms to a more radical questioning of what it means to build responsibly in a resource-constrained world. Life cycle thinking, circular economy principles, bioclimatic design, and nature-based solutions are no longer optional enrichments of the design process but structural components of any credible response to the climate emergency.

At the same time, the digital transformation is not simply a matter of new tools: it implies new epistemologies, new modes of collaboration, and new forms of knowledge production. The integration of Building Information Modelling, parametric design, digital fabrication, sensor networks, and machine learning into the design and construction workflow raises questions that are simultaneously technical, methodological, and pedagogical, and that our community is uniquely positioned to address.

Yet the conference also insisted on a less obvious, but equally vital, dimension of our disciplinary identity: the relationship with the past.

The legacy of Building Technology, its accumulated practices, its material intelligence, its constructive memory, is not merely a patrimony to be preserved but a living resource to be critically mobilised. The history of construction, the analysis of traditional techniques and local know-how, the study of how buildings have been modified, maintained, and adapted across time: all of this constitutes a form of knowledge that is irreplaceable in its specificity

and indispensable for responsible innovation. To go beyond the project means also to go through history, to draw on what has been built, tested, and transmitted in order to build more wisely.

The scientific contributions gathered in the conference, and therefore in this volume, are organised around three thematic clusters, each of which reflects a distinct but interconnected dimension of the disciplinary field.

Topic A — Construction and Conservation History

This cluster brings together research that engages with the historical and heritage dimensions of building knowledge. The contributions investigate the evolution of construction techniques, the structural logics embedded in historical artefacts, the material cultures of different building traditions, and the methodological tools available for the reading, documentation, and interpretation of the existing built heritage.

Understanding the past is not a preliminary to understanding the present: it is constitutive of it. These contributions affirm that historical knowledge is a form of design intelligence, essential not only for conservation and restoration practice but for orienting innovation in coherent and culturally grounded ways. The history of construction becomes, in this framing, a critical resource for interpreting, evaluating, and adapting inherited knowledge to the challenges of contemporary regeneration.

Topic B — Building Construction and Performance

This cluster addresses the technical and technological core of the discipline, engaging with questions of construction quality, building performance, and the increasingly complex regulatory and societal expectations that contemporary buildings are called upon to meet.

Energy efficiency, thermal and acoustic comfort, structural safety, accessibility, indoor environmental quality, and long-term durability are addressed not as isolated parameters but as interdependent dimensions of a systemic challenge. The contributions testify to the growing awareness that high-performance building cannot be achieved through disciplinary fragmentation: it requires an integrated, interdisciplinary approach capable of managing complexity, bridging the gap between research and practice, and generating solutions that are both technically robust and socially responsive. The dialogue between architectural and technological design emerges as a critical axis, a space of productive tension where formal intentions and material constraints must be continuously negotiated.

Topic C — Building Design and Technologies

This cluster looks towards the evolving frontier of tools, methodologies, and technological systems that are transforming the conditions of architectural production. Digital modelling and simulation,

innovative and bio-based materials, advanced manufacturing processes, computational design, generative and AI-assisted tools, and environmental impact assessment define the instruments and paradigms that are redefining what it means to design a building in the twenty-first century.

The contributions in this cluster do not merely describe technical novelties but engage critically with their implications for professional practice, for the division of roles and responsibilities within design teams, for the relationship between designers and fabricators, and for the pedagogical mission of our university programmes. The future of Building Technology, as these contributions collectively suggest, will be shaped not only by what tools become available but by the intellectual and ethical frameworks within which they are deployed.

Read as a whole element, the three clusters trace a complex and interconnected landscape of knowledge where historical understanding, technical mastery, and design intelligence are not separate domains but mutually constitutive dimensions of a shared disciplinary project.

This is, ultimately, the ambition of Colloqui.AT.e 2026: that the richness and diversity of the research carried out within our community, when brought into dialogue, can generate something more than the sum of its parts: a collective intelligence capable of rising to the challenges of a moment that demands,

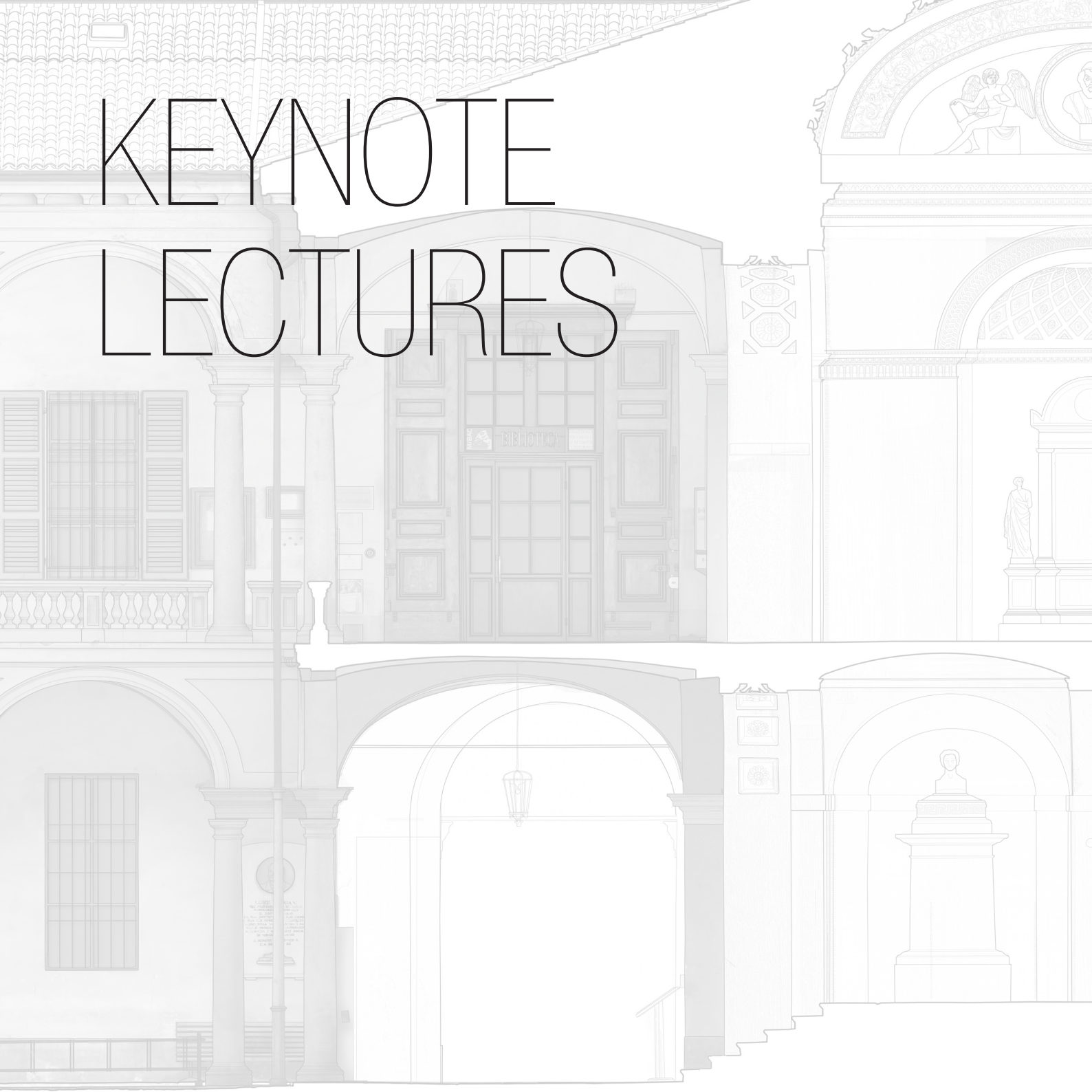
from all of us, clarity of thought, rigour of method, and breadth of vision.

We extend our deepest gratitude to all authors who submitted their works and engaged with the themes of the conference, and to the colleagues who actively cooperated in the blind review process of all the contributions received.

The quality and variety of the papers received confirms, once again, the vitality of Building Technology as a field of inquiry and the strength of the national academic community that sustains it. We hope that this Book of Abstracts will serve not only as a record of what was presented and discussed but as a stimulus for new connections, new collaborations, and new research trajectories, within our community and beyond it.

Daniela Besana, Alessandro Greco, Marco Morandotti

KEYNOTE LECTURES





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A NEW MODEL FOR URBAN REGENERATION - PRINCIPIA S.P.A. EXPERIENCE AND APPROACH

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Urban regeneration today represents a fundamental challenge in making cities more sustainable, inclusive, and resilient. The many Italian and international experiences demonstrate the importance of conscious and long-term actions capable of guiding urban development toward increasingly virtuous models. Among the most significant examples in Italy in recent years, the Milano Innovation District project "MIND" certainly deserves mention. Developed on the site of Expo Milano 2015, Principia successfully transformed the area into an innovation district hosting research institutions, universities, hospitals, and businesses. A sustainability-oriented development approach, attention to functional mix, the identification of effective public-private partnership models, and the ability to attract funding constitute the solid foundations underpinning Principia's work. These same principles have also been applied in the case of Parco Cardano in Pavia. This project can be interpreted as an opportunity to reconnect the city with the surrounding agricultural

landscape through a district capable of accommodating spaces for research and innovation in a thoughtful and responsible manner, while integrating environmental, social, and cultural needs. Its main objective is to enhance an urban area through interventions designed to improve the quality of life for the businesses that will establish themselves there, as well as for the nearby academic community, fostering collective use and a stronger sense of belonging to the place. Among the key strategies implemented by Principia are a strong focus on urban greenery, the promotion of biodiversity, and the creation of accessible and multifunctional spaces for work and research, also intended for social interaction and cultural activities. In this sense, both MIND and Parco Cardano may be seen as models of balance between land preservation and sustainable urban development. The contribution concludes with a reflection on the transferability of this model of public-private collaboration within the context of the twin ecological and digital transition.



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DESIGNING CHANGE

MASSIMO ROJ

FOUNDING PARTNER & CEO - PROGETTO CMR

Architecture has always reflected the spirit of its time: it tells the story of society's evolution, interprets technological innovation, and translates cultural and economic transformations into space. Through a journey spanning more than thirty years of design experience, this keynote speech offers a reflection on integrated design as a tool capable of connecting architecture, engineering, design, and strategic vision. From hand drawing to digital processes, from the transformation of workplaces to new models of sustainability and urban regeneration, the narrative retraces significant milestones in the evolution of contemporary design, linking projects, historical contexts, and social change.

The case studies presented demonstrate how every project emerges from the meeting of technique and creativity, functional requirements and the ability to interpret the needs of people and cities. "Designing Change" thus becomes not only the title of a conference, but also an invitation to reflect on the role of the designer today: a professional called to engage with ever-growing complexity, capable of understanding the present and imagining future scenarios through a multidisciplinary, open, and responsible approach. Humanity really does love turning existential uncertainty into keynote speeches. Still, this one has a solid intellectual structure.

A-CONSTRUCTION AND CONSERVATION HISTORY

D. Mohr

AS-BUILT BIM AND MEP DEVELOPMENT. THE MODELLING OF ELECTRICAL SYSTEMS OF IBF BELLOTTI AND RELATED IFC ISSUES

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MEP modelling plays a central role in the development of digital twins within the BIM methodology, as it supports the management of building systems and their interaction with sensor networks governing building performance and operation. Within the PNRR Tecnodigit research project, MEP modelling was applied to the Ion Beam Facility underground experiment, starting from the electrical system. A key challenge was the development of an IFC model compliant with the system hierarchy defined by ISO/IEC 81346, in accordance with the requirements of LNGS technicians and the shared WBS/PBS.

The IFC structure was required to both reflect the organization imposed by the standard and ensure explicit links between electrical system components and the architectural and structural domains. This paper discusses the main issues related to as-built BIM MEP modelling and presents the adopted solutions to comply with standard specifications, overcoming established modelling practices and software limitations.

KEYWORDS

BIM, MEP, BREAKDOWN STRUCTURE, IFC STRUCTURE, ELECTRICAL SYSTEMS, ISO/IEC 81346, SOFTWARE LIMITATIONS, GRAN SASSO NATIONAL LABORATORY

CONSERVATION AND RESTORATION OF ADOBE MASONRY IN ANCIENT BABYLON (IRAQ). THE CASE OF THE TEMPLE OF NINMAKH

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The paper presents the results of the project for the conservation and restoration of the adobe walls of the Temple of Ninmakh in ancient Babylon (Iraq), a UNESCO World Heritage Site. Through an in-depth analysis of the artifact, the original construction techniques of the neo-Babylonian era and subsequent modern reconstructions were investigated, highlighting structural criticalities and degradation linked to both environmental factors and incongruous interventions of the past. The research focuses on the characterization of the constituent materials, in particular the soils used for the production of adobe, and on the historical strategies of protection of the masonry, such as the use of bitumen as a barrier against rising damp. At the same time, a process of recovery of traditional local knowledge has been initiated, integrated with contemporary scientific methodologies, in order to define reliable protocols for

the production of new elements compatible with the original ones. Experimental activities, conducted mainly in situ, included particle size analyses, mechanical tests, and durability checks, allowing the optimization of earth mixtures and production techniques. The results showed that the adoption of traditional practices, such as long earthen mix maturation times, significantly improves the mechanical and hygroscopic performance of the material. The methodological approach developed represents an integrated model that combines empirical knowledge and scientific research, ensuring material compatibility, sustainability, and reproducibility of interventions. In addition, the project contributed to the training of specialised local skills, which are crucial for the long-term maintenance of Babylon's earthen architectural heritage

KEYWORDS

BABYLON ARCHAEOLOGICAL SITE., ARCHAEOLOGICAL RECONSTRUCTED MONUMENTS CONSERVATION. ADOBE HERITAGE CONSERVATION., ADOBE PRODUCTION TESTING., SUSTAINABLE PRESERVATION PRACTICES

FROM SMARTPHONE-BASED PHOTOGRAMMETRY TO XR FOR THE ACCESSIBILITY OF WATER UBH: THE CASE STUDY OF PALOMBARO PURGATORIO VECCHIO CISTERN IN MATERA, ITALY

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The increasing vulnerability of Underground Built Heritage (UBH) calls for systematic knowledge-building and robust documentation strategies that can simultaneously support conservation planning, risk mitigation, and public dissemination. In complex hypogeal environments, often characterised by irregular geometries, restricted accessibility, and critical lighting conditions, digital technologies are reshaping heritage practice by enabling the rapid acquisition, modelling, and sharing of high-resolution 3D datasets, transforming survey outputs into interoperable assets for analysis, communication, and valorisation. This paper investigates a low-cost, replicable workflow for the 3D documentation of the Palombaro Purgatorio Vecchio (Matera, Italy), based exclusively on smartphone photogrammetry (SfM–MVS) and validated against professional mobile mapping data. A rigorous acquisition protocol (controlled imaging settings, planned trajectories, and adequate overlap) was coupled with structured data processing to generate dense point clouds, textured meshes, and derivative technical

products (plans, sections, orthometric views). Metric validation was performed in open-source environments by constraining registration and scaling with a SLAM reference point cloud and by computing cloud-to-cloud distances to quantify geometric discrepancies. Results demonstrate that, despite the intrinsic limitations of consumer-grade sensors, a carefully designed and controlled workflow can deliver models with high visual fidelity and metric performance compatible with the functional requirements of heritage documentation intended for digital fruition. The outcomes support the integration of 3D models into open Web3D platforms, enabling remote access and the delivery of structured historical and material information to heterogeneous audiences. Overall, the study confirms that smartphone-based photogrammetry represents a viable and sustainable approach for the rapid documentation and dissemination of fragile UBH, provided that methodological rigour and awareness of accuracy constraints guide both acquisition and validation.

KEYWORDS

SMARTPHONE PHOTOGRAMMETRY, XR, UBH, HISTORICAL WATER SYSTEMS, SASSI OF MATERA

INTEGRATION OF BIM MODELLING AND IMMERSIVE TECHNOLOGIES FOR THE SAFE USE OF CULTURAL HERITAGE

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The increasing use of digital models for the conservation and management of Cultural Heritage has broadened the prospects and objectives related to the use of immersive environments for risk management. One of the most critical areas concerns fire safety, which requires the study and definition of evacuation strategies compatible with morphological complexity, the preservation of heritage values, and the current regulatory framework, as well as the development of effective communication strategies addressed to visitors. Evidence in the existing literature highlights that the integration of digital modelling and immersive technologies remains limited with regard to the joint safeguarding of both the asset and its users, despite the widely acknowledged potential of such approaches. In response to this gap, the paper proposes the development of a framework based on the integration of BIM modelling with immersive visualisation —

implemented within a neutral environment and in real time — accessible through standalone immersive headsets and a holographic stage. This is intended to support both the decision-making process of technical users and the subsequent communication to non-technical users. The study defines a digital environment enabling the three-dimensional visualisation of evacuation routes, critical points, and safety devices in order to clarify appropriate behaviour to adopt in emergency situations. Compared with more conventional virtual reality based solutions, the proposed system introduces an experiential approach to safety, intended to enhance risk awareness and behavioural learning. The prototype is conceived as replicable in complex historic contexts and oriented towards the preventive dissemination of protection strategies, balancing heritage conservation with user safety.

KEYWORDS

ARCHITECTURAL HERITAGE, MIXED REALITY (MR), HBIM, RISK MANAGEMENT, DECISION SUPPORT TOOL

PROTECTIONISM AND CONSTRUCTION EXPERIMENTATION: “AUTARCHIC” CONCRETE IN ITALY

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Italian autarchic policies imposed a profound revision of construction practices, directly affecting the use of concrete and reinforced concrete. The progressive restriction of materials considered strategic, particularly iron and timber, rendered reinforced concrete a problematic technique and triggered a phase of widespread experimentation aimed at reducing the use of metal reinforcement, rationalising structural solutions, and reworking the concrete mix. Through a cross-analysis of regulations, patents, manuals, and technical journals of the period, this contribution reconstructs the main strategies adopted to adapt concrete to the new production conditions: the optimisation of the relationship between calculation, form, and material; experimentation with alternative

materials to conventional reinforcement; and the revision of cementitious mixes through the use of resources of national origin. These practices reveal a constant tension between the requirements of control and standardisation and the variability introduced by material, territorial, and site-specific conditions. “Autarchic concrete” thus emerges not as a unitary typology, but as a field of heterogeneous and experimental practices developed in response to political and economic constraints, in which material austerity acted simultaneously as a limitation and as a driver of innovation. This perspective makes it possible to reinterpret the autarchic experience not merely as a contingent phase of adaptation, but as a technical and cultural laboratory for twentieth-century construction.

KEYWORDS

AUTARCHY, MATERIALS, REINFORCED CONCRETE, VALORISATION, CONSTRUCTION SYSTEMS, TWENTIETH-CENTURY ARCHITECTURE

CONSCIOUS ADAPTIVE REUSE OF THE FORMER ROMA SHIPYARD IN ADDAURA (PALERMO)

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This paper offers a critical analysis of the adaptive reuse of a significant example of industrial architecture located in Addaura, Palermo, designed by Francesco Damiani Mancinelli, son of Giuseppe Damiani Almeyda, a leading figure in nineteenth-century Palermo architecture. Between 1919 and 1924, Damiani designed and supervised the reinforced concrete structures of the buildings of the Roma Shipyard, applying the innovative theories and calculation methods he had acquired during his Civil Engineering studies at the Polytechnic University of Turin. Over time, the complex underwent substantial functional transformations. Following the failure of its original industrial use, it was converted into a seaside colony in the 1930s, later transformed into a training institute for war orphans after 1945, and subsequently adapted into a regional training center and public administrative offices. The complex is currently subject to a new adaptive reuse project aimed

at establishing an environmental and marine research center within a newly designed urban park. Through a comparative analysis of archival documentation—particularly the original drawings preserved in the Damiani Archive—and the recent rehabilitation projects, the paper demonstrates how the reuse interventions and regulatory upgrades, grounded in a thorough historical and constructive understanding of the buildings, respect their architectural identity without compromising their original morphological, typological, and structural characteristics. In conclusion, the study proposes a critical reflection on the potential for dialogue between scientific knowledge and the operational practices of public administrations, advocating—as exemplified in this case—integrated and collaborative strategies of adaptive reuse for the conscious regeneration of modern architectural heritage.

KEYWORDS

RESTORATION OF MODERN ARCHITECTURE, REINFORCED CONCRETE STRUCTURES, HISTORICAL-ARCHIVAL RESEARCH, HISTORICAL KNOWLEDGE

LIMEWASH AS A CYCLICAL PROTECTIVE SYSTEM: HISTORICAL AND STRATIGRAPHIC STUDY OF CALCARENITE SURFACES IN THE CITY OF MATERA (ITALY)

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This paper investigates limewash layers applied on calcarenite masonry in the building heritage of Matera (Southern Italy), a site inscribed on the World Heritage List by UNESCO in 1993. The study focuses on the technical function, stratigraphic consistency, and long-term maintenance role of lime-based surface treatments within the built environment of the city. The research is part of a broader doctoral project addressing architectural surfaces in Mediterranean contexts, interpreted not merely as aesthetic finishes but as active interfaces between material, environment, and construction culture. Two case studies are examined: the church of San Giovanni Battista (formerly Santa Maria la Nova) and the north-eastern chapel of San Francesco d'Assisi. Archival documentation and historical sources record repeated applications of limewash between the eighteenth and nineteenth centuries. In contrast, early 20th century restoration practices promoted

their removal in favour of exposed stone, altering both material perception and the protective balance of calcarenite surfaces. The research adopts an integrated methodology combining archival research, in situ observation, high-resolution photography, and optical microscopy for microstratigraphic analysis. This approach identifies multiple superimposed lime layers and reconstructs historical application cycles, clarifying their interaction with the porous calcarenite substrate. The results support the interpretation of limewash as a cyclical protective system embedded in historical maintenance practices rather than a decorative treatment. By reassessing the technical and cultural significance of lime-based surface finishes and the documented use of limewash, the study contributes to debates on restoration approaches, material durability, and the redefinition of authenticity in Mediterranean architectural heritage.

KEYWORDS

LIMEWASH, CALCARENITE, ARCHITECTURAL SURFACES, OPTICAL MICROSCOPY, MEDITERRANEAN HERITAGE, MAINTENANCE PRACTICES

EPISTEMOLOGICAL FRAMEWORK FOR THE KNOWLEDGE OF 20TH-CENTURY URBAN HERITAGE IN ITALY: FROM ARCHIVAL ANALYSIS TO A DSBN-TAXONOMY-BASED WEBGIS PLATFORM

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Within the research “Safeguard of Modern Urban Heritage: a cross-disciplinary webGIS for knowledge, monitoring, and risk analysis”, funded under the PRIN 2022 programs, this paper presents the development and architecture of the “SMUH” webGIS platform, an innovative digital tool dedicated to the knowledge, monitoring, and risk analysis of 20th-century architectural and infrastructural heritage. The research addresses the challenges posed by the vast volume and fragmentation of archival documentation related to modern construction, proposing an epistemological framework capable of transforming heterogeneous data into structured and semanticized data frameworks. Developed entirely on open-source technologies, the platform integrates traditional GIS mapping with BIM models (IFC) for interactive 3D visualization accessible

via the web. A central aspect of the work is the extension of the National Synthesis Database (DSBN) data model used as informative structure of the webGIS platform. Through the implementation and enhancement of the meta_inst parameter, the system establishes a bi-univocal link between individual building units and archival sources preserved in local archives. The effectiveness of this methodology is demonstrated through the case study of the Borgo Trento district in Verona. By cross-referencing data from various archival funds, the platform was populated with detailed information regarding construction periods, material techniques, and conservation status. In conclusion, the study proposes the webGIS as a structured digital archive capable of supporting heritage-making processes and urban planning decisions for the contemporary city.

KEYWORDS

CONSTRUCTION HISTORY, WEBGIS, DATA MINING, 20TH-CENTURY HERITAGE, BIM-GIS INTEROPERABILITY

POP-UP STRUCTURES FOR CULTURE. A CONTEMPORARY CONSTRUCTION HISTORY BETWEEN PROCESSES, TECHNOLOGIES, SUSTAINABILITY, AND LANGUAGE

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Since the beginning of the twenty-first century, cultural institutions around the world, especially museums and art galleries, have increasingly and consistently supported programs for the realization of temporary, "pop-up" structures for the promotion of seasonal events, positioned halfway between exhibition design and permanent architecture.

The research project "Pop-up Structures for Culture. Analysis and Documentation for the Sustainability of the Future," coordinated by the University of Rome Tor Vergata (PI: Gianluca Capurso, Co-PI: Lorenzo Grieco) and funded by the Italian Ministry of Culture – Directorate-General for Contemporary Creativity within the framework of the call "Sustainable Architectures X – first edition," examined the realization of these works, some of which were designed by well-known architects, through the lens of construction history. This contribution briefly presents some results of the

studies conducted. Through the analysis of a selection of international cases built from 2000 to the present (including some specific programs such as the Young Architects Program, the Serpentine Pavilions, and MPavilion), the essay highlights: the adoption of innovative construction processes in order to comply with strictly predetermined timeframes and budgets, often based on the contribution of specialized engineering firms and on the early involvement of the contractor; the role of structural design and technological innovation in defining the architectural language and the communicative strategy of the works; sustainability as a factor capable of guiding both expressive choices and construction-related ones. The article also presents the results of an experimental attempt to historically document the construction of ephemeral structures through the use of virtual reality.

KEYWORDS

TEMPORARY STRUCTURES, CONSTRUCTION HISTORY, SUSTAINABILITY, ARCHITECTURAL LANGUAGE

REINHABITING THE EXISTING BUILT HERITAGE OF THE MADONIE INNER AREA (SICILY) THROUGH CO-HOUSING MODELS

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This paper presents the current progress of the PhD research project Re-inhabiting Madonie. Tradition and innovation for the compatible recovery of architecture and the promotion of local production chains, developed within the curriculum Sustainable Architectural Design: A Human-Centered Approach. The research focuses on the Madonie inner area, one of the eleven inner areas identified in the Sicilian Region, comprising 26 municipalities affected by depopulation trends, socio-economic fragility, and a large stock of vacant or underused buildings. The study considers this built heritage as a strategic resource for territorial regeneration, identifying its recovery and adaptive reuse as a necessary condition for fostering repopulation processes and local development. Attention is devoted to vernacular architecture, traditional construction techniques, and local materials, which are critically analyzed and reinterpreted from a contemporary

perspective. Through the examination of representative case studies from the Madonie context, the research develops architectural proposals and technological solutions at the building scale, conceived as replicable models across different municipalities and consistent with the current regulatory framework. In parallel, integrated territorial strategies are explored to support place-based reactivation and the attraction of new residents. The article outlines the research methodology, objectives, and expected outcomes, focusing on a pilot case study: a disused public residential building located in the municipality of San Mauro Castelverde, identified within an experimental repopulation initiative for the Madonie area. The contribution investigates the reconfiguration of the building into co-housing models, exploring architectural solutions compatible with local and national regulations and aligned with the social goals of the broader project.

KEYWORDS

REINHABIT INNER AREAS, MADONIE, REHABILITATION AND REUSE, VALORIZATION OF EXISTING BUILT HERITAGE, CO-HOUSING MODELS

HBIM-BASED LCA OF ALTERNATIVE MAINTENANCE STRATEGIES FOR TRAVERTINE FAÇADE CLADDINGS IN HIGH-VALUE BUILDINGS: IMPLEMENTING LITERATURE-BASED SCENARIOS FOR PALAZZO DEGLI UFFICI, EUR S.P.A.

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This paper proposes an HBIM-based Life Cycle Assessment (LCA) workflow to compare three maintenance strategies for directly adhered natural-stone façade cladding (NSC), identified through a targeted review of the scientific literature. The workflow is applied to Palazzo degli Uffici (EUR s.p.a., Rome), a high-value building whose travertine envelope requires maintenance planning that preserves aesthetic quality while ensuring performance needs. The assessment focuses on use-stage modules B2–B4; the corresponding life cycle inventory is partially enriched using an BIM model through an IFC format to derive consistent quantities of natural-stone cladding (NSC) and its original

metallic fastening elements. Maintenance scenarios are derived from literature-based strategies specific to NSC and parameterized by intervention types, frequencies, and the percentage of façade area affected by each activity. Results are discussed in terms of environmental trade-offs across strategies, showing how different intervention logics can shift impacts between frequent, low-intensity operations and less frequent, material-intensive works. The study aims to support public administrations responsible for conserving natural-stone façades in high-value Italian building stocks from the Fascist era by integrating environmental criteria into maintenance planning.

KEYWORDS

BUILDING INFORMATION MODELLING (BIM), LIFE CYCLE ASSESSMENT (LCA), HERITAGE BIM (HBIM), FAÇADE CLADDING, NATURAL STONE CLADDING, RESTORATION

SENSOR PLACEMENT STRATEGIES IN VAULTS: CONSIDERATIONS AND BEST PRACTICES

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Monitoring historic vaults presents significant challenges due to restricted accessibility, heritage protection constraints, and the frequent presence of cracks that do not necessarily indicate immediate structural failure. Nevertheless, understanding the evolution of these pathologies is essential to prevent reaching critical limit states that could result in irreversible damage or collapse. This chapter examines the role of sensor-based monitoring as a fundamental tool for the preventive conservation, safety assessment, and efficient management of vaulted structures in historic buildings. It discusses the key structural, environmental,

and dynamic parameters to be measured, emphasizing the importance of strategic sensor placement based on prior structural analysis and constructive knowledge. The integration of monitoring systems with digital tools such as Heritage Building Information Modeling (HBIM) and digital twins is highlighted as a means to enhance data interpretation, risk assessment, and decision-making. By distinguishing between occasional data acquisition and continuous sensor monitoring, the chapter proposes a data-driven framework for optimizing conservation strategies while minimizing intervention and preserving heritage value.

KEYWORDS

HBIM, HERITAGE, SENSORS, MONITORING

TOWARDS THE INTEGRATION OF AGENTIC AI SYSTEMS IN DIGITAL KNOWLEDGE PROCESSES FOR BUILT HERITAGE

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Built heritage knowledge is multi-domain, temporally stratified, and shaped by interpretation under uncertainty. Digital knowledge models, such as HBIM, archival repositories, and knowledge graphs, have significantly improved the representation and preservation of evidence, and HBIM, in particular, holds potential to improve interdisciplinarity among experts involved in the study, analysis, conservation and enhancement of built heritage. However, current solutions often remain representation-centric: they store and structure information effectively, yet they struggle to govern interoperable, collaborative, and iterative knowledge work across expert communities. In parallel, generative AI is rapidly being adopted in the built environment as an interface for querying, synthesizing, and operating on heterogeneous sources. Yet these models are probabilistic: without explicit constraints, they can produce fluent but ungrounded statements and can weaken provenance and

accountability, giving the “illusion of knowledge that emerges when surface plausibility replaces verification”. Building on recent distinctions between AI agents (tool-augmented systems that execute bounded tasks) and agentic AI (more orchestrated, multi-agent, memory and goal-driven architectures), this paper proposes a conceptual framing for using generative models not as autonomous decision-makers, but as bounded computational mediators coordinating multiple models (LLMs, VLMs) and heterogeneous sources. The focus shifts to the human-machine interaction: auditable coordination of retrieval, comparison, and model update across domains, grounded in curated knowledge models, provenance preserving operations, uncertainty aware representations, and expert validation. The aim is to outline design requirements for reliable AI-assisted workflows in built heritage research, enabling interoperability without undermining scientific rigor.

KEYWORDS

BUILT HERITAGE, AGENTIC AI, HBIM, KNOWLEDGE GRAPHS, SEMANTIC INTEROPERABILITY

PRELIMINARY PERFORMANCE-BASED EVALUATION FRAMEWORK FOR THE STRENGTHENING OF THIN MASONRY VAULTS USING RECYCLED POLYMER COMPOSITE STRIPS

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Thin masonry vaults represent a structurally efficient historical construction system widely diffused throughout the Mediterranean basin. Their mechanical behaviour is primarily governed by geometry-driven form resistance and interlayer cohesion, while collapse mechanisms are typically associated with instability phenomena triggered by support settlements, horizontal actions, and lack of maintenance. In recent decades, externally bonded Fibre Reinforced Polymer (FRP) systems have been extensively adopted to enhance vault performance by increasing load-bearing and global stiffness. However, such systems may modify the original membrane-based behaviour of thin vaults, introducing stiffness increments that alter stress redistribution between layers. Furthermore, their reliance on virgin materials and high embodied energy raises additional concerns within the transition towards circular construction practices. This study proposes a

preliminary performance-based framework to investigate recycled polymer composite strips, manufactured from recycled poly-propylene (PP) derived from waste fishing nets and marble powder waste, as an alternative strengthening solution for thin masonry vaults. A comparative finite element modelling approach is adopted to analyse structural response and stress redistribution in unreinforced, FRP-strengthened, and recycled composite strips configurations. Rather than pursuing mechanical equivalence with conventional FRP systems, the framework explores the controlled elasticity of the recycled composite as a design parameter to mitigate excessive stiffness increases and preserve the original structural behaviour. By linking material properties, reinforcement layout, and global response indicators, the study contributes to the development of performance-oriented and circular strengthening strategies for historical masonry vaults.

KEYWORDS

THIN VAULTS, CONSOLIDATION, FRP, COMPOSITE MATERIAL, CIRCULARITY

THE BUBBOLE CONSTRUCTION TECHNIQUE: THE CASE STUDY OF VILLA GATTINI IN MATERA

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Within the spectrum of traditional building techniques in Southern and Central Italy, several constructive solutions can be identified that, over time, enabled the realization of durable and functionally efficient structures. Among these, vaulted systems incorporating bubble represent a particularly significant typology. Bubble are hollow cylindrical terracotta elements, historically derived from Roman olla-type vessels and commonly referred to as clay jars or hollow clay units. Over the centuries, these components underwent continuous development and, depending on the regional context, were known by different names, including tubuli, cannoni, pignatielli, carusielli, caccavelle, and mummarelle. Their use was generally associated with high-status constructions. They were employed both within partition walls, where they enhanced thermal insulation—particularly in heated environments such as thermal halls—and within large vaulted structures, where their primary function was to reduce structural dead load. A notable example can be observed in several vaulted spaces and in the corner towers of Villa Gattini in Matera. These towers represent an additional fortification phase superimposed upon an earlier rural complex, constructed at a time when

the expansion of brigandage transformed fortified farmsteads into strategic elements of territorial control and agricultural defense. The villa stands as one of the most refined examples of rural residential architecture in the region, illustrating the transition from agricultural and pastoral masserie to representative masseria-villa complexes. From a constructive standpoint, the vaulting system was executed symmetrically, starting from the springing line formed by tuff ashlar blocks. Longitudinal courses of staggered bubble were then laid progressively, bonded with a mortar composed of carefully sieved soil, slaked lime, and a small proportion of gypsum added to accelerate setting. In the upper portion of the vault, rubble infill was introduced to improve overall stability and load distribution. Over time, this technique has largely fallen into disuse, primarily as a result of renovation interventions that failed to preserve or fully understand the historical construction system. Nevertheless, it remains an exceptional example of how pre-modern building practices effectively addressed both thermal performance and structural stability, anticipating principles that are now central to contemporary sustainable construction.

KEYWORDS

BUBBOLE, MASSERIE FORTIFICATE, VILLA GATTINI, MATERA

STEEL, PREFABRICATION AND WORKING-CLASS HOUSING IN POST-WAR EUROPE: STUDIO BBPR AND THE ECSC PROGRAM BETWEEN EXPERIMENTATION AND COMPROMISE

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This article examines the contribution of Studio BBPR to the workers' housing program promoted by the European Coal and Steel Community (ECSC) in the early 1950s, with particular attention to the relationship between European technological ambitions and Italian construction practices. The research is based on the analysis of documentation preserved in the Studio BBPR Archive at MAXXI Museo Nazionale delle Arti del XXI secolo, including design drawings, technical reports, minutes of meetings and correspondence between the architects, institutional bodies, and industrial stakeholders involved.

The study focuses on the roles played by Studio BBPR within the ECSC Technical Commission and reconstructs the theoretical and methodological positions expressed by BBPR regarding the industrialization of the building process, the use of steel, and prefabrication. Through

an analysis of the designs and construction sites of the ECSC housing estates in Sesto San Giovanni and Napoli Fuorigrotta carried out by the BBPR studio, the paper highlights the difficulties encountered in translating Community guidelines into operative construction solutions, revealing the gap between the European theoretical framework and the productive conditions of the Italian building industry.

The contribution clarifies how the limited use of steel and prefabrication in Italy resulted from a combination of structural, economic, and cultural factors that conditioned the outcome of these ECSC experiments in Italy. From this perspective, the analysis of BBPR's contribution allows the Italian experience of the ECSC to be interpreted as an unfinished laboratory, revealing the difficulties of integrating architectural design, industry, politics in the Italian context of the 1950s.

KEYWORDS

EUROPEAN COAL AND STEEL COMMUNITY, STUDIO BBPR, WORKERS' HOUSING, PREFABRICATION AND STEEL CONSTRUCTION, INDUSTRIALIZATION

KNOWLEDGE-BASED REGENERATION OF AT-RISK ITALIAN HISTORIC VILLAGES: A PROCESS-ORIENTED FRAMEWORK FOR THE RECOVERY OF THE EXISTING BUILDING HERITAGE

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The abandonment of minor historical villages represents one of the most critical challenges for the conservation of Italy's widespread built heritage. These settlements, characterized by stratified construction systems and strong relationships between architecture, landscape, and local culture, are increasingly exposed to material decay, structural vulnerability, and loss of social function. Addressing such complexity requires moving beyond isolated restoration projects toward structured and replicable conservation methodologies. This paper proposes a conservation-oriented methodological workflow for the regeneration of historical abandoned or at risk of abandonment Italian villages. Grounded in Italian restoration theory and architectural engineering practice, the workflow articulates a sequence of interconnected phases: contextual and historical analysis, multi-scale survey and diagnostics, conservation-compatible structural assessment, definition of intervention criteria, and development of

compatible reuse scenarios. Rather than prescribing predefined technical solutions, the methodology emphasizes knowledge-based decision-making and adaptability to different territorial and typological conditions. The workflow is validated through its application to a representative Italian historic village, located in Valdichiana Senese, Tuscany. The case study demonstrates the effectiveness of the approach in integrating conservation principles, structural safety, and functional reactivation within a coherent process. Finally, the paper discusses the replicability of the methodology at the national scale, identifying decision criteria, limits, and governance challenges. The research contributes to architectural engineering approaches to heritage conservation by advancing a process-based framework for the restoration, conservation, and enhancement of existing building heritage in minor historical settlements.

KEYWORDS

ADAPTIVE REUSE, BUILT HERITAGE RESTORATION, ARCHITECTURAL ENGINEERING, CONSERVATION-ORIENTED WORKFLOW

DETECTION AND CLASSIFICATION OF PIEZOMETRIC TOWERS USING CONVOLUTIONAL NEURAL NETWORKS

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This paper describes the design and implementation of an automated system for identifying and georeferencing piezometric towers in the Lombardy region. The research uses automated techniques, specifically convolutional neural networks based on the YOLO object detection architecture, to integrate and overcome the limitations of traditional survey methods. The model was trained on a dataset of satellite images acquired through Google Maps API, processing approximately 35,000 tiles to cover the

entire regional surface. Data labeling was performed using Labellmg software in Pascal VOC format. The model achieved optimal performance with a confidence threshold between 0.70 and 0.75, correctly identifying the majority of piezometric towers in the Lombardy region. Although applied to specific structures, this georeferenced classification method using neural networks shows promising results as a useful operational tool for territorial planning and the management of abandoned infrastructure.

KEYWORDS

PIEZOMETRIC TOWERS, YOLO ARCHITECTURE, GEOREFERENCED INFRASTRUCTURE MAPPING, CONVOLUTIONAL NEURAL NETWORKS, OBJECT DETECTION IN SATELLITE IMAGERY.

HISTORIC LAYOUTS AND SUSTAINABLE DESIGN: VITRUVIAN HERITAGE, INTERDISCIPLINARY ANALYSIS AND ENHANCEMENT STRATEGIES FOR THE REHABILITATION OF ARCHITECTURAL HERITAGE

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The chapter analyses the architectural layout as a fundamental technical heritage for understanding historical architecture and guiding contemporary interventions in heritage. The discovery of the Vitruvian Basilica in Fano (2026) allows us to verify the correspondence between text, geometry and archaeological evidence, demonstrating the validity of Vitruvian principles and their cognitive dimension. The comparison with the findings of the Roman circus of Valencia confirms the technical continuity of the layout in the Roman Mediterranean area. These case studies allow us to add and integrate a reflection on

design and value improvement as a strategic phase for the sustainable rehabilitation of built heritage. The incorporation of efficient information management methodologies, interdisciplinary coordination and energy efficiency criteria links the historical knowledge of the route with the current challenges of conservation, management and urban sustainability. Together, the chapter shows how the understanding of the historical layout and the contemporary management of design converge in the same logic of innovation, preservation and technical responsibility.

KEYWORDS

VITRUVIUS, ARCHITECTURAL LAYOUT, HISTORICAL GEOMETRY, ARCHAEOLOGY, REPRESENTATION, COGNITION AND ABSTRACTION, BUILT HERITAGE, SUSTAINABLE REHABILITATION, DESIGN MANAGEMENT, INTERDISCIPLINARY COORDINATION

COMPARATIVE DIACHRONIC ENVIRONMENTAL EVALUATION OF DESIGN ALTERNATIVES FOR PIAZZALE DELLA PACE, PARMA (1960s—PRESENT)

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This study offers the first diachronic environmental systematization of built and unbuilt projects for Piazzale della Pace, Parma, from the 1960s to today, addressing a long-standing gap in the urban debate on the square's redevelopment. While the area has been the object of architectural and political controversy, environmental performance has remained largely overlooked. Through a qualitative comparative analysis, the research examines how different design interventions integrated specific solutions to promote the overall environmental values by using permeable, impermeable surfaces, vegetation strategies, and prospective nature-based solutions. The methodology reconstructs masterplans from archival materials, iconographic sources, and technical documentation. Assuming the 1985 asphalt-paved

parking lot as the base case, the study evaluates the most relevant proposal according to key selected parameters: vegetated and drain-age-capable surfaces, under-canopy shading potential, and the presence of blue-green infrastructures. The findings reveal substantial variation in environmental performance across the examined projects. Early proposals exhibited limited ecological sensitivity, whereas later interventions demonstrated increasingly a climate-sensitive approach, despite persistent criticalities. Eventually, the study establishes a historically informed framework for understanding how design decisions made across six decades have shaped the environmental and urban potential of a major heritage-sensitive public space.

KEYWORDS

PIAZZALE DELLA PACE, ENVIRONMENTAL EVALUATION, PERMEABLE SURFACES, OPEN SPACE RATIO, VEGETATION.

THE VALORIZATION OF CORPORATE HERITAGE FROM DOCUMENTS TO EXTENDED REALITY: CONSTRUCTION STORIES OF THE PALAVELA IN TURIN (1961-2006).

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This contribution highlights the critical role of construction company archives as primary sources for studying twentieth-century Italian structural and construction experimentation. Despite their historical significance, these archives are often inaccessible, prompting a need for innovative valorization strategies. Within the framework of industrial heritage studies, this research proposes the use of advanced digital models and Extended Reality (XR) environments to bridge the gap between complex documentary sources and public accessibility through a specialized methodological workflow. This process involves the processing of archival metadata, philological geometric, and informative

modeling based on documentary evidence, and the development of a Virtual Reality (VR) environment. The research centers on the Palavela in Turin as a paradigmatic case study, tracing its evolution from the 1961 Italia '61 celebrations to its 2006 transformation in ice-skating arena, by integrating heterogeneous records from the MAIRE Historical Archive and bibliographic sources from both periods. The final output is a VR environment designed to provide access to the lost 1961 design and the photographic collections of the two construction sites, effectively transforming technical archival data into an immersive, intelligible experience for both specialists and the public.

KEYWORDS

INDUSTRIAL HERITAGE, CONSTRUCTION HISTORY, CONSTRUCTION SITES, OPENBIM, VIRTUAL REALITY (VR)

A H-BIM-BASED METHODOLOGICAL FRAMEWORK FOR DIGITAL TWIN APPLICATIONS IN MODERN ARCHITECTURE: THE FONDAZIONE GARZANTI BUILDING IN FORLÌ

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The recognition of twentieth-century architecture as cultural heritage requires methodological tools capable of addressing both its technological specificity and its conservation needs. Modern buildings frequently combine industrialised construction systems with bespoke architectural solutions, experimental materials, and design-driven construction details that challenge conventional Building Information Modelling (BIM) approaches. In this context, Historic/Heritage Building Information Modelling (H-BIM) is increasingly understood not only as a geometric modelling tool, but as a knowledge-based environment integrating historical documentation, semantic information, and diagnostic data. This paper proposes a methodological framework for the application of H-BIM and Digital Twin concepts to modern architectural heritage, focusing on their role in rehabilitation-oriented design and long-

term conservation strategies. The framework combines archival research, reality-based surveying, interpretative H-BIM modelling, and semantic enrichment within a unified information environment. The methodology is tested on the Fondazione Garzanti building in Forlì, designed by Gio Ponti, which represents a significant example of Italian modern architecture characterised by strong authorship and construction experimentation. The study demonstrates how H-BIM can operate as a critical knowledge system and as a design-support tool, enabling explicit management of data reliability, Levels of Development, and conservation-related information. The results also highlight the potential and the limits of H-BIM as a basis for future Digital Twin implementations aimed at the sustainable management of modern architectural heritage.

KEYWORDS

H-BIM, DIGITAL TWIN, MODERN ARCHITECTURAL HERITAGE, ARCHITECTURAL CONSERVATION, REHABILITATION DESIGN, SURVEY AND MODELLING

THE SECOND LIFE OF HERITAGE: OPPORTUNITIES AND CHALLENGES IN THE ACTIVE REUSE OF HERITAGE

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This article explores the growing phenomenon of reusing high-heritage-value real estate —such as churches, convents, monasteries, palaces, castles, and industrial architecture— for commercial purposes, including hotels, restaurants, and event spaces. It examines the tension between the need for heritage conservation and the economic and social opportunities that arise from adapting these buildings to new uses.

Active and appropriate planning, management, and reuse are identified as key factors for developing a viable and beneficial strategy to ensure the long-term preservation of these structures. However, it is acknowledged that this approach entails significant risks and challenges that must be carefully mitigated to guarantee its success.

KEYWORDS

CULTURAL HERITAGE, ADAPTIVE REUSE, CONSERVATION, SUSTAINABILITY

CONTEXT-SPECIFIC STRATEGIES FOR MOUNTAIN VILLAGE REGENERATION: A METHODOLOGICAL AND APPLIED STUDY OF THE VIA MERCATORUM

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In Europe, rural and mountain villages are increasingly affected by depopulation, land abandonment, and the deterioration of built heritage, raising the need for regeneration approaches capable of linking territorial strategies with site-specific architectural interventions. However, existing approaches often fail to translate territorial analyses into operational, design-oriented decisions at the settlement and building scales. This paper proposes a multiscale, design-oriented regeneration framework tested along the Via Mercatorum, a historic mountain route connecting a system of small settlements in Northern Italy. Rather than treating regeneration as a series of isolated projects, the framework integrates territorial analysis, settlement morphology, building typologies, and conservation conditions to support context-sensitive decision-making. The methodology combines village classification based on topography and urban layout with building-scale surveys and typological analysis, allowing the identification of

differentiated intervention strategies. Results highlight the Via Mercatorum as a structural system reconnecting dispersed settlements, landscapes, and architectural heritage. Conservative restoration and public-space interventions enhance material authenticity, accessibility, spatial quality, and recognisability along the route. Targeted building interventions enable adaptive reuse through compatible functions supported by reversible and flexible architectural and technological solutions. The study demonstrates how coordinated, smallscale interventions can generate cumulative effects at the settlement level, contributing to the revitalisation of rural villages while respecting their historical and environmental context. The proposed framework is transferable to other mountain and inner-area contexts and provides a basis for future developments integrating technological innovation, socio-economic indicators, and long-term impact assessment.

KEYWORDS

RURAL VILLAGE REGENERATION, MOUNTAIN SETTLEMENTS, MULTISCALE ANALYSIS, TECHNOLOGICAL SOLUTIONS, ADAPTIVE REUSE

METHOD FOR THE SEMI-AUTOMATIC ANALYSIS OF HISTORIC MASONRY

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The approach of masonry typology is suitable for being applied in the shape of cluster analysis, thus improving its objectiveness and facilitating its automation. By making the masonry typological study an automated process, driven by statistical segmentation, the level of detail -appropriate to historic walls- could be maintained and the analysis could be extended to large contexts. Consequently, the contribution of masonry typology to the mechanical and energy modelling of historic stone walls would be improved. The relevant progress of image processing techniques can support

the automation of masonry typology analysis, with the aim to extract qualitative and quantitative information on the wall construction features and process them by means of cluster analysis. This is the purpose of the method for the semi-automatic analysis of historic-masonry images, which is described in this paper and was the object of a recent patent. The logical scheme of the proposed method is exposed and its relationship with building energy modelling and the basics of masonry typology are discussed.

KEYWORDS

HISTORIC MASONRY TYPOLOGY, STONE WALLS, IMAGE SEGMENTATION, ICT, ENERGY AND ENERGY PERFORMANCE, U-VALUE

DIGITAL SURVEY FOR THE IMPLEMENTATION OF SCAN-TO-BIM PROCESSES IN UNIVERSITY BUILDING HERITAGE: THE CASE OF THE CRAVINO CAMPUS BY GIANCARLO DE CARLO

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This paper presents the results of a research activity focused on the development and testing of Scan-to-BIM methodologies applied to university building heritage still in use, through the case study of the Engineering Block at the Cravino Campus in Pavia, designed by Giancarlo De Carlo. The research investigates the integration of archival studies, terrestrial laser scanning, and parametric modelling in order to produce a reliable HBIM model capable of documenting the current state of the building while supporting future conservation and management strategies. A digital survey campaign was carried out using a Leica RTC360 laser scanner, resulting in 350 scans and a final alignment error of 4 mm, ensuring high metric reliability. Particular attention was paid to the challenges posed by the modular

and repetitive architectural layout, which required a controlled registration workflow and targeted modelling strategies. The Scan-to-BIM process was developed in Autodesk Revit, defining structural grids, levels, and parametric families in accordance with UNI 11337 standards (LOD D). The resulting HBIM model functions as an interoperable and updatable digital archive, capable of integrating geometric accuracy with constructive and material information. The study demonstrates how Scan-to-BIM can become a methodological tool not only for metric documentation but also for critically interpreting modern university heritage, supporting informed maintenance, adaptive reuse, and lifecycle management.

KEYWORDS

DIGITAL SURVEY, SCAN-TO-BIM, HBIM, UNIVERSITY BUILDING HERITAGE, GIANCARLO DE CARLO, PAVIA

CATALAN “CATHEDRALS OF WINE” AS INDUSTRIAL MED HERITAGE: THE ROCAFORT DE QUERALT COOPERATIVE CELLAR

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Catalan cooperative wineries, known as the “Cathedrals of Wine,” are a distinctive form of industrial heritage where architectural quality, structural innovation, and collective organization converge. Built mainly in the early twentieth century, these facilities were promoted by agricultural cooperatives to modernize wine production while reinforcing local identity in rural areas. Despite their recognized historical and architectural value, their potential as active resources for territorial development and sustainable regeneration in Mediterranean contexts remains underexplored. This paper investigates Catalan cooperative wineries as industrial heritage assets within a comparative Mediterranean framework, with reference to Spanish and Italian cases. The Rocafort de Queralt Cooperative Cellar, designed by Cèsar Martinell, is presented as a representative case study. A qualitative, inter-disciplinary methodology is applied, combining historical research, architectural and structural analysis, typological comparison, and review of technical studies. Attention is given to spatial organization, construction techniques, materials, and environmental performance in relation to production

workflows and climate. Traditionally, industrial heritage valorisation has followed two trajectories: maintaining original industrial functions or implementing adaptive reuse. While adaptive reuse is now widespread, effective conservation requires seeing these sites as cultural assets generating long-term social and economic value. Reuse of former production spaces -public facilities, cultural venues, or mixed-use environments - reinforces identity and supports socio-economic transformation. Industrial tourism further enhances interpretation, engagement, and territorial promotion. The results highlight how rational design, low-cost construction, and structurally efficient solutions, rooted in Mediterranean building culture, ensure functional continuity and adaptability. Beyond their original role, the “Cathedrals of Wine” exemplify living industrial heritage capable of supporting heritage-led regeneration, industrial tourism, and community-based development. This study frames cooperative wineries as early examples of smart, sustainable, and community-oriented architecture, offering lessons for rural and Mediterranean heritage rehabilitation.

KEYWORDS

INDUSTRIAL HERITAGE, COOPERATIVE WINERIES, CATALAN ARCHITECTURE, MEDITERRANEAN CONTEXT, STRUCTURAL SYSTEMS, SMART REHABILITATION, RURAL DEVELOPMENT

THE RINALDA TOWER IN LECCE: HISTORICAL AND ARCHITECTURAL ANALYSIS AND PROPOSAL FOR CONSERVATIVE RESTORATION.

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Torre Rinalda, one of the many coastal towers in the municipality of Lecce, was built in the 16th century as a defensive structure against Saracen raids and is now in a state of ruin, making it urgent to reflect on its historical, architectural and cultural value. This study analyses the history of the tower not only from a technical and constructional point of view, but also through a geographical and identity-based interpretation, recognising it as a symbol of the coastal defence of Salento and a witness to centuries of transformation and resistance. The research was conducted through the exploration of historical archives, consultation with the Superintendency and analysis of local bibliographic sources, as well as photographic surveys, drawings and

historical maps. Particular attention was paid to the materials: a comparison between the ancient carparo stone and the additions used in previous restorations highlighted the importance of using stones compatible with the original to ensure durability and respect for historical integrity. The proposed restoration and enhancement project integrates architectural protection and redevelopment of the surrounding landscape, providing for measures to protect the base of the tower, the use of compatible materials and the development of public spaces along the coast. The aim is to preserve Torre Rinalda as a cultural and landscape heritage site, promoting its historical significance and creating new opportunities for tourism and cultural enjoyment for the local community and future generations.

KEYWORDS

TORRE RINALDA, COASTAL TOWERS, SALENTO

TEMPORARY HABITAT. SELF-CONSTRUCTION AS A MODEL OF A SIMPLE TECHNOLOGY

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The paper proposes an applied research and teaching experience that the DICAAR of the University of Cagliari has been carrying out for about fifteen years through the construction of small architectural devices and temporary installations for the regeneration of public space. These experiences can be considered part of a paradigm shift in contemporary design that places the relationships between time, resources, people and places at the centre of reflection. A new model of micro-architecture is explored using simple construction techniques, based on principles of modularity and low tech-high thinking, aimed at producing unique, site-specific results. The multidisciplinary group Unica

Space Force operates in three different areas: the UNICASA project, which involves the regeneration of the open spaces of the University of Cagliari; rural workshops that have addressed a series of design issues in smaller contexts throughout the region; and interior design projects that explore the smallest dimensions of architectural space. These experiences represent a model of regeneration based on the construction of physical devices that allow spaces to be transformed quickly and with few resources. They constitute a shared test with the recipients of a future architecture, reducing the risks of out-of-scale interventions.

KEYWORDS

TEMPORARY ARCHITECTURE, LOW-TECH, WOOD CONSTRUCTION, ARCHITECTURAL ENGINEERING, SELF-CONSTRUCTION

FROM VERNACULAR RESILIENCE TO ADAPTIVE REGENERATION: ANALYSIS OF TRADITIONAL CONSTRUCTION LOGICS FOR THE SUSTAINABILITY OF BUILT HERITAGE IN EXTREME CONDITIONS

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Global cultural heritage faces unprecedented threats deriving from armed conflicts and extreme climatic events, which highlight the ineffectiveness of linear and standardized reconstruction models. Such approaches, focused on the emergency, tend to ignore the local identity and the material continuity of places. The present study proposes the overcoming of this dichotomy through a multidisciplinary methodology that integrates vernacular construction intelligence with digital innovation. The research, based on a literature review and on the analysis of international case studies, aggregates the results into three analytical clusters: conflicts, disasters, and climate. The collected evidence validates significant performance indicators, including energy saving through the upcycling of rubble, the reduction of costs, and thermophysical

optimization via bio-based materials and hygrothermal simulations compliant with the EN 15026 standard. The study introduces a conceptual framework, a model that unifies the paradigms of material bank and memory twin. By treating debris as traceable resources through digital product pass-ports, the framework facilitates reconstruction strategies consistent with the principles of the New European Bauhaus. Although the conceptual framework is positioned at an experimental maturity level, it traces a pragmatic route for the ecological transition of restoration. The conclusions outline a future trajectory focused on prototypical validation and on Public-Private-People Partnership (P4) governance models, inspired by the management of the Commons, to bridge the gap between digital simulation and social repair.

KEYWORDS

VERNACULAR ARCHITECTURE, POST-EMERGENCY RECONSTRUCTION, CIRCULAR ECONOMY, HBIM-GIS, NEW EUROPEAN BAUHAUS, MATERIAL BANK, MEMORY TWIN

INNOVATIVE PLASTERS FOR THE ENERGY RETROFIT OF THE ITALIAN MODERN HERITAGE: THE CASE STUDY OF “ORTI DI SPAGNA” INA-CASA DISTRICT IN VERONA (1949-53)

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The energy intervention on Italian building stock from Twentieth century presents several critical issues. This stock is a rather complex cultural heritage: on the one hand, in fact, it is made up of works recognized as part of the history of Twentieth-century Italian architecture, on the other hand, it is made up of settlements of anonymous buildings. The paper reports the ongoing research to apply experimental thermal ash-lava based plasters on INA-Casa buildings in order to avoid traditional thermal cladding (EPS) that change the

volumetric and architectural features of the buildings. The energy modelling – through EnergyPlus – tested the thermal performances before and after the use of ash-lava based plaster and EPS cladding, in order to analyse the energy performance. The case study is offered by the “Orti di Spagna” an INA-Casa neighbourhood in Verona, built in 1949-53. In this case the experimental plasters help to safeguard the architectural features with specific constraints (historical, urban and environmental).

KEYWORDS

CONSTRUCTION HISTORY, ENERGY REFURBISHMENT, INNOVATIVE PLASTERS, INA CASA, VERONA

REFLECTING ON HISTORIC MASONRY CONSTRUCTION

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The contribution is a summary of reflections carried out by the author for several years regarding peculiar aspects of historic masonry construction. The widespread diffusion of this material in the construction history might suggest that there are no little-known aspects relating to the reasons that led to the affirmation of this technique starting from the great achievements of antiquity. But as often happens in cases where the success of a technical solution goes beyond the full awareness of its nature, even in the case of historic constructions, the effectiveness of the results obtained prevails over the understanding of all the steps or underlying meanings

that have characterized these achievements. The three parts of which the contribution is composed refer to as many issues that represent aspects little or not at all addressed in texts dealing with historic constructions or architectures. The first reflection concerns the use of “poor” mortars as a conscious technical choice, aimed at allowing a high level of transformability of buildings and savings in material consumption. The second concerns the meaning to be attributed to the use of brick or stone in the religious architectures of the Christian West. The last part is dedicated to the appearance of the medieval brick, so different from the bricks used in Roman times.

KEYWORDS

CONSTRUCTION HISTORY, HISTORIC MASONRY, MEDIEVAL BRICK, STEREOTOMIC VAULT, MAUSOLEUM OF THEODORIC

EXPERIMENTAL INVESTIGATION OF HISTORIC MULTI-LEAF STONE MASONRY UNDER COMPRESSION USING DIC (DIGITAL IMAGE CORRELATION).

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This study contributes to the understanding of the compressive behavior of historic stone masonry. Laboratory tests were carried out on double-leaf masonry walls composed of two non-collaborating layers, with the aim of reproducing the behavior of masonry constructed without adherence to the principles of regola dell'arte. A primary objective is to analyze the mechanical behavior of masonry under compressive loading. Experimental results obtained using both a traditional measurement technique based on Linear Variable Displacement Transducers (LVDTs) and the Digital Image Correlation (DIC) technique are examined to identify the failure modes in stone masonry and to investigate the distribution of compressive strains. A second objective is to validate the application of DIC to stone masonry in combination with LVDT systems. The irregularity of this masonry, resulting from the

heterogeneous nature of the stones, complicates data acquisition using contact-based transducers, which require smooth and regular surfaces, as well as optical techniques such as DIC. The limitations and data gaps of LVDT measurements are addressed through the use of DIC, highlighting the advantages of the digital approach. Unlike traditional contact-based methods, DIC relies on optical cameras and does not require physical contact with the specimen during testing. Moreover, it provides continuous full-field measurements throughout the experiment, allowing the evaluation of displacements and deformations over the entire specimen rather than at a limited number of localized points. Overall, this research provides valuable insights into the mechanical behavior and failure mechanisms of historic stone masonry, contributing to a more accurate characterization of this construction typology.

KEYWORDS

HISTORIC MASONRY, UNIAXIAL COMPRESSION, DIGITAL IMAGE CORRELATION, MULTI-LEAF MASONRY, STONE MASONRY

FROM INVISIBLE CULTURE TO PARTICIPATION INFRASTRUCTURE: DIAGNOSING CULTURAL PARTICIPATION GAPS IN CITIES

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In many European cities which are characterised by dense cultural assets, people pass museums, libraries, and cultural buildings without knowing what happens inside, who they are for, or whether they are open and accessible to them. Cultural opportunities exist, yet the connection between these opportunities and everyday urban life often remains weak, limiting people's ability to become aware of, interpret, and meaningfully engage with what the city already provides. This paper argues that cultural participation gaps are not primarily a problem of provision, but of visibility, communication, and discoverability. It introduces the concept of participation infrastructure to describe the socio-technical conditions through which cultural opportunities become perceptible, understandable, and actionable within everyday urban environments. Two conceptual models are developed. The Cultural Disconnection Pathway (CDP) explains how weak awareness and visibility create participation breakdowns that ultimately

affect urban quality of life. The AVEP framework (Awareness, Visibility, Engagement, and Participation) reconceptualises participation as a sequential process in which upstream conditions shape whether engagement can emerge across built and digital environments. Using the context of a mid-sized European university city as an illustrative reference, the paper translates these concepts into a practitioner-oriented framework linking cultural mapping, digital communication, governance coordination, and building-scale design strategies. The paper positions participation infrastructure as a multi-scalar design challenge operating from the governance of culture in the city to the design of building thresholds, interfaces, and everyday points of encounter. It argues that a "beyond the project" perspective requires architects and planners to evaluate success not only through the delivery of buildings, but through whether the environments they create genuinely enable participation in the civic and cultural life of the city.

KEYWORDS

CULTURAL PARTICIPATION; PARTICIPATION INFRASTRUCTURE; BUILDING TECHNOLOGY; DIGITAL COMMUNICATION; CULTURAL VISIBILITY; URBAN QUALITY OF LIFE.

INHABITING SEISMIC RISK: ENVIRONMENTAL REGENERATION, COLLECTIVE RISK MANAGEMENT, AND LAND ACCESS IN MEXICO CITY

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Mexico City faces seismic risks, social inequality, and environmental degradation, exacerbated by urban policies that prioritize the commodification of land over collective rights. Located in a seismic zone and on an ancient lakebed, the city suffers from subsidence, subsoil contamination, and the displacement of vulnerable communities to high-risk areas. The 'Inhabiting Seismic Risk' project proposes a comprehensive urban intervention model that articulates community co-responsibility, environmental regeneration, and heritage rehabilitation, aiming to guarantee equitable access to land as a collective right. Focused on the Historic Center, it promotes the rehabilitation of buildings through collectives that promote usufruct as a legal

alternative to private property, preventing displacement and strengthening community permanence. The model incorporates geophysical analysis, sustainable water and soil management strategies, and a participatory methodology to mitigate seismic risk, conserve heritage, and regenerate the ecological environment. This proposal integrates technology, socio-environmental justice, and community self-management and seeks to combat gentrification by strengthening the social fabric. It seeks to promote a political, technical, and cultural transformation that returns communities to the center of territorial management, redefining life in vulnerable urban contexts.

KEYWORDS

SEISMIC, REGENERATION, RISK, REHABILITATION, MITIGATION, MODEL

AI-BASED VIRTUAL RECONSTRUCTION IN HERITAGE CONSERVATION: DIGITAL STRATEGIES FOR PRESERVING HISTORIC BUILDINGS

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The digital transition in heritage conservation is reshaping the operational relationship between structural assessment, material authenticity, and reconstruction strategies. This paper frames AI-based virtual reconstruction as a computational extension of conservation engineering, supporting analytical understanding and preservation-oriented decision-making for historic buildings. A methodological framework is introduced in which generative and inference-based artificial intelligence models are employed to formulate and evaluate structurally consistent hypotheses regarding lost or collapsed architectural components. The study addresses the tension between the conservation principle of material

legibility, requiring clear differentiation between original fabric and new interventions, and the increasing capacity of AI systems to infer plausible “as-built” configurations from incomplete datasets. The approach is tested through the cases of Matrera Castle (Spain) and Rocca Calascio (Italy), where AI-driven digital reconstructions are developed based on structural logic, constructional typologies, and comparative architectural data. Within this framework, AI-generated models are defined as explicitly documented and critically validated analytical instruments that complement—without substituting—physically grounded restoration practice, ensuring methodological transparency and engineering robustness in digital heritage preservation.

KEYWORDS

ARTIFICIAL INTELLIGENCE, GENERATIVE MODELS, VIRTUAL RECONSTRUCTION, DIGITAL HERITAGE, HERITAGE CONSERVATION

DESIGN, CONSTRUCTION, AND PATENT: LUIGI PELLEGRIN AND THE PREFABRICATED SYSTEM FOR THE «CONCETTO MARCHESI» SCHOOL COMPLEX (1975-1983) IN PISA, ITALY

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This paper investigates the development of the prefabricated construction system adopted for the «Concetto Marchesi» school complex in Pisa (1975–1983), one of Luigi Pellegrin's most significant experiments in industrialised school buildings. The study aims to reconstruct how the construction system evolved across the design, tender, and construction phases, and to clarify how the interaction between architectural design and building production shaped that evolution. The research draws on bibliographic and archival sources, including competition drawings, executive project documents, construction records, and

patent files. Through a comparative analysis of these materials, the paper examines the relationship between the system conceived during the design phase and the system ultimately implemented on site. The case study shows that the prefabricated system did not arise from a linear design process but from a progressive redefinition driven by collaboration between the architect and the contractor, culminating in the 1979 patent. By foregrounding this dynamic process, the paper contributes to a broader understanding of the role of technical and productive actors in the industrialisation of Italian school construction.

KEYWORDS

PREFABRICATION IN ITALY, LUIGI PELLEGRIN, PRECAST CONCRETE, PATENT, SCHOOL BUILDINGS

AUGMENTED REALITY FOR TEACHING HISTORICAL MASONRY VAULTING METHODS

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Emerging technologies and the effort to maintain historical heritage are fueling renewed interest in masonry. Despite ongoing advancements in architectural and construction research, the restoration and building of vaults and domes remain challenging, with issues like high costs, a shortage of skilled workers, and low productivity. Documenting efficient historical methods, such as the thin-tile vaulting technique (a scaffold-

free method using thin tiles), is vital for preserving this knowledge. Typically, learning this technique requires years of hands-on experience guided by a master mason. This paper presents initial results of a project exploring how Augmented Reality can help transfer practical skills. A case study on constructing a lowered vault demonstrates how adopting Augmented Reality impacts accuracy assessed.

KEYWORDS

AUGMENTED REALITY, HISTORICAL CONSTRUCTION TECHNIQUES, SCAFFOLD-FREE, THIN TILE VAULTING, KNOWLEDGE TRANSFER.

KEY POINTS FOR THE CONSERVATION OF MODERN HERITAGE. THE CONSERVATION MANAGEMENT PLAN FOR 1930S PIER LUIGI NERVI'S AIRCRAFT HANGAR IN SALERNO

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The paper presents the key methodological and operational principles that guided the drafting of the Conservation Plan for the aircraft hangar designed by Pier Luigi Nervi and constructed in 1939 in the Salerno area for the Royal Italian Air Force. Rather than providing a comprehensive illustration of the Plan in its overall structure, the contribution seeks to highlight the principles, tools, and critical stages that led to its formulation, which has currently reached an advanced phase of research, interpretation, and systematisation of data. The Conservation Plan is conceived as a cognitive, operational, and management tool aimed at the protection, planned conservation, and enhancement of an emblematic work of the modern reinforced concrete heritage. In line with the international scholarly debate on the conservation of twentieth-century architecture,

the study adopts as its methodological framework the Conservation Management Plan promoted by ICOMOS and the principles articulated in the Burra Charter, critically reinterpreting them in relation to the constructive, material, and cultural specificities of modern architecture. The overarching objective is to govern conservation interventions and guide future transformations of the asset through an in-depth understanding of its material and immaterial values, pursuing a balance between conservation, compatible use, and the requirements of functional and regulatory adaptation. From this perspective, the Plan aims to move beyond a merely restrictive, constraint-based approach to protection, positioning itself instead as a dynamic and process-oriented tool capable of supporting design and management decisions over time.

KEYWORDS

MODERN HERITAGE, CONSERVATION PLAN, 20TH-CENTURY ARCHITECTURE, PIER LUIGI NERVI

FROM GEOMETRY TO KNOWLEDGE MODELING: A SYSTEMATIC REVIEW OF INTEGRATED DIGITAL METHODOLOGIES FOR BUILT HERITAGE

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The digital transition in the technical architecture sector requires a paradigm shift in the preservation of existing buildings, marking the transition from mere geometric representation to modelling and knowledge management.

This systematic review analyses the methodological evolution of technologies applied to the built heritage, highlighting how new tools are redefining the processes for documenting an increasingly fragmented heritage. Moving beyond the limitations of the traditional Scan-to-BIM approach, which focuses solely on the as-built model, the study explores a workflow that evolves towards hybrid data acquisition, combining instrumental surveying and archival sources, ultimately consolidating into a document to HBIM approach. In this scenario, the historical document (technical drawings,

manuals, patents) becomes the generative matrix of the information model for structuring the data.

Faced with an ever-growing volume of data, the focus shifts toward ontology-based semantic enrichment. The study analyses how the use of Semantic Web technologies, Knowledge Graphs and Linked Open Data (LOD) enables this heterogeneous information to be structured, overcoming the rigidity of closed relational databases to facilitate advanced visualisation and the use of collaborative platforms.

A methodological framework thus emerges in which the digital model transcends the role of a technical archive and static repository to become a dynamic memory management system, essential for supporting informed interventions on existing data and ensuring the sustainability of information over time.

KEYWORDS

HBIM, DIGITAL ARCHIVES, KNOWLEDGE GRAPHS, WEB SEMANTICO, KNOWLEDGE MODELING, ARTIFICIAL INTELLIGENCE

DESIGNING WITH INFORMALITY: SPATIAL COMPLEXITY IN ADAPTIVE ARCHITECTURAL AND URBAN REGENERATION

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Contemporary urban discourse too often overlooks the social complexity, spatial flexibility, and resilient place-based identities that characterize informal settlements. These environments are frequently framed through narratives of deficiency and disorder, yet such characterizations mask what is present. This paper challenges these deficit-based frameworks by exploring the architectural and urban potential embedded within informal contexts. Rather than viewing informality as a problem requiring correction, the research recognizes these environments for what they are: sites of incremental adaptation, collective practice, and design innovation that offer valuable lessons for contemporary urbanism. The research employs comparative analysis of contemporary interventions involving cultural, social, and architectural regeneration within informal settlements. Using a theoretical framework that combines Kim Dovey's work on self-organized architectural systems with IEREK research establishing criteria for urban design processes, by Salihbegovic et

al., the study conducts a threefold evaluative analysis assessing spatial, architectural, and social characteristics of each intervention in relation to existing informal urban fabrics. Through systematic cross-comparison, the research identifies recurring formative elements, ordering principles, and adaptive strategies that enable productive engagement with informality. The findings reveal how interventions can build constructively on existing conditions rather than imposing external solutions, demonstrating approaches that strengthen community resilience, preserve local identity, and support meaningful integration within broader urban systems. By reframing informal settlements as repositories of spatial knowledge rather than deficient conditions, this paper contributes to evolving paradigms in urban design. It advocates for methodologies grounded in careful observation, adaptation, and collaboration, recognizing and leveraging the complexity inherent in self-organized environments.

KEYWORDS

INFORMAL SETTLEMENTS, URBAN REGENERATION, SELF ORGANIZED ARCHITECTURE, COMMUNITY RESILIENCE, SPATIAL COMPLEXITY, ADAPTIVE STRATEGIES

TYPOLOGICAL CHARACTERS OF THE DIFFUSE SUBURBAN ARCHITECTURE IN PALERMO: THE CASE OF VILLAGRAZIA-AMBLERI

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This paper investigates the transformation dynamics of traditional architecture in the suburban area of Palermo with an analysis of the small rural settlement of Villagrazia, historically characterized by aristocratic villas, rural dwellings, mills, and an intensive agricultural landscape (citrus and olive grows, medlars, vineyards, etc.). Despite recent transformations, Villagrazia still preserves significant rural features, and its built heritage exhibits highly stratified material and construction characteristics. Based on a systematic survey of 227 buildings, the study develops a multi-scalar and integrated methodological frame-work aimed at interpreting the relationship between architectural tradition, contemporary technological implementations, and ongoing changes in residential practices. The research combines qualitative and quantitative tools through a structured survey system, enabling an in-depth analysis of typological consistency, constructive techniques, state of conservation, architectural components. Attention is also paid to the impact of incongruous elements and modern technological additions on traditional architecture. This study codified and aggregated the collected data into thematic indicators to further synthesized the analysis through

a composite Criticality Index, specifically designed to assess the physical, material, and relational degradation of building façades. Rather than serving as a merely descriptive indicator, the developed index functions as a decision-support tool to define priorities and strategies of compatible intervention. Main results indicate that the primary source of alteration is not a structural decay, but the cumulative effect of uncoordinated technological insertions, which significantly compromise architectural readability and the overall urban image. Based on these findings, the paper also proposes a set of criteria and intervention scenarios for the rehabilitation and enhancement of the built heritage, focusing on public space regeneration, mitigation of incongruous elements, and upgrading of the residential building stock. The proposed approach seeks to reconcile conservation, rehabilitation, and innovation promoting a sustainable and context-sensitive regeneration strategy capable of fostering a compatible integration between tradition and contemporary needs. Ultimately, the proposed framework returns a complete set of consistent data useful for professionals, petitioners, urban planners, and scientists, working in the areas of traditional architecture, smart rehabilitation, and urban regeneration.

KEYWORDS

DIFFUSE ARCHITECTURE, CONSTRUCTIVE TECHNOLOGIES, TRADITIONAL ARCHITECTURE, BUILT HERITAGE, URBAN RE-GENERATION

UNDERGROUND MILITARY ARCHITECTURE AESTHETICS. A CASE STUDY OF CULTURAL REGENERATION

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In former Yugoslavia, the idea of empowering and uniting different territories under a political and social project became visible through a threefold architectural production. From civic centers as communal spaces for interaction and education, to memorials and commemorative structures as a reconciliation with the past, to military buildings as a testimony of the process of political empowerment and security. These visionary and utopian legacies, scattered in different contexts, reinforced political order for decades and demonstrated exceptional architectural and engineering innovations. This article aims to analyze the architectural and spatial value of the ARK D-0 and Paklenica Bunkers, underground architectural structures that denote

innovation, technological inventiveness and utopian projects of a former military system now used as cultural and tourist attractions. Through a comparative aesthetic analysis, the research will focus on three essential aspects: their architectural and spatial quality, the benefits of reuse and the similarities between these two case studies. These buildings are not only visionary architectural solutions but also indicative of an immersive potential that could serve as a guideline for numerous abandoned former military structures and their transformation into a network of centers for cultural and educational exchange. From the reinvention of the connotative meaning those typologies carry to a new livable architecture imbued with novel usage.

KEYWORDS

UNDERGROUND MILITARY ARCHITECTURE, BUNKERS, CULTURAL REGENERATION, AESTHETIC ASSESSMENT, ARCHITECTURAL IDENTITY

CONTEXT-RESPONSIVE DESIGN METHODOLOGIES AS TOOLS FOR SOCIO-CULTURALLY SUSTAINABLE BUILDINGS

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In contemporary times, architecture has been significantly shaped by globalisation, standardisation, and economic interests. Together, these forces have contributed to the decline of local architectural languages and led to the visible homogenisation of built environments. Simultaneously, efforts to address sustainability have largely prioritised environmental and technical performance over social and cultural dimensions. This paper investigates how contemporary buildings can engage more consciously with their socio-cultural surroundings through context-responsive approaches. Combining a semi-systematic literature review with a comparative analysis of four European case studies, the research identifies recurring design methods and

strategies. The findings demonstrate that successful contextual integration is rarely achieved through direct formal imitation. Instead, reinterpretation, material anchoring, and spatial alignment emerge as dominant strategies. These approaches enable contemporary architecture to mediate the tension between global development and local uniqueness. However, the study argues that context-responsiveness cannot be reduced to a set of formal tools alone. Rather, it requires a shift in architectural philosophy and design processes in which context is treated as a generative and relational framework. By integrating socio-cultural embeddedness into sustainable design thinking, architecture can move toward a more balanced and meaningful understanding of sustainability.

KEYWORDS

ARCHITECTURE, SENSE OF PLACE, ARCHITECTURAL IDENTITY, SOCIO-CULTURAL SUSTAINABILITY, DESIGN METHODOLOGY, CONTEXT-RESPONSIVE DESIGN

RECONVERSION AND RESTORATION OF AN INDUSTRIAL ARCHITECTURAL SITE IN THE AGRO NOCERINO—SARNESE REGION

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From the late 18th century and for the following two centuries, there was a strong and high-profile rise in the establishment of factories and industrial plants in Southern Italy, and in Campania in particular, often financed and built with foreign capital. This was the case with canneries, textile mills, tobacco factories in the Agro Nocerino-Sarnese region, and many other factories in the province of Salerno. Specifically, this study examines, analyzes, and proposes the conversion of a water-powered proto-industrial factory—fed by a dedicated canal drawing water from the Sarno River—used for the mechanical spinning of flax and hemp and, in particular, for weaving.

The industrial complex in question consists of three naves in plan view, the central one of which is equipped with water wheels that transmit hydraulic power to the upper floors. The building envelope consists of load-bearing masonry with a double row of cast-iron pilasters topped with capitals typical of 19th-century industrial architecture. The ongoing challenge of converting and reusing now obsolete and unused industrial buildings and complexes is a highly topical issue that cuts across many disciplines, including economic, political, social, and cultural ones

KEYWORDS

HYDROPOWER, PROTO-INDUSTRY, INDUSTRIAL ARCHAEOLOGY, RESTORATION, REUSE

CONSTRUCTION COMPANY ARCHIVES: TOOLS FOR INDUSTRIALISED BUILDING HERITAGE DOCUMENTATION. THE CASE OF THE BORINI COSTRUZIONI

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Knowledge of building company archives is one of the premises for the documentation and management of industrialised buildings, also through the contribution of digital tools (databases, platforms, etc.) that facilitate access to documentary sources and the sharing of information data. The scientific collaboration between the Department of Civil Engineering of the University of Calabria and the Archivio di Stato of Turin is situated in this framework, focusing on the study and enhancement of the Borini construction company archive. The methodology developed for the archival investigation involves the study of the series constituting the Borini archive and the identification of works and documents

of interest, the organization of archival data and the digitalisation of selected documents, and the definition of analysis paths for the knowledge of entrepreneurial activity in the field of building industrialisation. The outputs of the archival investigation will constitute a set of digitized data and documents, preliminary to the implementation of digital tools for the use of the Borini archive, useful both to scholars of twentieth-century Italian construction and to stakeholders involved in the management of the heritage studied. The catalogue of materials is organized on several levels, aiming to highlight entrepreneurial strategies, recurring industrialisation techniques and works.

KEYWORDS

BORINI COSTRUZIONI, BUILDING INDUSTRIALISATION, CONSTRUCTION COMPANIES ARCHIVES, DIGITALISATION, PREFABRICATION

BLUE AND RED BRICKS: A COMPARATIVE STUDY IN CHINA AND ITALIAN TRADITION

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This article considers one of the many ways in which properties govern the development of particular architectural structures by a comparative study of blue bricks from Huizhou, China, and red bricks from Italy. Although the article does not focus on analyzing production methods as much as on outlining how these brick types have achieved distinct structural performance by adopting different masonry methods relevant to their respective constructions. The thinness and high strength of Huizhou blue bricks are found to be supporting forces for the lofty, fire-resistant “horse-head wall” structure, as well as delicate-brick-carving

techniques. Italian red bricks, on the other hand, are standardized in terms of specifications and stability, thus serving as a supporting force for the highly complex arch and dome systems of classic Italian architecture. The article concludes that, across different cultural contexts, brick materials are not only functional vehicles for supporting architectural structure and decoration but also a material basis on which regional cultural traits and architectural language are defined. The study's outcome consequently provides new insights into the structural preservation of traditional brick-and-stone architectural heritage in a cross-cultural context.

KEYWORDS

HUIZHOU BLUE BRICKS, ITALIAN RED BRICKS, REDUCTION FIRING, MASONRY METHODS.

THE ARCHITECTURE OF THE UNIVERSITY CAMPUS: TYPE AND MORPHOLOGY FOR URBAN REGENERATION

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The guiding principles at the heart of every university policy are typically focused on the quality of teaching and research, staff and students. All of these elements are certainly necessary, but they are undoubtedly not sufficient. They are fundamental components that must exist and coexist, but they cannot be separated from a pillar that supports the stability and solidity of excellent university complexes: the quality of buildings and spaces dedicated to university life and functions. The example of USA University Campus and facilities offers important references. Many among the most prominent Universities in the US have their main Campus built in the 20th Century using Classical Architecture. From

Killian Court at the MIT in Cambridge to Caltech in Los Angeles, from Columbia University in New York City to Bertram Grosvenor Goodhue Main Campus of the University of Texas at Austin. This quite unique Tradition expands even in Europe in the Universidad Laboral in Gijon and the Città Universitaria in Rome and continues with recent interventions such as Leon Krier's Auditorium at the University of Miami and Robert A. M. Stern's buildings in Stanford and Harvard. This paper will analyse these projects and do a comparative study outlining the persistence of Classical Architecture in 20th Century Academic Institutions.

KEYWORDS

CLASSICAL ARCHITECTURE, UNIVERSITY CAMPUS, URBAN REGENERATION, BUILDING TYPE, COMPARATIVE

INTEGRATING CONSERVATION AND BUILDING RISK MITIGATION ISSUES INTO THE RECOVERY OF 20TH-CENTURY HERITAGE

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Recovering 20th-century architectural heritage requires approaches that integrate conservation needs and safety concerns, which are often seen as conflicting. This paper proposes an operational methodology based on the centrality of knowledge, articulated in historical analysis, thematic reading through the Twentieth-Century Historic Thematic Framework, and recognition of the outstanding values to be preserved according to the Madrid–New Delhi Document, integrating them with the priorities of urban safety connected to the theme of Building Risk. The application of this approach to the recovery protocol for the facades of a 20th-century building, built in Naples as part of the great Sanitation Plan started in 1884, allowed us to understand the architecture not only as a technical object, but also as a testament to the processes of urbanisation, technological innovation,

and building experimentation that were typical of the early 20th century. Material and technological diagnostic investigations highlighted vulnerabilities directly related to the identified values. The intersection of these features produced a value–vulnerability matrix that informed design choices, mediating between architectural identity and building risk mitigation rather than simply responding to performance issues. The case study shows that a comprehensive and critical approach to knowledge is essential for projects that combine protection and security, providing a replicable model for interventions on modern heritage. This offers a tangible contribution to current discussions about the future of these structures, which are important for understanding the recent past and creating a positive legacy for the future.

KEYWORDS

20TH-CENTURY BUILT HERITAGE, HERITAGE CONSERVATION, KNOWLEDGE-BASED PRESERVATION, BUILDING RISK MITIGATION, VALUE–VULNERABILITY ASSESSMENT

METHODOLOGICAL APPROACHES TO THE CONSERVATION OF SELECTED POST-WAR EXPERIMENTAL ARCHITECTURAL WORKS IN CASSINO BY GIUSEPPE NICOLOSI

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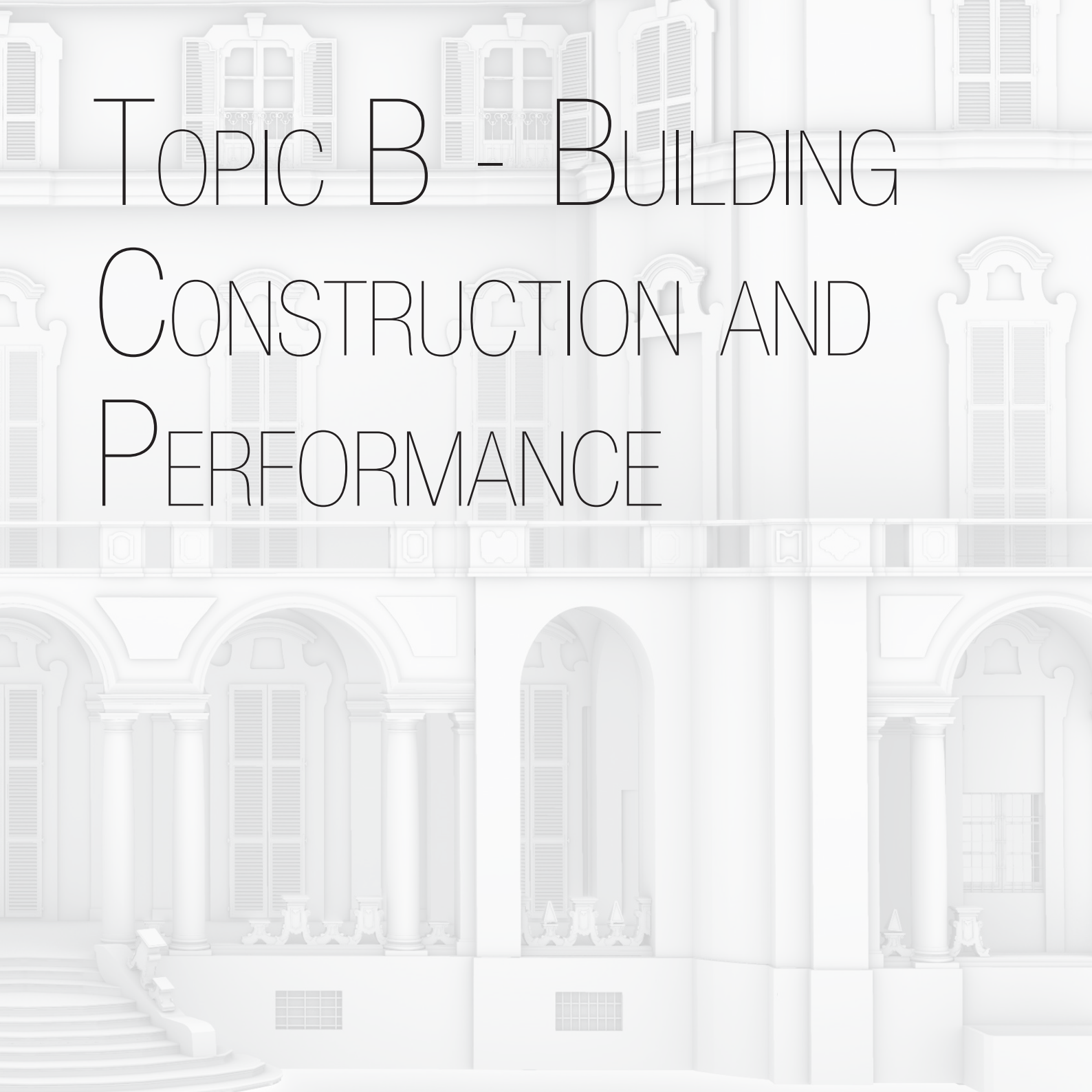
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The building heritage of the second half of the twentieth century presents significant operational challenges in conservation and intervention practices, primarily due to the lack of manuals and guidelines and recognisability of these works. These difficulties do not stem from a shortage of knowledge concerning individual materials or construction elements which have been extensively investigated through scientific and technological research but rather from the absence of adequate contextualisation of such knowledge with respect to the experimental construction techniques adopted in many Italian buildings of the twentieth century. Consequently, a mere aggregation of existing studies proves insufficient to define appropriate intervention protocols, particularly when based on consolidated practices developed for the restoration of historical architecture. This paper proposes an operational methodology grounded in the

reconstruction of the construction history of individual buildings, through the analysis of the design, planning, and execution phases, as well as site-related processes. This approach enables the identification of original technical and constructive solutions and the underlying causes of structural and material vulnerabilities, thereby guiding targeted and coherent intervention strategies. The methodology is applied to the case study of buildings designed by Giuseppe Nicolosi in Cassino during the post-war reconstruction period. An extensive archival investigation conducted in public and private archives allowed for the cataloguing, digital acquisition, and critical analysis of design and construction documentation. The comparison between the original configuration of the buildings and their current condition made it possible to identify critical issues and to define operational guidelines.

KEYWORDS

GIUSEPPE NICOLOSI, BUILDING CONSERVATION AND REHABILITATION, GUIDELINES



TOPIC B - BUILDING CONSTRUCTION AND PERFORMANCE

CLIMATE-CHANGE, USERS' THERMAL COMFORT AND HISTORICAL URBAN OPEN AREAS: A SIMULATION-BASED APPROACH FOR RISK ASSESSMENT IN OUTDOOR OVERHEATING SCENARIOS

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Historic Urban Open Areas (H-UOAs), and in particular, urban squares, are increasingly exposed to the impacts of climate change, which are further intensified by the Urban Heat Island (UHI) effect. These conditions modify local microclimates and can generate significant thermal stress for outdoor users, in view of overheating scenarios. Prolonged exposure to high temperatures may lead to dehydration and other health issues, especially for vulnerable groups such as elderly or toddlers. For this reason, assessing heat risks under current and future climate-change scenarios is urgently needed. This study develops a simulation-based approach to assess overheating effects on H-UOAs users. The simulation-based approach uses ENVI-MET to model microclimatic conditions under present-day and future climate-change scenarios for 2050 and 2080. The simulations incorporate

user presence and behaviour to estimate potential thermal stress, including physiological indicators such as sweat rate and water loss, allowing identification of critical thresholds associated with dehydration and heat risk. The contribution applies the methodology to two H-UOAs in Italy, located in Bari and Naples, chosen for their comparable morphological characteristics. Results highlight how projected climate change could intensify urban overheating in H-UOAs, altering user comfort, spatial use, and exposure to thermal stress. The study demonstrates the value of integrating microclimatic simulations with user-centered analysis to support risk assessment in H-UOAs. By focusing on future climate scenarios, these findings provide insights into potential challenges for urban planning and public health management in historical cities as well.

KEYWORDS

HISTORIC URBAN OPEN AREAS, OVERHEATING, CLIMATE CHANGE, OUTDOOR THERMAL COMFORT, USER EXPOSURE AND VULNERABILITY

HISTORIC URBAN BUILT ENVIRONMENTS AND FLOOD RISK: CLUSTER- AND SCENARIO-BASED APPROACHES TOWARD DECISION-SUPPORT DIGITAL TOOLS

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Historic Urban Built Environments (HUBEs) are increasingly exposed to flood events whose impacts are amplified by dense urban fabrics, stratified construction systems, and complex patterns of use. In this context, risk assessment and mitigation tasks require tools capable not only of integrating heterogeneous data, but also of supporting the construction and communication of meaningful scenarios for decision-making and stakeholder engagement. This paper proposes a digital, scalable methodology that combines GIS-based analysis with BIM approaches and VR solutions to develop HUBE Typologies (HUBETs) prone to flood risk. HUBETs are grounded in buildings and open-space clustering. The core of the approach hence lies in the identification of recurrent built and functional patterns within HUBEs, translated into typological clusters that synthesize construction features, spatial configurations, and occupancy profiles. These clusters are then implemented through parametric mapping

within BIM models and immersive VR environments, enabling the exploration of HUBETs flood dynamics, physical vulnerability settings, user factors, as well as emergency and evacuation conditions across multiple representative scenarios rather than isolated case studies. A multi-scalar logic links urban-scale spatial analysis to detailed block- and building-scale models, supporting the selection of priority areas and the generation of scenario-based narratives tailored to different stakeholder needs (including those related to the activation of evacuation procedures). The application is based on a HUBE in Central Italy exposed to fluvial flood risk demonstrates the capabilities of the proposed approach. By embedding cluster-based reasoning into BIM and VR workflows, the proposed methodology facilitates participatory processes, scenario comparison, and knowledge transfer among technical experts, public authorities, and non-specialist actors

KEYWORDS

FLOOD EVACUATION, FLOOD RISK ASSESSMENT, TYPOLOGICAL CLUSTERING, HISTORIC URBAN ENVIRONMENT

EVALUATION OF FUNCTIONAL PROPERTIES OF GYPSUM-SPENT COFFEE GROUND BIOCOMPOSITES

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Coffee is the most consumed beverage in the world, every year coffee waste increases in landfills and to dispose of it is necessary recycling systems to use it as composting or production of pollution to activate incinerators. This article will analyze the mechanical and water absorption performance of gypsum and spent coffee ground composites for construction applications. Similar analyses were performed with different binders, such as cement, lime, geopolymers, clay or resins. The aim is to understand whether a gypsum-based material, a building material produced at low temperatures and low emissions, can be able to guarantee good performance by adding an aggregate like spent coffee ground.

The research analyse the material to replacing similar building products produced with greater pollution, according to the principles of Circular Economy and waste reuse of the Minimum Environmental Criteria. The flexural and compressive strength values identified are 7MPa and 12 MPa respectively, excellent values for gypsum and comparable to cementitious composites. Furthermore, water absorption tests showed a capillarity index ranging from 3 g to 0.2 g with 20 wt.% SCG, on the other hand for water absorption for diving the values decrease from 53 % to 20 %, but are still higher than other studies analysed.

KEYWORDS

SPENT COFFEE GROUND, GYPSUM, BIOBASED MATERIALS, CONSTRUCTION MATERIALS, CIRCULAR ECONOMY

CIRCULARITY BETWEEN AND RECIPIENT BUILDINGS: THE STRUCTURAL STEEL PERSPECTIVE

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Circular economy in architecture is frequently approached through technical solutions and end-of-life scenarios, often assuming that circularity can be achieved by optimising individual materials or components. This paper challenges that assumption by arguing that, when structural systems are involved, circularity cannot be treated as an intrinsic property of materials but must be understood as a relational condition emerging between buildings. Focusing on structural steel, the paper proposes a framework based on the concepts of Building and Recipient Building, through which circular processes are interpreted as transfers of configuration, information and regulatory

legitimacy across architectural contexts. Within this perspective, strategies such as reuse, recondition, contextual repurpose and remanufacture are not considered equivalent options, but distinct degrees of relational continuity shaped by design decisions and normative constraints. Rather than promoting reuse as an isolated objective, the contribution situates circularity within a broader architectural discourse on adaptability, transformation and material availability. By reframing circularity as a relational and design-driven process, the paper positions architecture as an active agent in governing structural continuity across building lifecycles.

KEYWORDS

CIRCULAR ECONOMY, STRUCTURAL STEEL REUSE, BUILDING, RECIPIENT BUILDING, DE-CONSTRUCTION.

HOW ARTIFICIAL INTELLIGENCE IS PERFORMING IN THE FIELD OF BUILDING FIRE SAFETY?

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Building fire safety engineering is a complex and multidisciplinary field that integrates fire dynamics, building design, human behavior, emergency management, and regulatory compliance. The increasing availability of Large Language Models (LLMs) offers new opportunities to support safety-critical, knowledge-intensive decision-making processes. Although LLMs have shown strong performance in domains such as healthcare, law, and industrial safety, their applicability to building fire safety engineering has not yet been thoroughly investigated. This paper examines the performance of artificial intelligence in this domain by evaluating multiple commercial and open-source LLMs. A Retrieval-Augmented Generation (RAG) architecture is also employed to ground model outputs in official Italian fire safety regulations, significantly reducing the risk of hallucinations. A structured benchmarking methodology is adopted, combining accuracy-based

metrics with latency measurements to assess both effectiveness and operational feasibility. Furthermore, the performances of high-accuracy LLMs are compared with that of expert fire safety professionals using the same standardized assessment material. The results reveal clear trade-offs between model size, inference latency, and deployment constraints. However, when appropriately constrained and adapted to the domain, LLMs can achieve accuracy levels comparable to trained human experts, particularly in factual recall and regulatory interpretation. These findings suggest that LLMs can effectively support professionals by improving access to regulatory knowledge, enhancing consistency, and reducing cognitive load. Rather than replacing human decision-makers, LLMs should be viewed as decision-support tools, especially valuable for training, compliance verification, and emergency preparedness in building fire safety engineering.

KEYWORDS

ARTIFICIAL INTELLIGENCE, LARGE LANGUAGE MODELS, FIRE SAFETY ENGINEERING, BUILDING SAFETY, RETRIEVAL-AUGMENTED GENERATION

EVALUATION TOOLS FOR DESIGN ALTERNATIVES IN THE PRELIMINARY DESIGN OF STUDENT HOUSING

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The issue of student housing is a central one within the Italian higher education system. The shortage of accommodation that characterizes the current scenario limits the attractiveness of universities and undermines their competitiveness at both national and international levels. It therefore appears necessary to strengthen the supply of student housing in order to ensure greater residential accessibility within a market affected by increasing demand and high rental costs. In response to this situation, ministerial funds and calls for proposals encourage the development of new student residences and the creation of additional bed spaces through forms of financial co-participation between the public and private sectors. However, ministerial co-financing calls require very short timeframes for the submission of proposals, resulting in the need to accelerate decision-making processes, particularly during the early stages of the design process. Within this operational context, rapid

assessment tools for comparing design alternatives applied to student housing find a particularly suitable field of application, enabling stakeholders and decision-makers to identify solutions that best meet requirements in terms of performance, costs, benefits, and overall project sustainability. Starting from a practical need to compare design alternatives, the research proposes the development of a qualitative–quantitative evaluation system. From a methodological perspective, the study begins with an analysis of the regulatory requirements governing the design of student residences, integrated with an examination of the main design and market trends. On the basis of this analysis, evaluation parameters are identified and articulated at both the building scale and the room scale. Finally, the application of the proposed evaluation system to a case study is presented as an example of its use.

KEYWORDS

STUDENT HOUSING, ASSESSMENT, EVALUATION TOOL, DESIGN PARAMETERS

URBAN BUILDING ENERGY MODELING FOR CONSTRUCTION SECTOR DECARBONIZATION: INSIGHTS FROM A SYSTEMATIC REVIEW AND A DISTRICT- SCALE CASE STUDY

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The decarbonization of the construction sector is a strategic component in the pursuit of carbon neutrality by 2050, as this sector significantly contributes to global energy consumption and greenhouse gas emissions. Achieving climate targets requires moving beyond the traditional building-centric approach, which has proven inadequate in capturing the complexity of urban settlements, towards methodologies capable of operating across multiple scales and integrating energy-related, territorial, and decision-making dimensions. This shift calls for a structural rethinking of analytical and design processes, as well as of the tools supporting policies and intervention strategies, with an increasing emphasis on integrated and data-driven approaches. In this context, Urban Building Energy Modeling (UBEM) has emerged as a methodology for evaluating the energy performance of building stocks at the urban scale. By integrating energy models,

geospatial data, and digital tools, UBEM enables the quantification of energy consumption and emissions, the simulation of transformation scenarios, and the support of urban energy planning and decarbonization strategies. This article provides a critical review of the decarbonization pathway of the construction sector, starting with an analysis of the European and Italian regulatory frameworks, the current state of scientific research, and the tools currently available for assessing energy and environmental performance. It further examines the state of the art in UBEM methodologies and demonstrates the usefulness of this approach by presenting a case study focused on the optimization of a district located in Lecco, Italy. From this perspective, Urban Building Energy Modeling assumes a strategic role not only as a simulation tool, but also as an instrument supporting decision-making processes and governance of the ecological transition.

KEYWORDS

DECARBONIZATION, URBAN BUILDING ENERGY MODELING, MULTISCALE APPROACH, ENERGY SIMULATION, CONSTRUCTION SECTOR, CARBON NEUTRALITY

BUILDING-SCALE ENERGY EVALUATION OF CEMENT MORTARS WITH RECYCLED MUSSEL SHELL AGGREGATES

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The construction sector plays a central role in strategies to reduce energy consumption and climatechanging emissions, making it a priority to improve the performance of building envelopes through sustainable solutions with low environmental impact. In this context, this study analyses the energy-saving potential of a biocomposite cement mortar obtained by completely replacing natural sand with recycled mussel shells, used as a finishing layer for the building envelope. The research is a continuation of previous experimental investigations, in which mortar containing mussel shells with a continuous particle size distribution of 0–4 mm showed balanced behaviour in terms of workability, water behaviour, mechanical performance, and thermophysical properties, and was therefore selected as a case study. The energy performance of

the mussel shell-based mortar is evaluated through dynamic energy simulations conducted on a simplified residential building model, comparing the results with those obtained using a traditional reference mortar made with natural sand. The simulations are extended to different climatic contexts representative of hot, temperate, and cold climates in order to evaluate the robustness of the proposed solution. The results show a systematic reduction in annual energy requirements associated with the use of mortar containing mussel shells in all the analysed climatic contexts. The study highlights how finishing materials with reduced thermal conductivity, obtained from the valorisation and reuse of fishery waste, can contribute significantly to improve the energy performance of the building envelope, particularly in retrofit projects.

KEYWORDS

CIRCULAR ECONOMY, WASTE REUSE, BIOCOMPOSITE MORTAR, VIRTUAL ENERGY SIMULATION, ENERGY PERFORMANCE.

URBAN HEAT ISLAND ASSESSMENT IN HISTORIC URBAN CONTEXTS: THE CASE OF FLORENCE

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Cultural heritage sites located in historic urban centers are increasingly exposed to thermal stress, often associated with the Urban Heat Island (UHI) phenomenon, which remains poorly investigated in the context of historic districts. This paper investigates the UHI effect in the historic center of Florence, focusing on an area of approximately 888m x 500m between Palazzo della Signoria and the Boboli Gardens. The selected study area includes two natural elements - a water body and a major green space - that may significantly influence local microclimatic conditions. The UHI assessment was carried out using the CFD-

based microclimatic software ENVI-met, integrated with QGIS for geometric input preparation and spatial analysis of the simulation outputs. The results confirm the presence of a pronounced UHI effect during the nighttime in compact and densely built areas, with temperature differences reaching up to 3 °C compared to the green area. Localized cooling effects associated with the river and the Boboli Gardens were identified; however, these effects appeared to be affected by wind direction, urban morphology, and distance from the riverbanks.

KEYWORDS

URBAN HEAT ISLAND, URBAN CLIMATE, MITIGATION, HISTORIC CENTER, ENVIRONMENTAL DESIGN

MICROCLIMATE-DRIVEN ASSESSMENT OF DISTRICT-SCALE OVER-HEATING UNDER FUTURE CLIMATE SCENARIOS: THE STANIC DISTRICT IN BARI

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Contemporary urban growth in Mediterranean cities is increasingly characterised by densification processes within consolidated built environments, which intensify local overheating risks under climate change. As urban thermal stress emerges as a systemic outcome of interactions among built morphology, surface sealing, vegetation performance, and ventilation regimes, the development of heat-resilient built environments requires microclimate-driven strategies to guide future urban transformations.

This study presents initial results from the UHBioFeat project (“Urban Heat simulation and satellite fed modelling for the assessment of Bio Feature in climate change”) by assessing the microclimatic impacts of planned urban development in the Stanic district of Bari (Italy), focusing on the “Villaggio del Lavoratore” neighbourhood and its surrounding industrial area. An integrated methodology is adopted, combining

GIS-based modelling of Actual and Planned Built Developments with mid-term climate projections generated through the Future Weather Generator tool under the SSP2–4.5 scenario. High-resolution ENVI-met simulations are performed to compare present-day and 2050 conditions at both spatial and Local Climate Zone (LCZ)-based levels. Findings indicate projected mean air temperature in future outline increases of approximately +0.8 to +1.0 °C across residential and industrial LCZs, with stronger amplification in new densified sub-areas. Results also reveal the limited mitigation effectiveness of existing green infrastructure, such as Lama corridors, when vegetation is unmanaged and seasonally dry. Overall, the study highlights the need for policymakers to prioritise wider application of permeable pavements, irrigation-supported urban greenery, and morphological control of new developments in order to preserve local ventilation and enhance summer heat resilience.

KEYWORDS

LOCAL CLIMATE ZONES, URBAN OVERHEATING, MEDITERRANEAN CITIES, CLIMATE-RESPONSIVE BUILT ENVIRONMENT

FULL-SCALE PROTOTYPING FOR HYGROTHERMAL MONITORING OF EARTHEN PLASTER: WINTER SET-UP VALIDATION AND PRELIMINARY INDICATORS

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Within the ITER project (Intonaci di Terra Ecologici Riciclabili - Recyclable Ecological Earthen Plasters), this study presents full-scale prototyping and initial in-situ monitoring of recyclable earthen plasters enhanced with agricultural residues and stone by-products. Two identical masonry test boxes were built in Catania (Italy) to compare an innovative earthen plaster (containing marble dust, sisal fibres) with a reference natural hydraulic lime (NHL) system by keeping the same geometry, orientation, envelope assemblies and openings. The monitoring framework includes outdoor weather and indoor microclimate conditions, as well as indoor and outdoor surface temperatures for a wall oriented due west. Temperatures were recorded every 10 minutes using one PCE-T 394-ICA datalogger per

prototype and four type-K contact probes per test box (two external, two internal). The pilot dataset spans 15 December 2025 (afternoon) to 19 December 2025 (morning), providing around 4 days of continuous records. Results show that the earthen prototype exhibited lower internal peak temperatures and oscillations and slightly larger time delay than the lime reference; these findings are reported as descriptive and non-conclusive. On the contrary, the lime prototype reached higher external daytime maxima while minima were comparable. Plausible drivers are discussed and next steps of the research introduced, such as multi-season monitoring and forcing-coupled interpretation with robust attenuation and lag descriptors.

KEYWORDS

BUILDING ENVELOPE, OUTDOOR EXPOSURE TESTING, SURFACE TEMPERATURE DYNAMICS, SUSTAINABLE CONSTRUCTION MATERIALS, NATURAL HYDRAULIC LIME PLASTER, ARCHITECTURAL TECHNOLOGY.

FROM ACADEMIC KNOWLEDGE TO PUBLIC POLICY: THE CAMPI FLEGREI BRADYSEISMIC CASE

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Enhancing academic knowledge requires a structured, continuous synergy between universities and territories, capable of translating research into cultural advances and operational tools for the community. This contribution presents the Campi Flegrei case as a paradigmatic experience of knowledge enhancement, grounded in long-standing technical-scientific support to Public Administrations and articulated through multiple forms of institutional cooperation. The research activity has produced innovative outcomes across several levels: cultural redefinition of risk-related issues; implementation of policies oriented towards multi-risk governance; development of rapid assessment tools for urban systems vulnerability in support of territorial preparedness. Specifically, the integrated analysis of the unique seismic-deformation dynamics of bradyseism and the impacts of recent crises has led to the identification of Bradyseismic Risk as an autonomous and atypical scenario, characterised by low-intensity,

high-frequency solicitations with cumulative effects on buildings, infrastructures, and the population. These advances promoted a substantial paradigm shift: from a post-event emergency response model toward an approach focused on prevention, conscious coexistence with risk, and territorial resilience. This framework was formalised by the research group of the University of Naples Federico II within the Grande Progetto Pozzuoli and subsequently adopted at ministerial level through Decree-Law no. 140/2023 and related implementation plans. The developed methodological tools support strategic, technical, and financial decision-making, contributing to both urban systems resilience and emergency planning. The Campi Flegrei case, therefore, constitutes an exemplary practice of multilevel risk governance, grounded in stable integration between research, institutions, and the territory, and in a bottom-up model to address local risks, needs, and interventions.

KEYWORDS

MULTI-LEVEL POLICY TRANSFER, APPLIED RESEARCH, CO-PRODUCTION OF KNOWLEDGE, RISK GOVERNANCE, ADAPTIVE GOVERNANCE

COMPARATIVE ANALYSIS OF REGULATORY FRAMEWORKS FOR BAPV AND BIPV IN HISTORIC BUILDINGS ACROSS IEA PVPS MEMBER COUNTRIES

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The integration of photovoltaic (PV) technologies in historic buildings represents a critical intersection between climate mitigation objectives and cultural heritage preservation. Within countries participating in the International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS), regulatory approaches to Building Applied Photovoltaics (BAPV) and Building Integrated Photovoltaics (BIPV) in heritage assets vary significantly, reflecting differences in heritage governance, planning systems, and energy policy priorities. This work provides a comparative analysis of the existing national normative and policy frameworks photovoltaic installations in historic buildings across selected IEA PVPS member countries.

First, it examines the legal foundations for heritage protection, planning authorization procedures, and the existence of guidelines for PV in historic buildings or contexts. It then correlates regulatory stringency and

interpretation with recent installation trends, identifying whether advanced BIPV solutions benefit from greater institutional acceptance compared to conventional BAPV systems. Finally, the analysis is complemented by a review of manufacturers, commercially available products, and selected case studies that analyze how technological innovation responds to regulatory constraints. Finally, a shift in several countries is highlighted from restrictive and conservative criteria toward more flexible approach based on energy performance and aesthetical integration, particularly where PV systems function as architectural components (BIPV) rather than adding elements (BAPV).

This work contributes to the understanding of how regulatory frameworks influence technological adoption and market development in heritage-built environments aiming to reconcile decarbonization targets with conservation principles.

KEYWORDS

BUILDING INTEGRATED PHOTOVOLTAIC (BIPV), HISTORIC BUILDING, RENEWABLE ENERGY.

GREEN FAÇADES: EXPERIMENTAL APPROACHES FOR THE SUSTAINABLE MANAGEMENT OF NATURE-BASED SOLUTIONS

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Green façades are increasingly adopted as integrated Nature-Based Solutions for improving environmental performance, microclimatic regulation, and architectural quality in compact urban environments. Despite their recognized benefits, the widespread implementation of Vertical Greenery Systems (VGS) is frequently hindered by uncertainties related to long-term management, maintenance complexity, operational safety, and cost-effectiveness. This study presents an experimental and comparative assessment of two principal VGS typologies—green façades and living walls—focusing on their design configurations, plant selection, irrigation systems, and maintenance regimes. The research is grounded in in situ pilot installations and structured monitoring protocols, incorporating quantitative and qualitative indicators such as vegetative growth dynamics, system efficiency, maintenance frequency, operational risks, and lifecycle-related costs. The results

reveal substantial differences between VGS typologies in terms of technical performance, maintenance intensity, and long-term sustainability, highlighting critical trade-offs between technological complexity and operational manageability. Building on the experimental evidence, the paper proposes an operational maintenance framework aimed at optimizing resource use, reducing costs, and enhancing system durability. The framework is subsequently tested and validated through its application to a specific case study, demonstrating its adaptability to real-world constraints and its potential for replication across diverse urban contexts. The findings provide actionable knowledge for designers, facility managers, and policy makers, supporting the development of robust, low-maintenance, and economically sustainable vertical greenery strategies within contemporary urban regeneration processes.

KEYWORDS

VERTICAL GREENERY SYSTEMS, MAINTENANCE STRATEGIES, URBAN SUSTAINABILITY, LIVING WALLS, GREEN FAÇADES

USER-CENTERED PROTOTYPING OF A NOVEL MULTI-RISK URBAN FURNITURE: A VIRTUAL REALITY-BASED STUDY INTEGRATING THERMAL COMFORT AND FLOOD RESILIENCE IN PUBLIC OPEN SPACES

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Urban centers are increasingly exposed to extreme weather events that threaten the safety and comfort of public spaces. In this context, it is necessary to find innovative and flexible strategies to mitigate the risk of these events to people. This study proposes the development and prototyping through virtual reality (VR), using the CAVE system, of multifunctional urban furniture capable of generating shaded public spaces, supporting urban socialization, adaptable to different contexts, and able to respond to extreme events such as heat waves and floods. The urban furniture was developed following the principles of "Security by Design", modularity, and customizability, starting from the concept of multifunctional urban furniture. Subsequently, a three-dimensional model of an urban portion of the city of Senigallia (AN), representative of a Mediterranean coastal urban centers, was implemented

in Unity to test the urban furniture in an immersive environment simulating two emergency scenarios (heat waves and floods). More than 50 participants interacted with the VR scene and the integrated urban furniture to evaluate its aesthetics and effectiveness in responding to simulated emergencies. Furthermore, the effectiveness of the virtual reality system for prototyping and training in emergency situations was evaluated. The results were positive across the board. The furnishings were appreciated both for their aesthetic appeal (85% of participants expressed agreement or strong agreement) and for their effectiveness in both emergency situations (90% of participants expressed agreement or strong agreement), particularly the flood. The approach based on the implementation of virtual reality proved to be a useful and promising tool for prototyping and training, and easy to use.

KEYWORDS

DIGITAL PROTOTYPING, VIRTUAL REALITY, BEHAVIORAL-BASED DESIGN, BUILT ENVIRONMENT MANAGEMENT, CLIMATE RESILIENCE, SERIOUS GAMES

MACHINE LEARNING IN THE DESIGN OF CONSTRUCTION MATERIALS AND COMPONENTS: A SYSTEMATIC REVIEW OF CARBON-BASED APPLICATIONS IN CEMENT-BASED SYSTEMS

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The construction sector faces increasing pressure to reduce environmental impacts while improving the performance and functionality of building materials. Cement-based systems are widely adopted yet carbon-intensive and primarily structural. Achieving enhanced durability or functional properties (e.g., sensing or electro-thermal response) commonly requires additional components, increasing complexity and environmental burden. In this context, carbon-based additives—such as carbon nanotubes, graphene derivatives, carbon fibers, and biochar—have been increasingly investigated as multifunctional strategies to enhance mechanical performance, electrical conductivity, and durability in cementitious systems. In parallel, artificial intelligence (AI) and machine learning (ML) have emerged as effective tools for modeling complex material behavior governed by non-linear, high-dimensional relationships. In this context, the present study reports a PRISMA-

guided scoping review to map AI/ML applications for the design and analysis of cement-based materials incorporating carbon-based additives. The search identified 741 records of English-language journal articles published between 2013 and 2026. Following multi-stage screening based on predefined inclusion criteria and scope boundaries, 34 studies were selected. The included studies were analyzed by carbon-based additives (e.g., CNTs, graphene derivatives, fibers, biochar), AI/ML approach (e.g., tree-based ensembles, neural networks), and predicted outcomes (e.g., strength, durability-related metrics, and functional properties). Results show a strong focus on CNT- and graphene-based systems, with ensemble and tree-based ML dominating. Most works address mechanical prediction, while thermal and broader multifunctional properties remain underexplored, highlighting opportunities for more integrated, data-driven material design.

KEYWORDS

ARCHITECTURAL ENGINEERING, CARBON-BASED CONSTRUCTION MATERIALS, CEMENTITIOUS COMPOSITES, ARTIFICIAL INTELLIGENCE, MACHINE LEARNING

EVALUATING HAIL RISKS TO BUILDING-MOUNTED PV SYSTEMS LIFE CYCLE

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Building-mounted photovoltaics (BMPV) are increasingly pivotal for sustainable energy generation and the decarbonization of the global energy grid. As policy frameworks accelerate the adoption of these systems within the built environment, ensuring their lifecycle resilience against environmental hazards becomes a critical engineering challenge. Among these threats, hail hazards pose a significant risk to the physical integrity and long-term viability of solar infrastructure. This study presents a comprehensive probabilistic risk assessment of BMPV systems by leveraging a performance-based engineering approach. The framework integrates high-resolution hail hazard models, physical vulnerability assessments, and consequence modeling to predict damage scenarios. Our analysis identifies hail size as a highly correlated intensity measure for front-glass

fracture, providing a reliable metric for predicting system failure. The results quantify a substantial impact on system performance: for modules with 3.2 mm glass thickness, hail risk can reduce the operational lifespan by up to 9.34 years and slash the Energy Return on Energy Invested (EROI) by 42.76%. Even with 4 mm glass, the lifespan decreases by 0.78 years, with a 5.89% reduction in EROI. Furthermore, repair costs are found to be significant relative to both initial capital expenditures and the total expected hail-related losses for entire building envelopes. These findings underscore the urgent need to incorporate probabilistic hail risk into lifecycle analyses and to establish minimum impact-resistance standards based on localized hazard levels to safeguard the future of urban renewable energy.

KEYWORDS

BUILDING-MOUNTED PHOTOVOLTAICS (BMPV), HAIL HAZARD PROBABILISTIC RISK ASSESSMENT, PERFORMANCE-BASED ENGINEERING, LIFE CYCLE ASSESSMENT (LCA), ENERGY RETURN ON ENERGY INVESTED (EROI)

DEVELOPMENT OF A NEW SOFTWARE TOOL FOR ENERGY, ENVIRONMENTAL AND ECONOMIC PERFORMANCE OF BUILDING ROOFING SOLUTIONS

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Climate change and increasing urbanization are exacerbating building overheating and cooling energy demand, highlighting the need for effective passive cooling solutions. Ventilated and Permeable Roofs (VPR), and in particular the HEROTILE-based Roof (HBR), have demonstrated significant potential in reducing solar heat gains and cooling energy consumption. However, current regulatory frameworks and assessment tools lack methods to properly quantify their energy, environmental, and economic benefits, especially in summer conditions. This paper presents the development and application of SUPERHERO, a new software tool developed within the LIFE SUPERHERO project, designed to assess and compare roofing solutions by integrating dynamic energy simulation, Life Cycle Costing (LCC), and Life Cycle Assessment (LCA). The tool enables the evaluation of heating and

cooling energy demand, maximum external roof surface temperature, global costs and payback period, and environmental impacts over the life cycle, including both embodied and operational stages.

An exemplary application to a roof retrofit of an attic building in Rome (Italy) is presented, comparing a traditional roof with an HBR solution. Results show a reduction in total annual energy consumption (-16%), mainly due to lower cooling demand (-44%), a decrease in maximum roof surface temperature, a payback period of approximately 20 years, and significant reductions in life-cycle environmental impacts, particularly during the use phase. The SUPERHERO software represents a practical decision-support tool for designers, consultants, and public administrations, fostering informed adoption of passive cooling roofing technologies and supporting climate adaptation strategies.

KEYWORDS

BUILDING ROOF, ENERGY PERFORMANCE, LIFE CYCLE COSTING, LIFE CYCLE ASSESSMENT, VENTILATED TILED ROOF, CLAY TILE

COMBINING ONSITE MONITORING AND ENVI-MET MODELLING: A MULTI-SCALE LCZ-BASED ANALYSIS OF THE URBAN HEAT ISLAND PHENOMENON IN THE METROPOLITAN AREA OF BARI

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The Urban Heat Island (UHI) phenomenon is a critical environmental stressor driven by the complex interplay among urban morphology, land cover, and geographic positioning. This study investigates the spatial thermal variability of the metropolitan area of Bari (Italy) by applying the Local Climate Zones (LCZ) framework to three representative districts. Such districts are selected within the case studies included in the UHBioFeat project (Urban Heat simulation and satellite fed modelling for the assessment of Bio Feature in climate change). Through an extensive field monitoring campaign conducted in August 2025 and subsequent microclimatic simulations using ENVI-met, the research evaluates how built density and canyon geometry influence daytime heat accumulation and nocturnal cooling rates. Findings reveal that site-specific configurations significantly dictate thermal profiles, with the industrial-residential mix of the Stanic

area recording the highest average temperatures, while the sparsely built fabric in Valenzano (BA) exhibited the highest nocturnal cooling capacity due to its higher Sky View Factor and abundance of natural surfaces. At the micro-scale, targeted comparisons demonstrated that variations in urban canyon orientation and localized shading from buildings and vegetation can generate temperature discrepancies of up to 3 °C between adjacent sites. Numerical validation indicated that while CFD models successfully reproduce macro-scale thermal trends, they encounter limitations in capturing rapid localized fluctuations and tend to overestimate nocturnal heat retention. Ultimately, the study underscores that urban climate resilience depends on a multi-scale approach to planning, prioritizing the mitigation of radiative trapping through controlled building density, enhanced urban porosity, and the strategic integration of green infrastructure.

KEYWORDS

URBAN HEAT ISLAND, URBAN MORPHOLOGY, LOCAL CLIMATE ZONES, IN-SITU MEASUREMENTS, SEA BREEZES

A NEW ITALIAN LEXICON TO PERFORM SENTIMENT ANALYSIS OF BUILDINGS' MAINTENANCE REQUESTS

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Natural Language Processing (NLP) and Text-Mining techniques are increasingly applied in Facility Management (FM) to extract knowledge from unstructured data such as maintenance requests and inspection reports. The aim is to optimize the time, resources and costs of managing complex buildings. However, the informal, abbreviated, and domain-specific language of such texts limits the performance of generic NLP models. The Technical Language Processing (TLP) paradigm addresses this issue by adapting NLP methods through specialized preprocessing and domain lexicons. Among the different methods to extract information,

lexicon-based approaches are valuable for their transparency and ease of integration, in contrast with semi-automated lexicon induction through embedding similarity, and with hybrid systems combining rule-based precision with machine learning adaptability and large language models. This study proposes a semi-automated TLP-based lexicon induction framework validated on operational FM data. The framework supports interpretable, scalable, and trustworthy automation of maintenance request analysis, aligning linguistic insights with structured asset information for improved decision-making in FM operations.

KEYWORDS

TECHNICAL LANGUAGE PROCESSING, FACILITY MANAGEMENT, PEOPLE PERCEPTION, BUILDING MAINTENANCE CLADDING, RESTORATION

DESIGN OF A FOLDING FAN INSPIRED ADAPTIVE FAÇADE SYSTEM FOR DAYLIGHT AND GLARE CONTROL: A PARAMETRIC AND SIMULATION BASED APPROACH

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Adaptive façades offer strong potential to improve visual comfort and indoor environmental quality, but their dynamic behavior complicates performance evaluation using conventional simulation workflows. Existing methods are not optimized to manage multiple façade configurations and control strategies, resulting in high computational effort and limited applicability during early design phases. This study presents a simplified parametric workflow for evaluating performance of adaptive façades in terms of visual comfort amelioration. The proposed method integrates daylight and glare metrics with a radiation-based control strategy that links incident solar radiation to different configurations of the façade. Useful Daylight Illuminance Low (UDI-L) and Daylight Glare Probability (DGP) were calculated at selected hours on representative days, and the most suitable façade configuration for each condition was associated with the corresponding radiation value. This

correlation was used to generate an adaptive control schedule, enabling the façade's dynamic behavior to be represented through a single annual daylight simulation. The workflow was implemented in Grasshopper and applied to a commercial building in China characterized by extensive south-facing glazing. Results indicate that the adaptive façade significantly modifies daylight distribution and reduces glare compared to a reference case without adaptive features. On the ground floor, Daylight Autonomy decreased from 90% to 81%, Useful Daylight Illuminance increased from 67% to 73%, and DGP decreased from 0.52 to 0.28. On the upper level, Daylight Autonomy decreased from 91% to 81%, Useful Daylight Illuminance increased from 70% to 76%, and DGP decreased from 0.67 to 0.30. Beyond performance evaluation, the workflow supported the translation of the adaptive concept into a modular technological façade system.

KEYWORDS

ADAPTIVE FAÇADE, VISUAL COMFORT, DAYLIGHT SIMULATION, GRASSHOPPER

INNOVATIVE HYBRID TIMBER-MORTAR CONSTRUCTION SYSTEM: LCA ANALYSIS AND COMPARISON WITH A TRADITIONAL DRY CLT SYSTEM

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In recent decades, timber construction systems have experienced remarkable development in Europe due to their sustainability, thermal performance, indoor comfort, and aesthetic qualities. Various hybrid construction systems have also emerged, combining the properties of wood with other materials to further enhance specific performance aspects. This research investigates a timber-mortar construction system (NIDUS), which combines a lightweight wooden frame (balloon frame) with a lime-based infill (lime, perlite, and hemp) that provides thermal mass and wall continuity. The timber-mortar system is therefore compared with the Cross Laminated Timber (CLT) construction system. The study employs an integrated methodological approach combining design activities, digital modeling, and mock-up experimentation to compare the energy performance and environmental impact of the two construction systems. The initial phase involves the

design of nodes and stratigraphies, along with thermo-hygrometric and energy analyses to assess the building envelope's performance. Four design solutions were analysed: two for the NIDUS and two for the CLT system. Subsequently, 3D digital models were used as references for energy and environmental simulations. In parallel, aspects related to prefabrication, assembly times, construction sequencing, and connection quality were evaluated using two full-scale mock-ups, constructed by the National Research Council - Institute for Bioeconomy (CNR-IBE) at its laboratories. The results highlight that the timber-mortar system achieves performance comparable to CLT, representing a viable solution. In particular, the system's greater thermal mass contributes to improved summer performance, while life-cycle impacts in terms of Global Warming Potential (GWP) are approximately 6% lower, excluding biogenic carbon.

KEYWORDS

TIMBER CONSTRUCTION, HYBRID TIMBER-MORTAR SYSTEMS, ENERGY SIMULATION, LIFE CYCLE ASSESSMENT, FULL-SCALE MOCK-UP

BRIDGING NEUROSCIENCE AND RESEARCH: NEUROSCIENCE AND AI AS TOOLS FOR SELF-ASSESSMENT OF ARCHITECTURAL QUALITY IN DESIGN STUDIES

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This paper explores the integration of neuroscientific approaches and artificial intelligence in architectural education, examining how these emerging tools could possibly enhance self-assessment practices in design studies. As technical education in architecture faces mounting demands for interdisciplinarity, evidence-based design, and demonstrable learning outcomes, the limitations of purely subjective evaluation become increasingly apparent. The discipline has historically lacked systematic knowledge frameworks capable of connecting design decisions to their measurable impacts on human experience and environmental performance, leaving students without reliable mechanisms for assessing whether their design genuinely promote health, well-being, and beauty. Drawing from recent developments in neuroscience applied to the built

environment and generative AI capabilities, this study presents a case study applied in the integrated laboratory sessions of an Architectural Engineering course, in which specific neuroscientific metrics, such as biometric responses to spatial qualities, and AI-supported analysis can be tackled to further engage and empower students to critically evaluate their own design decisions. This approach responds to calls for transforming design education for the 21st century while maintaining the creative core of architectural practice. The paper contributes to ongoing discussions about knowledge systems in architecture, interdisciplinary education, and the role of emerging technologies in shaping future practitioners who can design healing, sustainable environments that genuinely promote human flourishing.

KEYWORDS

ARCHITECTURAL EDUCATION, NEUROSCIENCE, ARTIFICIAL INTELLIGENCE, DESIGN QUALITY EVIDENCE-BASED DESIGN, SELF-ASSESSMENT

SUPPORTING DECISION-MAKING IN HISTORICAL URBAN BUILT ENVIRONMENTS UNDER MULTIPLE DISASTER RISK SCENARIOS: A MESO-SCALE AND BEHAVIOURAL-BASED APPROACH

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Historical Urban Built Environments (HUBEs) are often exposed to multiple hazards, combined with spatiotemporal dynamics of space use and user presence. Decision-making for risk reduction and mitigation should therefore rely on holistic assessment approaches integrating hazard, vulnerability and exposure conditions under different scenarios. In this context, the identification of the riskiest areas (“hot-spots”) in HUBEs is crucial to support local authorities in the prioritisation of intervention strategies. A mesoscale analysis perspective is particularly suitable for this purpose, as it focuses on urban public open spaces (e.g. streets and squares), which play a key role in everyday activities, user behaviour, and emergency conditions. Accordingly, this paper proposes a mesoscale, behavioural-based methodology for dynamic single to multi-risk assessment in HUBEs, aimed at supporting decision-makers in the identification of risk “hot-

spots” under changing hazard and use conditions. Building upon consolidated assessment frameworks, the method integrates hazard intensity, physical vulnerability, user exposure and user vulnerability, with specific reference to floods and earthquakes as critical sudden-onset hazards for HUBEs. Building-level data are aggregated into synthetic risk indices at the open-space level, accounting for alternative hazard scenarios and typical occupancy patterns. The methodology is applied to the historic city centre of Senigallia (AN). Results demonstrate the capability of the approach to identify flood- and earthquake-related “hot-spots” depending on both risk factors and user dynamics. The framework supports decision-making by enabling the prioritisation of interventions on critical open spaces and the tailoring of risk mitigation and management strategies to specific hazard and use scenarios.

KEYWORDS

RISK ASSESSMENT, FLOOD RISK, EARTHQUAKE RISK, URBAN BUILT ENVIRONMENT, URBAN OPEN SPACES, USER EXPOSURE

OFF-SITE PREFABRICATED FAÇADE SYSTEMS FOR THE ENERGY RETROFIT OF EXISTING BUILDINGS STOCK: INSIGHTS FROM A CASE STUDY

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The decarbonization of the European building stock requires a substantial acceleration of deep renovation processes, particularly for existing residential buildings, whose technological features and energy performance often no longer meet current stringent standards. Off-site prefabricated façade systems represent a strategic and industrialized solution for energy retrofit, enabling high-performance upgrades while reducing construction time, on-site impacts, and minimizing disruption to occupants' daily activities. However, existing studies often focus on single technological or performance aspects without providing an integrated design and implementation framework. This paper provides an overview of the Italian building stock and the relevant regulatory framework. It investigates the potential of prefabricated systems, particularly multilayer timber- and metal-based modules, for façade retrofit. The study aims to define a structured design and performance-oriented framework for prefabricated façade systems and to analyse their applicability through a real case

study. Key aspects include panel stratigraphy, mechanical behavior under wind loads and weather conditions, and the design of joints and connections, which are critical to ensuring overall system performance, including air permeability, water tightness, thermal and acoustic response, durability, and fire safety. The contribution lies in the integration of design criteria, performance requirements, and implementation aspects within a single analytical approach. The methodology is presented from preliminary surveys and digitalization through design, manufacturing, and on-site installation, integrating the retrofit modules with existing building components. A case study illustrates the application of externally mounted modular panels combining insulation, finishes, and building systems. Results show that off-site façade systems can achieve reliable performance, shorten construction time, and support replicable, large-scale renovation strategies, while highlighting challenges related to initial costs, regulatory alignment, and long-term performance monitoring.

KEYWORDS

PREFABRICATED, FAÇADE SYSTEMS, CLADDING, RETROFITTING, TOLERANCES, ENERGY SAVING

BEYOND THE SHADOW. NEW FRONTIERS IN PASSIVE COOLING IN ARCHITECTURE

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A landscape that has long been focused primarily on reducing winter energy consumption has recently shown growing experimental interest in passive cooling. In this context, the study analysed the potential of pilot projects based on innovative and adaptive solutions, with reference to the Mediterranean climate and summer energy renovation measures. As part of activity line 4.6 of the Electricity System Research, initial considerations were made on university residences affected by retrofitting processes also supported by PNRR

funds. The Papardo Residence in Messina was identified as a significant case study, as it is currently undergoing redevelopment. Strategies aimed at improving summer comfort and reducing the risk of overheating were therefore proposed and evaluated using specific performance indicators. The next phase of the research involves dynamic simulations and in situ monitoring activities, with the aim of providing reliable data to support effective and replicable design choices in the Mediterranean context.

KEYWORDS

PASSIVE COOLING, NATURAL VENTILATION, ADAPTIVE ENVELOPE, HYBRID COOLING SYSTEMS, BUILDING RETROFIT

INTEGRATED MULTI-METRIC OPTIMIZATION OF FIXED SOLAR SHADING SYSTEMS IN A RETROFIT UNIVERSITY LIBRARY

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Visual comfort in academic libraries plays a fundamental role in supporting users' well-being and productivity. Adequate daylighting enhances visibility and reduces eye strain; however, excessive daylight can cause glare and overheating, requiring solar shading to control gains and optimize building energy performance. Current European Standards, including EN 17037 and EN 12464-1, predominantly rely on static daylight metrics, which may not fully represent the temporal variability of indoor luminous conditions. This study propose an integrated multi-metric framework for the optimization of fixed vertical solar shading systems in the Poli-Library at the Polytechnic University of Bari (Italy). The space, originally designed as offices and later converted into a reading room, features continuous strip windows orient-ed along an East-West axis with a -20° rotation, resulting in significant exposure to direct

solar radiation during morning and afternoon hours. A comparative analysis was conducted through a multi-software simulation approach combining static metrics (Daylight Factor), climate-based daylight metrics (sDA, cDA, mDA, UDI), and glare indices (DGP, DGI). Several louver configurations were iteratively tested to balance daylight availability and glare mitigation under seasonal solar conditions. The optimized configuration reduced excessive illuminance conditions (UDI>2000 lux) from 22.65% to 6.95%, while maintaining sDA and cDA values within recommended thresholds and significantly lowering glare risk during critical hours. The results demonstrate that the evaluation of isolated daylight indicators is insufficient for retrofit educational environments and highlight the necessity of an integrated, climate-based assessment framework to define robust and balanced solar shading strategies.

KEYWORDS

VISUAL COMFORT, DAYLIGHT FACTOR (DF), DAYLIGHT AUTONOMY (DA), USEFUL DAYLIGHT ILLUMINANCE (UDI), READING ROOM, RETROFITTING

A FRAMEWORK FOR THE PRELIMINARY ASSESSMENT OF OVERHEATING RISK IN RESIDENTIAL PORTFOLIOS

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Building thermal resilience may be defined as a building's ability to maintain a comfortable and safe indoor thermal environment for its occupants throughout its lifetime; particularly during extreme heat events arising from climate change. In this context, this paper presents a semi probabilistic method for the preliminary risk assessment of indoor overheating in free running apartment buildings, in present and future climate scenarios. A comprehensive assessment is achieved by accounting for the uncertainty in climate and occupant behaviour as well as using an indoor temperature threshold supported by literature from medical research. The proposed methodology adopts a zone ID-based modular approach that analyses risk by apartment

by inputting simple information of the building's composition and its location, making this framework applicable to common building configurations without the need for detailed data or the necessity of running building simulations for each building. This means that this framework allows for a rapid preliminary risk assessment of large building portfolios, like social housing, for future-proofing strategies. To demonstrate the practicality of the developed method, a pilot application was done in the Sesto San Giovanni district in Milan where five buildings in a block were assessed in a matter of minutes using very little data and the outcomes were used to rank the priority of intervention among the buildings.

KEYWORDS

INDOOR OVERHEATING, HEALTH, CLIMATE ADAPTATION, FREE-RUNNING BUILDINGS, RESIDENTIAL BUILDINGS, LARGE-SCALE ASSESSMENT

AN ENHANCED VENTILATION THEORY FOR DISCONTINUOUS ROOFS: THEORETICAL FRAMEWORK, EXPERIMENTAL CHARACTERIZATION, AND INTEGRATION INTO BUILDING ENERGY MODELS

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Ventilated Permeable Roofs (VPRs) represent an effective passive cooling strategy for reducing summer thermal gains by exploiting wind-driven and buoyancy-driven airflow beneath roof tiles. Despite their potential, accurately modelling VPR performance remains challenging due to the complex and irregular geometry of roof tiles, which generates multiple distributed airflow paths and prevents the direct determination of key aerodynamic parameters, namely the discharge coefficient and the effective opening area. This study presents an integrated methodological framework combining a newly developed standardised permeability testing approach, machine-learning-based estimation of aerodynamic parameters, and dynamic building energy simulation to develop and validate a physically consistent airflow model for VPR systems. An experimental campaign involving 20 tile configurations was conducted under controlled laboratory conditions

to measure airflow rates across a range of imposed pressure differences. Reference openings with known geometric and aerodynamic properties were used to train a Gradient Boosting regression model, enabling the independent prediction of discharge coefficient (C_d) and area fraction of openings (A) for tile assemblies. The derived parameters were implemented within the Exterior Naturally Ventilated Cavity (ENVC) model of EnergyPlus and calibrated using monitored data from a full-scale roof demonstrator located in Reggio Emilia (Italy). The calibrated model demonstrated strong agreement with experimental observation. The proposed framework establishes a reproducible and robust approach for the characterisation, modelling, and validation of VPR, supporting more accurate energy simulations and reliable performance prediction across different climatic conditions.

KEYWORDS

PASSIVE COOLING, VENTILATION THEORY, DISCONTINUOUS ROOFS, THERMAL COMFORT, ENERGY CONSUMPTION

EVALUATING THE BENEFIT OF VENTILATED AND PERMEABLE CLAY TILE ROOFS THROUGH A USER-FRIENDLY DATA SHARING PLATFORM AND A LONG-TERM MONITORING CAMPAIGN

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Building indoor overheating is a critical challenge during summertime leading to high cooling energy demand. Ventilated and Permeable clay tile Roofs (VPR) and HEROTILE-Based Roofs (HBR) represent a durable, low-cost passive cooling solution capable of reducing roof surface temperatures and limiting indoor heat gains. This study presents a data-driven evaluation of VPR performance through a long-term monitoring campaign of real building demonstrators and a data sharing platform (HU-BES, HUman-BEhaviors monitoring data Sharing) developed within the LIFE SUPERHERO project. The platform was designed to allow both expert and non-expert users to access user-friendly key performance indicators, facilitating technical assessment, dissemination of VPR-HBR performance benefits, and stakeholder awareness. Monitoring data collected during summer periods before and after building renovation

were analyzed, through key performance indicators derived from the HU-BES platform and additional ad-hoc analyses, including roof surface temperature, heat flux entering the buildings, indoor ceiling temperature, and temperature difference between roof surface and outdoor air. Overall, this work highlights the efficacy of ventilated and permeable clay tile roofs in mitigating summer overheating and supporting climate-adaptive building strategies. Indeed, the performance of building demonstrators with the original roof and after retrofitting with HBR was compared under comparable outdoor climatic conditions, ensuring a robust benefit assessment. Results demonstrate that HBR installations substantially reduced roof surface temperatures up to 23% and ceiling surface temperature up to 8%, decreasing incoming heat flux, cooling energy demand and CO₂ emissions between 44 to 91%.

KEYWORDS

VENTILATED AND PERMEABLE ROOFS, DATA SHARING PLATFORM, BUILDING MONITORING, ROOF THERMAL PERFORMANCE

STRATEGIES FOR LIGHTWEIGHT AND SUSTAINABLE ARCHITECTURAL SYSTEMS

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In recent times, the AEC sector has shown a growing interest in natural materials and digitally informed design to develop lightweight and adaptable building solutions that meet the needs of contemporary society. This paper investigates and synthesizes current knowledge on flexible formwork systems, kerfing technique, biocomposites, and additive manufacturing, as these approaches are considered particularly promising for the development of light-weight structural systems with complex geometries. Lightweight and flexible formworks represent a promising solution to reduce material waste in the construction of complex geometries. The direct connection between form and force in these structures leads to the optimal use of material strengths and efficient material use. Within this framework, kerfing emerges as an effective technique for converting rigid wooden panels into bending-active components capable of producing continuous curved surfaces with reduced weight and high geometric accuracy. Some experimental projects show

the possibility of using biocomposites for light-weight construction. Biocomposites offer many advantages over traditional materials, including reduced CO₂ emissions and potential carbon neutrality, thermal insulation capabilities, low weight, and increased energy efficiency. Robotic spraying processes, such as bioshotcrete, allow their deployment at an architectural scale with a high geometric adaptability, enabling the formation of monolithic curved systems. Some experimental projects prove the architectural and functional potential of this technique, showing how robotic spraying can convert traditional natural materials into lightweight, durable, and sustainable building systems. This study presents preliminary outcomes of a state-of-the-art narrative review with the goal of establish a framework for the design of lightweight, durable, and sustainable pavilions and building elements. The research highlights how the integration of natural materials and computational technologies can enable new, sustainable approaches to contemporary construction.

KEYWORDS

FLEXIBLE FORMWORK, KERFING TECHNIQUE, BIOCOMPOSITES, ADDITIVE MANUFACTURING, BIOSHOTCRETE

AILANTHUS ALTISSIMA AS A SUSTAINABLE CONSTRUCTION RE-SOURCE, TURNING AN INVASIVE ALIEN SPECIES CHALLENGE INTO CIRCULAR ECONOMY OPPORTUNITIES

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Invasive alien species (IAS) pose significant ecological, economic, and in-frastructural challenges worldwide. Among these, *Ailanthus altissima* (the tree of heaven) has rapidly spread across Europe, North America, and Asia, causing biodiversity loss and structural damage to urban and rural built environments. At the same time, the substantial biomass generated by IAS removal represents an underutilized resource. This review examines the eco-logical impacts and wood properties of *A. altissima* by synthesizing data from scientific literature and global databases. In addition, it explores European and international policies governing IAS management and biomass utilisation, highlighting

both regulatory opportunities and constraints. Based on this analysis, potential applications of *Ailanthus* wood in sustainable building and rehabilitation are discussed, including solid-wood and engineered products suitable for non-structural and secondary structural interventions. By framing IAS management within circular economy and bio-based construction approaches, this work proposes a conceptual pathway to convert ecological challenges into innovative, sustainable material solutions, promoting environmentally responsible construction practices while supporting biodiversity conservation objectives.

KEYWORDS

INVASIVE ALIEN SPECIES, AILANTHUS ALTISSIMA, SUSTAINABLE CONSTRUCTION, CIRCULAR ECONOMY, BIO-BASED MATERIALS, SMART REHABILITATION

TOWARDS A HOLISTIC PARADIGM IN HOSPITAL DESIGN: A DECISION-SUPPORT FRAMEWORK FOR DESIGNING AND MANAGING HEALING ENVIRONMENTS

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The healthcare sector is a strategic cornerstone of the European economy, yet hospital design often prioritises technical efficiency over occupant wellbeing. Following the 2024 Energy Performance of Buildings Directive (EPBD), which mandates Indoor Environmental Quality (IEQ) as a core pillar of building performance, there is an urgent need for integrated assessment tools. To address this, the primary objective of this study is to develop a systematised catalogue of Key Performance Indicators (KPIs) for the multidimensional assessment of healthcare spaces, aiming to bridge the gap between technical building performance and occupant experience. To achieve this goal, a systematic literature review was conducted following PRISMA guidelines, supported by 44 selected studies. The results identify 11 thematic scopes encompassing

physical, environmental, acoustic, and psychological factors. Measurement methodologies are classified into five recurrent approaches: instrumental, subjective, observational, analytical, and biometric. The findings highlight a significant shift towards anthropocentric research, correlating building performance with clinical outcomes—such as Length of Stay (LOS)—and staff productivity. The resulting catalogue serves as an operational Decision-Support Tool (DST), enabling hospital managers to identify performance gaps and prioritise evidence-based interventions. By integrating technical metrics with human perceptions, this framework facilitates a transition towards personalised and adaptive care, ensuring that the built environment functions as an active therapeutic agent rather than a passive container for medical services.

KEYWORDS

HEALTHCARE ENVIRONMENTS, INDOOR ENVIRONMENTAL QUALITY (IEQ), KEY PERFORMANCE INDICATORS (KPIs), EVIDENCE-BASED DESIGN, HEALING ENVIRONMENTS, PATIENT-CENTRED DESIGN

HYPERSPECTRAL ASSESSMENT OF VEGETATION DEVELOPMENT ON THE INNOVATIVE CAPT-TILE MODULAR GREEN ROOF SYSTEM

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Green roofs represent an effective Nature-based Solution for mitigating urban heat island effects and improving stormwater management. However, their widespread adoption remains limited due to structural constraints, installation costs, and maintenance requirements. To address these challenges, the LIFE CAPT-TILE project has developed a modular green roofing system, based on clay tiles designed to support low-thickness soil layer for vegetation growth. In this study, a non-destructive monitoring approach based on hyperspectral imaging (HSI) is proposed to assess vegetation development on the CAPT-TILE system. Hyperspectral data were acquired under controlled lighting conditions at three development stages: hydromulch-only substrate (H01), early vegetation establishment (H02), and fully

developed vegetation (H03). Spectral signatures and the Normalized Difference Vegetation Index (NDVI) were analysed to evaluate the vegetation on hydromulch-based substrates. Results show a clear progression from H01 spectral responses to H03, with the latter featuring the typical healthy vegetation spectral signature. NDVI values increased consistently across development stages, even if, at H01 and H02 stages, NDVI appears to be influenced by the brightness and colour of the hydromulch substrate. These findings demonstrate the applicability of HSI as an innovative tool for quantitative and non-destructive monitoring of modular green roofing systems, and highlight its potential for extension to large-scale monitoring in real environments.

KEYWORDS

NATURE-BASED SOLUTIONS, GREEN ROOFS, MONITORING GREEN ROOFS, VEGETATION INDEX, HYPERSPECTRAL IMAGING

DEVELOPMENT OF INNOVATIVE BIO-BASED BUILDING MATERIALS USING BIOMASS FROM INVASIVE ALIEN SPECIES

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This study investigates the feasibility of producing bio-based building and construction materials by utilizing vegetable biomass from invasive alien species (IAS). In recent years, IAS have emerged as a primary threat to European biodiversity, destabilizing ecosystems and, in some instances, leading to the extinction of indigenous species. These species exhibit high growth and dispersal rates, further exacerbated by rising global temperatures due to climate change. The core concept of this research is defined by the necessity to up-cycle waste resulting from the management and disposal of invasive biomass in an effective way avoiding practices such as landfilling or incineration. This objective is integrated with the principles of sustainability and circular economy within the construction sector, essential factors for mitigating its significant environmental impact. Among the most widespread invasive species in the Mediterranean basin there is *Arundo donax*, commonly known as the

giant reed. Due to its rapid propagation mechanism, the mechanical performance of its culms, and its cost-effectiveness, it has been extensively employed in traditional architecture as a building material, often in combination with gypsum mortar, and for other everyday uses. With this in mind, the present study proposes the development of gypsum-based biomaterials for the construction industry. The experimental phase involves the addition of fibers obtained from processed *AD* culms, starting at a constant rate of 2 wt.% and increasing incrementally to determine the maximum viable capacity. This approach aims to reinterpret a traditional construction practice through a contemporary, technological lens. Main results showed that mixes with lower fiber contents simultaneously exhibit a more fluid and easily workable consistency, whereas those with higher fiber loadings are less workable but display superior mechanical performance, in agreement with the reinforcing contribution provided by the fibers.

KEYWORDS

BIOMATERIALS, ARUNDO DONAX, GYPSUM, CIRCULAR ECONOMY, SUSTAINABILITY

EMERGING EUROPEAN TRENDS IN SCHOOL DESIGN REGULATIONS: A COMPARATIVE READING TO UPDATE ITALIAN STANDARDS

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The role of educational spaces in learning processes has been widely studied and has recently been subject of national and international initiatives in Europe. However, architectural applications of innovative learning principles are still limited, mainly due to obsolete regulatory frameworks. This issue is even greater in Italy, where school building norms have been undergoing reform for the last fifty years. To provide useful insights for the renewal of Italian regulations, this paper examines exemplary approaches in European school building norms, with a specific focus on England, Portugal, France, and Spain. The main initiatives and regulatory instruments of the five countries are discussed and compared, investigating prescriptive and indicative norms for the sizing and characterisation of educational spaces. The result highlights several trends that should

be implemented in future Italian regulations. Traditional classrooms become flexible spaces, complemented by several informal areas supporting socialisation. Schools are conceived as civic centres that provide shared facilities to the surrounding territory. Regulations tend to loosen their prescriptive and standardising approach, limiting strict indications to ensuring safety, security and comfort, and leaving room for the requirements of teachers and local communities to be included in school projects. Thus, the design of innovative schools in Italy would be supported by a clear regulatory framework and could be further aided by additional tools focused on educational aims, organizational requirements, and the economic and environmental sustainability of renovation and new construction projects.

KEYWORDS

EDUCATIONAL SPACES, SCHOOL BUILDINGS, BUILDING REGULATIONS, INNOVATIVE LEARNING

INNOVATIVE LIGHTWEIGHT HOUSING MODULES IN CORRUGATED CARDBOARD WITH INTEGRATED GRAPHENE-BASED RADIANT HEATING SYSTEMS

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Lightweight temporary architecture requires construction systems that combine low environmental impact, rapid assembly, and energy autonomy without compromising indoor thermal comfort. Within this framework, the pre-sent study proposes the design and experimental validation of off-grid housing modules based on a prefabricated corrugated cardboard system (Ar-chicart), developed for tourist accommodation within the Gabbara Mining Park (Sicily). The research adopts a multi-scale approach, progressing from the architectural configuration of housing units to the detailed engineering of individual building components. To preserve envelope lightness while ensuring adequate thermal performance, a low-voltage electrothermal radiant heating system was integrated into the cardboard panels by applying a conductive polymer coating based on graphene and carbon black. The investigation was structured in two experimental phases. A preliminary study on reduced-

scale prototypes evaluated the interaction between the conductive coating and differently treated substrates (untreated, hydrophobic, and fire-retardant), analyzing electrical resistance evolution and heat distribution uniformity. Surface resistance reductions up to 78% were achieved after optimized coating deposition. The second phase involved full-scale panels tested under controlled electrical supply (up to 18 V), reaching surface power densities up to 199 W/m² and maximum temperatures around 39 °C without critical overheating when proper surface preparation was adopted. Results demonstrate that substrate pre-treatment is decisive in enhancing coating adhesion, electrical continuity, and thermal homogeneity. The integration of graphene-based electrothermal coatings within corrugated cardboard building systems represents a scalable, low-voltage, and sustainable solution for heating lightweight temporary architectures in environmentally sensitive contexts.

KEYWORDS

ARCHITECTURAL ENGINEERING, CARDBOARD ARCHITECTURE, GRAPHENE-BASED MATERIAL, ADVANCED MATERIALS, ELECTROTHERMAL HEATING, TEMPORARY ARCHITECTURE

SIGNIFICANT VEGETATION INDICES FOR THE EARLY DETECTION OF STRESS IN GREEN ROOFS AND GREEN WALLS

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Green Roofs (GRs) and Green Walls (GWs) are increasingly adopted as Nature-based Solutions (NbS) to mitigate the environmental challenges associated with urbanisation, while improving human well-being. However, the long-term effectiveness of these systems strongly relies on maintaining healthy vegetation. Timely detection of vegetation stress is therefore essential to optimise management strategies, reducing maintenance costs and operational effort. Traditional diagnostic methods are typically invasive, time-consuming, or limited to qualitative visual assessments. In this context, remote sensing technologies based on spectral reflectance analysis offer a non-destructive, rapid, and quantitative analysis for vegetation monitoring. Among the data processing approaches applied to these techniques,

Vegetation Indices (VIs) offer an efficient way to extract physiological and structural vegetation information from Multi- and Hyperspectral Imaging (MSI and HSI) data. This paper presents a review of six widely used VIs (i.e., NDVI, NDCI, PRI, SIPI, WI, and RGBVI) selected for their ability to capture complementary aspects of vegetation health relevant to GRs and GWs. The indices are discussed in terms of their theoretical basis, sensitivity to specific stress factors, and applicability to monitoring of building-integrated green systems. The review discusses both the potential and current limitations of VIs approach, highlighting their role in supporting early stress detection and effective management of urban green infrastructure.

KEYWORDS

GREEN INFRASTRUCTURES, HYPERSPECTRAL IMAGING, VEGETATION HEALTH, VEGETATION STRESS, VEGETATION INDICES

DESIGN FOR DISASSEMBLY: A REVIEW OF ITS STRATEGIC ROLE IN THE ECOLOGICAL TRANSITION OF THE BUILT ENVIRONMENT

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The increasing emphasis on sustainable and regenerative practices within the built environment is fostering a transition from the conventional linear construction model toward a circular framework that prioritizes resource efficiency, land-use reduction and waste minimization. Within this paradigm shift, structural disassemblability and reversibility emerge as key enabling factors. In a context where the AEC (Architecture, Engineering, Construction) sector is required to significantly mitigate its environmental footprint, the capability to develop buildings with high levels of adaptability, disassemblability, and material recoverability constitutes a fundamental prerequisite for

an effective ecological transition. This paper presents a critical review of the scientific literature on Design for Disassembly (DfD), outlining the current state of the art and consolidating existing knowledge on the topic. The review is structured into two main sections: the first examines recent research addressing DfD principles, design strategies, and assessment methodologies, while the second provides a critical synthesis of the findings emerging from the initial phase of the review process. The article aims to contribute to both academic research and professional practice by emphasizing the strategic role of DfD as a key approach for advancing a more sustainable and circular construction model.

KEYWORDS

DESIGN FOR DISASSEMBLY, CIRCULAR ECONOMY, DISASSEMBLY POTENTIAL, BUILDING DISASSEMBLY, REVERSIBLE CONNECTIONS, COMPONENT REUSE

FLOOD RISK ASSESSMENT IN HISTORIC URBAN BUILT ENVIRONMENTS: A NOVEL SCENARIO-BASED, USER-CENTRED FRAMEWORK AT THE PUBLIC OPEN SPACE SCALE

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Historic Urban Built Environments (HUBEs) located in riverine settings are particularly sensitive to flood risk due to their dense morphology, the concentration of functions in compact urban spaces, and the significant spatio-temporal variability in the number and typology of exposed users. In such contexts, understanding how hazard, exposure, and vulnerability combine during real flood events is essential to support emergency planning and in-form mitigation strategies. This study presents a flood-event-informed framework for assessing risks in HUBEs by integrating evidence from officially mapped flood conditions, cartographic data, and user-centred indicators within the scale of Public Open Spaces (POS). Official flood risk maps are exploited to delineate hazard in terms of flood footprint and street-level water conditions. These hazard layers are coupled with

time-dependent assessment of users' exposure and vulnerability, accounting for daily patterns, and with physical vulnerability aggregated from the building scale to POS. The resulting risk assessment captures how possible flood events could re-shape the usability and safety conditions of HUBEs, enabling the identification of critical hotspots and supporting the prioritization of emergency and adaptation measures. The framework is applied to Senigallia (Italy), which HUBE has experienced multiple severe floods in the past decades. Results show that highest flood risks concentrate along river-facing and intensively used POS under both still- and flowing-water scenarios, and they are primarily driven by the combined action of user vulnerability and hazard-related components, with exposure playing a secondary but spatially differentiating role.

KEYWORDS

RISK ASSESSMENT, FLOOD RISK, HISTORIC URBAN BUILT ENVIRONMENT, USER EXPOSURE AND VULNERABILITY, PHYSICAL VULNERABILITY, FLOOD HAZARD

GROUND CONNECTION IN TIMBER CONSTRUCTION ELEMENTS: TRADITION AND INNOVATION

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The ground connection is a technological and construction detail that must meet requirements of stability, durability, energy efficiency and system flexibility in a small space. The node is therefore highly complex in terms of design and execution, and its performance has an immediate impact on the entire structure. In the case of wooden structures, environmental conditions that interact with the intrinsic characteristics of high hygroscopicity and accelerated perishability of wood are particularly important. The ground connection also represents the “meeting point” between the constructed results of processes characterised by different execution tolerances, those relating to foundation and ground support structures and those relating to the assembly of prefabricated components. This often requires the provision of compensation solutions that ensure perfect contact at the interface necessary for the transfer of

stresses, while guaranteeing the required thermal and acoustic performance and the separation between hygroscopic and non-hygroscopic materials. The article initially analyses the technical and technological evolution that has characterised the main wooden construction systems, identifying the main problems affecting joints and the resulting strategies developed to overcome them. However, the goal of definitively overcoming the many problems still seems a long way off, considering the many cases of recently constructed wooden buildings that have serious durability issues. The most recent solutions for the correct resolution of the detail are therefore considered and critically analysed, proceeding from the techniques most directly related to the construction of reinforced concrete works to highly prefabricated components. In conclusion, some possible lines of development are outlined.

KEYWORDS

BUILDING TECHNOLOGY, TIMBER CONSTRUCTIONS TECHNOLOGY, TIMBER DURABILITY, TIMBER-TO-CURB CONNECTION, TECHNOLOGICAL DETAIL DESIGN

DEVELOPMENT AND APPLICATION OF A BIM-LCA PROBABILISTIC ASSESSMENT FRAMEWORK FOR HISTORIC BUILDING POST-EARTHQUAKE RENOVATION PROJECTS - CASE STUDY

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Numerous historical structures in Europe including churches, are at risk of destruction by calamities like earthquakes and seriously require security and reuse. Nevertheless, these buildings are mostly not fully documented, and it is very unclear what the material properties are and the construction methods. This complicates the ability to obtain a sound measurement of the environmental effect of possible renovation or reconstruction projects after damages.

To overcome this difficulty, the research work under this paper develops a probabilistic model of evaluation of the environmental contribution of historic buildings construction or reconstruction activities if supplementary

data are not available. This framework does not require the use of high-precision geometric models; instead, it relies on pre-existing CAD drawings, scarce archival sources, and on-site survey data to create a lightweight BIM model by means of semantic extraction and functional modelling. This is then followed by Monte Carlo simulation which probabilistically tackles the key major uncertainties, like material usage and production processes, to eventually give the probability distribution of the environmental impact indicators. This converts the existence of data gaps into measurable risks to decision-making.

KEYWORDS

BUILDING INFORMATION MODELING (BIM), LIFE CYCLE ASSESSMENT (LCA), HISTORIC BUILDING, SEMANTIC ENRICHMENT, SENSITIVITY ANALYSIS.

BIM—BLOCKCHAIN INTEGRATION FOR CONSTRUCTION SAFETY COMPLIANCE

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The construction industry is characterized by structural inefficiencies linked to fragmented processes and limited integration between digital systems and on-site operations. While Building Information Modeling (BIM) and Common Data Environments (CDE) have improved coordination and quality assurance, construction-site activities still face limitations related to data reliability and the absence of trusted verification mechanisms. This paper presents a digital operational framework

designed to connect physical construction-site components with a BIM-based database through QR-code identification, automated validation workflows, and cryptographic hash generation. The system enables secure data exchange and structured compliance documentation. The framework is demonstrated through application to a heritage refurbishment case study, supporting traceable safety monitoring and verifiable inspection records.

KEYWORDS

BLOCKCHAIN, CONSTRUCTION SITE MANAGEMENT, HEALTH AND SAFETY MANAGEMENT, FIELD BIM

RETHINKING THE DESIGN-TO-CONSTRUCTION PIPELINE: ROBOTIC EXPERIMENTS IN MASONRY CULTURE

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Robotics in construction is often narrated as a linear trajectory toward the full automation of the building site. However, the complexity of real-world construction, characterized by variability, unpredictability, and a strong artisanal component, makes this vision reductive as it fails to capture the impacts on a broader scale, which concern not only the construction phase of an architectural work but also the creative processes that underlie it. This paper presents and establishes a dialogue between two experimental research projects developed at Politecnico di Milano, aimed at introducing robotic systems for brick masonry construction. The

first, explores the operational autonomy of a mobile robotic platform capable of building walls directly on-site; the second, critically re-examines this approach by proposing a collaborative paradigm centered on ergonomics and human-machine interaction. Through a comparative analysis, the paper interprets these prototypes as milestones in a broader transition: from the robot as a substitute for human labor to the robot as the cognitive and physical infrastructure of the construction site. The outcomes offer a reflection on the future research horizons in redefining the relationships between design, construction, and innovation.

KEYWORDS

CONSTRUCTION ROBOTICS, MASONRY CONSTRUCTION, CONSTRUCTION SITE, DIGITAL TWIN, HUMAN-MACHINE INTERFACE, ALGORITHMIC DESIGN

BUILDING-SCALE OCCUPANT-BASED DIGITAL PREDICTIVE MANAGEMENT: RESULTS AND PROTOTYPE DEMONSTRATION OF THE DIGITMAN DECISION SUPPORT SYSTEM

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Public administrations, such as universities, manage complex building portfolios whose digital management is often impeded by fragmented data across maintenance, operations, and safety domains. This paper presents the out-comes of the Occupant-based DIGITal predictive MANagement to improve the built environment (DIGITMAN) project, which proposes a unified Digi-tal Decision Support System (DDSS) designed to optimize resource allocation. The research advances beyond static Building Information Modeling (BIM) by integrating dynamic occupancy data, IoT streams, Building Performance Simulation (BPS), and historical maintenance logs into a micro-services-based architecture. The developed prototype operates on two temporal logics: a "How-To" logic for daily

operational support, and a "What-If" logic for strategic scenario planning. Validated across two pilot university campuses in Italy (Università Politecnica delle Marche, and Politecnico di Milano), the system demonstrated the capability to: i) automatically classify maintenance requests with high accuracy (0.87) using Machine Learning (ML) techniques; ii) monitor real-time Indoor Environmental Quality to detect operational anomalies; and iii) perform multicriteria simulations wherein energy optimization scenarios are validated against evacuation safety constraints (e.g., escape route width and length ratios). The study confirms that integrating heterogeneous data into a unified web-based platform significantly enhances facility managers' capacity to plan interventions that ensure both energy efficiency and regulatory compliance.

KEYWORDS

DIGITAL TWIN, FACILITY MANAGEMENT, MICROSERVICES, PREDICTIVE MAINTENANCE, BUILDING PERFORMANCE SIMULATION, ENERGY MONITORING, MULTICRITERIA ANALYSIS.

SUPPORTING EARLY-STAGE DECISIONS FOR OFF-SITE CONSTRUCTION IN RENOVATION THROUGH BUILDING COMPLEXITY INDICATORS

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Off-site Construction (OSC) systems are increasingly promoted for their potential to accelerate building renovation and contribute to the decarbonisation of the built environment. However, their adoption remains uneven, particularly in countries such as Italy, where the existing building stock is morphologically and typologically heterogeneous and may limit the applicability of OSC solutions. Building on the outcomes of the OFFICIO Observatory, which provides a comprehensive overview of OSC development in Italy and Europe, this paper proposes a decision-support framework to assess the suitability of OSC across different building morphologies. The study explores the relationship between building complexity and the most appropriate renovation applications through a multi-level, case-based methodology. A high-level quantitative urban-scale analysis is conducted

using the city of Milan as a case study, leveraging publicly available datasets to evaluate large-scale OSC renovation potential. Selected buildings are then examined through qualitative building-scale analyses, informing the development of a stream-lined pre-design decision-making framework for stakeholders. A set of indicators capturing layout, volumetric, and envelope complexity is defined and applied to the case studies to synthesise key building characteristics and support applicability assessment in the early-design stage. The results indicate a high potential for OSC-based renovation in large, industrialised cities, while also highlighting varying degrees of compatibility across building types. The proposed framework supports early-stage decision-making and enables a more context-sensitive deployment of OSC within European renovation strategies.

KEYWORDS

OFF-SITE CONSTRUCTION, PREFABRICATION, BUILDING RENOVATION, DECISION SUPPORT TOOL, BUILDING COMPLEXITY, EXISTING BUILDING STOCK

RESIDENTIAL BUILDING ENERGY PERFORMANCE UNDER SSP SCENARIOS: A CASE STUDY FOR TRENTO

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Climate change is expected to significantly affect the energy performance of residential buildings, particularly in climate-sensitive European regions. However, most studies rely on Representative Concentration Pathways (RCPs) and focus on single case studies or limited archetypes, neglecting both the updated Shared Socioeconomic Pathways (SSPs) framework and the heterogeneity of local building stocks. In Italy, comprehensive analyses jointly addressing multiple construction periods, building typologies, and SSP scenarios remain limited. This study addresses these gaps by systematically assessing the evolution of heating and cooling energy needs and consumption of the residential building stock of Trento, under the four SSP scenarios. Eighteen archetypes were defined by combining two representative and morphologically opposite typologies, Single Family House (SFH) and Apartment Block (AB), characterized by markedly different surface-to-volume ratios, with nine construction periods. Dynamic simulations were performed in EnergyPlus using weather files generated in accordance with SSP scenarios. The results show a systematic decrease in heating requirements, whereas

cooling requirements increase substantially across all archetypes. By the end of the century, heating energy needs are expected to decrease by approximately 40–60%, whereas cooling energy needs may increase by 350–520% for SFH and 220–400% for AB. A key finding is that, at the 2050 horizon, differences among SSP scenarios are negligible for both energy needs and consumption, whereas substantial divergence emerges only in the second half of the century. Building compactness is a critical driver of future performance, as the higher surface-to-volume ratio of SFHs increases their sensitivity to climate change, leading to larger increases in cooling consumption than in AB, despite similar reductions in heating. These findings highlight the importance of accounting for building stock heterogeneity and morphological parameters when assessing climate resilience. By integrating SSP scenarios with a representative, temporally differentiated stock, this study provides consistent evidence on the future evolution of residential energy performance at the local scale, supporting urban energy planning and mitigation strategies that extend beyond a heating-centered perspective to address summer energy needs.

KEYWORDS

CLIMATE CHANGE IMPACTS, SHARED SOCIOECONOMIC PATHWAYS, RESIDENTIAL BUILDING STOCK, SURFACE-TO-VOLUME RATIO, BUILDING ENERGY PERFORMANCE

INTEGRATION OF GREEN FACADES IN EXISTING BUILDINGS IN THE MEDITERRANEAN AREA. INDOOR THERMAL BENEFITS EVALUATION

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The increasing levels of environmental pollution and the related climate change require concrete actions aimed at the pursuit of a truly sustainable global development, as indicated by the 17 Sustainable Development Goals (SDGs) of the UN 2030 Agenda. Among human activities, the construction sector, notoriously a consumer of energy and raw materials and a producer of waste and greenhouse gases, requires special attention. In order to increase the sustainability of buildings and cities and mitigate the effects of climate change, nature-based solutions can be adopted, including green roofs and vertical green systems. In particular, vertical greening strategies are one possible solution for increasing green spaces, especially in high-density urban areas with limited or no available land. The paper reports the results of a study conducted in the framework of a research

project that aims to assess the benefits of integrating green infrastructure into urban contexts (existing buildings and surrounding spaces) in the Mediterranean area. Using simulation software, the effectiveness of green screening systems was evaluated in terms of reduction of internal air temperatures. The study was conducted on a public housing complex built in Catania in the 1970s, considered significant for its typological, morphological, and technological characteristics. The installation of green facades was hypothesized on the southeast and southwest elevations. The results show that the application of green facades improves the indoor operating temperature for rooms facing southwest or southeast, with peak reductions ranging from -0.44 °C to -0.77 °C and average daily reductions ranging from -0.13 °C to -0.25 °C.

KEYWORDS

GREEN FACADE, THERMAL BENEFITS, ENERGY SAVING, EXISTING BUILDING STOCK, THERMAL SIMULATION

ASSESSMENT OF THE IMPACT OF DECISION-MAKERS' WEIGHTING IN FLOOD SUSCEPTIBILITY ASSESSMENT AT THE BUILDING SCALE

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Flood susceptibility in historic urban areas results from the combined effects of intrinsic building characteristics and the dynamic presence of users, which makes it necessary to develop and adopt building-scale assessment approaches capable of supporting conservation, retrofitting, and emergency planning measures. Aimed at contributing to this field, this study proposes an integrated methodology that combines static structural indicators with dynamic user-related variables within a GIS-based environment, enabling a coherent representation of both physical and functional components of susceptibility. A Monte Carlo-based sensitivity analysis is incorporated to evaluate the robustness of the resulting susceptibility classifications. The probabilistic exploration of alternative weight combinations enables the identification of stable

susceptibility patterns, highlights criteria with the greatest influence on output variability, and supports a more transparent interpretation of decision-making preferences. The methodology is applied to the historic centre of Bagnacavallo (Italy), a flood-prone heritage context, demonstrating how spatial and temporal variations in building use and user presence interact with structural fragilities. Results indicate that this probabilistic exploration strengthens the reliability of the assessment, supporting more stable and weight-independent outputs. Overall, the methodology offers a transparent and operational tool to guide targeted interventions, improve emergency preparedness and enhance user-centred resilience in flood-prone historic environments.

KEYWORDS

FLOOD RISK ASSESSMENT, USERS' EXPOSURE, USERS' VULNERABILITY, SPATIOTEMPORAL ANALYSIS, HISTORIC CITY

A PARAMETRIC TOOL FOR MULTI-STAGE, PERFORMANCE-ORIENTED DYNAMIC AND ADAPTIVE FACADE DESIGN: FROM CONCEPTUAL EXPLORATION TO DATA-DRIVEN DECISIONS

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The evolution of building envelope technology increasingly emphasizes adaptive and responsive systems, with dynamic façades emerging as a key innovation in contemporary architecture. Moving beyond purely aesthetic considerations, these systems actively modulate environmental conditions to enhance occupant comfort. This study introduces a classification framework based on five fundamental operating principles: sliding, rotating, folding, bending, and twisting, to support early-stage design evaluation

of heterogeneous dynamic façade solutions. Utilizing a parametric analysis tool, three dynamic shading strategies were assessed in a pilot parametric analysis pipeline across daylighting, view-out, and solar control performance domains. The framework demonstrates the value of structured multi-performance comparison for informed decision-making, enabling designers to relate intrinsic mechanical characteristics to environmental and occupant outcomes.

KEYWORDS

DYNAMIC FAÇADES, BUILDING ENVELOPES, PARAMETRIC DESIGN, DAYLIGHT, VIEW-OUT

THE POST-DISASTER RECONSTRUCTION PROCESS: THE CASES OF GEORGIA, MOLDOVA, AND UKRAINE IN THE REBUILD PROJECT

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Catastrophic events, whether natural or man-made, undermine the socio-economic stability of the affected areas, changing the existing balance at the cost of human lives and resources. The research illustrates the work carried out by the REBUILD project, an international capacity-building project in the field of vocational education and training (VET) and part of the ERASMUS+ program, and explores the reconstruction procedures and strategies in three target countries: Georgia, Moldova, and Ukraine. The study analyzes how the three states manage the immediate emergency phase and the long-term recovery periods, comparing common elements such as institutional governance,

intervention approaches, survey techniques, debris management, and BIM workflow. Starting from the local experiences gathered, the research aims to define a general framework, identifying the strengths that have emerged and the specific critical issues in each of the three national contexts. The results highlight how local starting conditions, the technical experience of the actors involved, institutional structures, and the nature of the event determine different outcomes even for states with a common historical background. For this reason, it is even more important to ensure high-level professional training that creates operators capable of working in contexts of great uncertainty

KEYWORDS

REBUILD, ERASMUS+, CATASTROPHIC EVENTS, RECONSTRUCTION PROCESS, BIM, SURVEYING TECHNIQUES

BENCHMARKING ENERGY MONITORED DATA IN PUBLIC HOUSING FOR THE DEVELOPMENT OF PREDICTIVE TOOLS

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The assessment of building energy performance is a critical prerequisite for the implementation of large-scale retrofit policies and demand-side management strategies. Specifically, the comprehension of multi-year consumption patterns constitutes the foundation for informed technical and economic decision-making in energy optimization. The research presented is based on three-year monitoring of five public housing buildings, operative since late 2021. The data analysis aims to quantify aggregate and unit-level electricity consumption, identify consumption peaks and load profile anomalies, highlight potential energy waste, and develop predictive models for future consumption. The availability of historical data enables meaningful temporal comparisons and the identification of recurring patterns in consumption behavior. The processed data are presented through an interactive tool designed to provide both a comprehensive overview of total building

consumption and detailed analysis at the individual dwelling unit level, thereby enabling differentiated levels of investigation based on specific requirements. Temporal analysis is conducted at monthly granularity through representations that enable visualization of consumption evolution over time and immediate identification of trends and significant variations. Consumption normalization constitutes a cornerstone of the analysis, performed through statistical analysis of historical data available for the 2022-2024 period. Automated flagging of anomalous consumption patterns is potentially indicative of equipment malfunctions or heat losses, or of conditions of social fragility or energy poverty that may require attention. The study findings enable the implementation of a continuous consumption monitoring system and the evaluation of installed equipment efficiency, facilitating the scheduling of predictive maintenance interventions.

KEYWORDS

ENERGY MONITORING, PERFORMANCE INDICATORS, BENCHMARK, PUBLIC HOUSING, PREDICTION TOOL

ENSEMBLE MACHINE LEARNING AND SHAP ANALYSIS FOR DATA-DRIVEN PREDICTION OF VENTILATED FAÇADE THERMAL PERFORMANCE

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Ventilated façades represent an effective strategy to improve building thermal performance in summer by exploiting natural ventilation within the cavity. However, predicting their thermal behaviour is challenging due to complex nonlinear interactions among envelope properties, façade configuration, and environmental conditions. This study proposes and validates a data-driven methodology to predict the temperature difference between cavity air and outdoor air ($\Delta T = T_{gap} - T_{ext}$), a direct indicator of natural ventilation intensity and thermal accumulation within the cavity. A comprehensive database of 18366 measurements was assembled from five real buildings equipped with ventilated façades, including thermophysical properties of the main wall and cladding and detailed meteorological boundary conditions. Three tree-based ensemble learning algorithms, XGBoost, Random

Forest, and LightGBM, were employed, with advanced hyperparameter optimisation and rigorous validation procedures. LightGBM provided the best performance, achieving an RMSE of 0.482, an MAE of 0.347, and an R^2 of 0.922 on an independent test set. SHAP analysis was integrated to enhance interpretability, revealing the dominant influence of wall thermal conductance and cavity geometry, as well as the indirect effects of climatic variables. The results demonstrate that the proposed framework can deliver accurate and physically interpretable predictions of ventilated façade behaviour using real monitoring data. The study also adopts a multidisciplinary approach, integrating expertise from building engineering, building physics, and computer science, and promotes synergies between theory, experimentation, and practice, thereby supporting design optimisation under summer conditions.

KEYWORDS

VENTILATED FAÇADES, MACHINE LEARNING, ENSEMBLE MODELS, SHAP INTERPRETABILITY, MULTI-SITE DATABASE, CAVITY TEMPERATURE PREDICTION

A SERVICE-LEARNING EXPERIENCE IN UGANDA: THE “VOLUNTEER’S HOUSE” PROJECT IN KUFFU

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This paper presents the design and construction of the “Volunteer’s House” in Kuffu (Nakaseke district, Uganda), developed through a partnership between the University of Catania and the Italian NGO “I Bambini di Antonio”. The project was conceived within service-learning pedagogical framework, integrating academic research, student involvement, and direct community engagement. Its primary objective was to promote sustainable construction practices in a context characterized by limited financial resources and environmentally impactful conventional building methods. In tropical Africa, the construction sector faces pressing challenges including rapid population growth, severe housing shortages, and the environmental burden associated with the widespread use of fired clay bricks, whose production significantly contributes to

deforestation and air pollution. The adopted strategies included the use of Interlocking Stabilized Soil Blocks (ISSBs), the integration of passive cooling measures, and the implementation of an alternative roofing system designed to enhance hygrothermal performance and reduce resource consumption. Dynamic thermal simulations were conducted to determine and optimize the building performance, demonstrating the effectiveness of the proposed solutions under local climatic conditions. The paper further documents the construction phase, highlighting the logistical, technical, architectural, and cultural challenges encountered during implementation. It concludes by identifying key barriers and opportunities for the broader adoption of sustainable construction practices in developing contexts.

KEYWORDS

SUSTAINABLE BUILDING CONSTRUCTION, INDOOR THERMAL COMFORT, TROPICAL CLIMATE, UGANDA, SERVICE LEARNING

DESIGN REASONING AND COMPUTATIONAL SIMPLIFICATION: A GOAL-ORIENTED FRAMEWORK FOR ENHANCED INTEROPERABILITY.

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The increasing complexity of architectural design demands computational models capable of representing not merely building components but systemic, goal-oriented relationships among spaces, technologies, and actors. Building upon earlier work as a conscious simplification strategy in design reasoning, this paper reformulates the systemic building model within a rigorous ontological and interoperability framework. By integrating systematized Knowledge Structures (KS), Relation Structures (RS), and prioritized Inference Engines (IE), the proposed model extends beyond traditional BIM/IFC object hierarchies toward a goal-driven semantic architecture. Recent advances in

ontology-IFC integration research are incorporated to strengthen semantic consistency, rule prioritization, and cross-domain interoperability. The resulting framework enables selective instantiation across heterogeneous ontological domains (Spatial and Technological Classes), mimicking expert designers' cognitive economy while ensuring logical coherence and data exchange compatibility. The paper formalizes the model, evaluates implementation strategies (Protégé/JessRules and Common LISP), and proposes an interoperability-aware inference hierarchy suitable for next-generation Computer (AI-)Aided Architectural Design systems.

KEYWORDS

ONTOLOGY-BASED DESIGN, IFC SEMANTICS, KNOWLEDGE STRUCTURES, HUMAN-MACHINE COLLABORATION

HEAT PUMP NOISE ASSESSMENT THROUGH A NOISE FOOTPRINT PERSPECTIVE

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This paper proposes a conceptual and methodological reframing of heat pump noise assessment through the lens of a “noise footprint” framework. While heat pumps are central to decarbonizing the building sector, their rapid deployment has generated growing concern over environmental noise, which remains poorly addressed. The suggested noise footprint framework adopts life cycle thinking, indicating noise as an environmental burden across the heat pump supply chain to provide a macro-level understanding of the technology’s total acoustic impact. Additionally, a micro-level strategic focus is placed on the use phase, identified as a critical stage where prolonged exposure can lead to annoyance and social conflict. Finally, responsibility allocation, conscious consuming and noise trade-offs are addressed.

It is argued that reliance on single-value sound power level indicators is insufficient, as human response to noise is strongly influenced by spectral, temporal and contextual characteristics. Drawing on Life Cycle Assessment logic, the noise footprint is positioned as a modular, life cycle-oriented midpoint measure, capable of integrating acoustic emissions with psychoacoustic and sound-scape dimensions. A noise footprint could enhance product accountability, support better governance and align climate-friendly technologies with social sustainability by embedding well-being within environmental performance assessment.

KEYWORDS

NOISE FOOTPRINT, HEAT PUMP, LIFE CYCLE ASSESSMENT, PSYCHOACOUSTICS.

EXPERIMENTAL INVESTIGATION OF AGEING EFFECTS ON SILICONE SEALANTS DURABILITY

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Silicones adopted for the construction of building envelopes are exposed to environmental and mechanical loads throughout their service life. Sealant durability is crucial, as these materials are responsible for a wide range of performances, including water and air-tightness of the façades. Silicone sealants may also fulfil structural requirements. To evaluate the effects of ageing on the properties of silicone adhesives, experimental durability testing methods were developed. The aim of this study was to assess the durability of a silicone sealant intended to be used for the refurbishment of a glazed

roof. Samples were prepared and artificially aged in a climatic chamber to simulate fifteen-twenty years of real-world exposure. The study evaluated the effects of UV radiation, dry-wet cycles, high temperature and frost on the sealing beads. After artificial ageing, both tensile-shear test and bending tests were performed on the samples. The results of the study demonstrated good durability of the material, as no defects were observed on the exposed surface. An increase of up to 100% in stiffness was recorded compared to unaged samples, without adversely affecting the expected performance.

KEYWORDS

SILICONE SEALING, DURABILITY, ACCELERATED AGEING, TESTING METHOD, FREE-FORM ENVELOPE

THE THERAPEUTIC GRADIENT OF THE BUILT ENVIRONMENT BOUNDARY: THERAPEUTIC GARDEN DESIGN FOR HEALTHCARE FACILITIES SERVING FRAGILE USERS

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In recent decades, the relationship between the built environment and health has taken a central role in the transdisciplinary debate between architecture, landscape, psychology and medicine. Within the paradigm of healing environments, therapeutic gardens represent spatial devices capable of promoting measurable psychophysical benefits, including stress reduction, mood improvement and support for cognitive processes. However, the literature has focused primarily on psychophysiological effects and vegetative aspects, paying less attention to the spatial mechanisms that mediate these benefits. The paper presents the initial results of ongoing research investigating the role of boundaries as a therapeutic device in gardens designed for vulnerable users, such as people with dementia, hospice patients and individuals undergoing rehabilitation. The paper presents the initial results of

ongoing research investigating the role of boundaries as a therapeutic device in gardens designed for vulnerable users, such as people with dementia, hospice patients, patients with rare diseases and individuals undergoing rehabilitation.

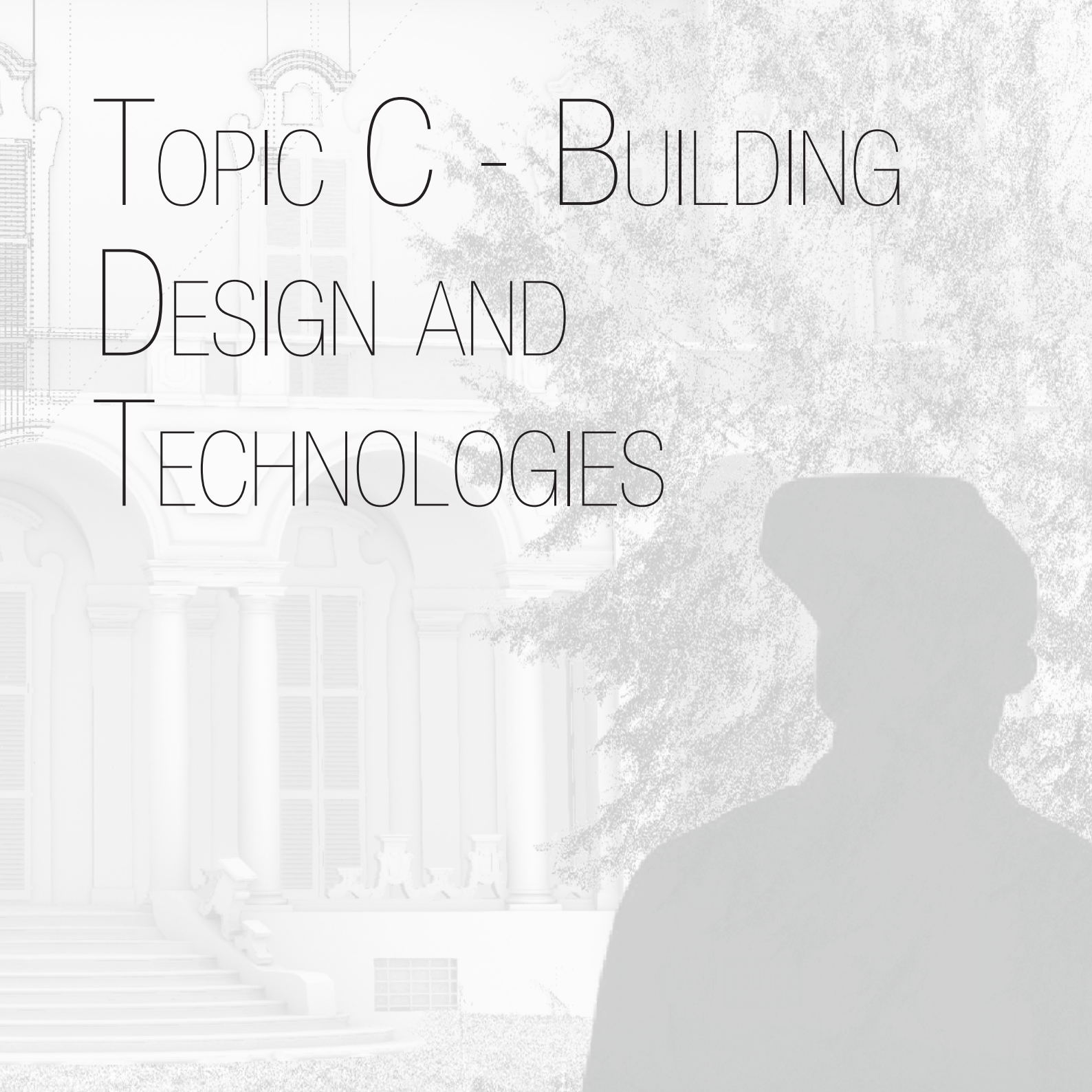
Through a comparative morphological analysis of three case studies—a therapeutic garden, a bioenergetic garden, and an Alzheimer’s garden—the research examines how different degrees of closure, permeability, and spatial articulation influence perceptions of control, orientation, and psychophysiological regulation, also in relation to the connected building structures. The results propose the concept of a “Therapeutic Boundary Gradient”, interpreting limits not as barriers but as dynamic mediators between safety, autonomy and relationships with the natural environment.

KEYWORDS

BUILT ENVIRONMENT, HEALING GARDEN, HUMAN WELL-BEING, HEALTHCARE FACILITIES, HEALTHY DESIGN.



TOPIC C - BUILDING DESIGN AND TECHNOLOGIES

The background features a faded, light-colored image of a classical building facade with columns and a large tree on the right. In the foreground, there is a dark silhouette of a person's head and shoulders, facing right.

DYNAMIC MATERIAL PASSPORTS FOR CIRCULARITY ASSESSMENTS AND LIFECYCLE INFORMATION FLOW

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With the growing need of conserving the existing resources of the world, construction industry is in the process of adopting circular economy (CE). The circularity potential of materials in a product varies with lifecycle changes, which could be tracked with innovative digital tools like Material Passports (MPs). However, recent practices highlight static behavior of information flows in MPs, and a lack of connection between MPs and circularity assessment models. These problems have hindered the transition towards digital CE for conventional practitioners. This study targets to resolve these problems using well adopted Building Information Modelling (BIM) tools and Material Circularity Indicator (MCI). The study introduces a concept of Dynamic Material Passport (DMP), defining

a technical framework for a real-time and efficient information updating model for construction materials throughout the lifecycle changes using BIM-based digital twin and MPs. A case study of a traditional window has been adopted to simulate the DMP prototype, where the replacement of different components is studied as lifecycle change. The results show an efficient system of tracking lifecycle changes in a construction product and dynamically updating relevant indicators in MPs. The study also shows a significant contribution in assessing circularity of construction materials and products using MPs and BIM.

KEYWORDS

MATERIAL PASSPORTS, DIGITAL CIRCULAR ECONOMY, MATERIAL CIRCULARITY INDICATOR (MCI), BUILDING INFORMATION MODELLING (BIM), DYNAMIC INFORMATION

ADDITIVE MANUFACTURING FOR SUSTAINABLE ARCHITECTURE: CRITICAL REVIEW

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Additive Manufacturing (AM) is one of the most relevant emerging technologies in advanced production, enabling the fabrication of complex components through highly digitalized and automated processes. In recent years, the construction sector has increasingly explored the potential of 3D printing to improve efficiency, reduce costs, and develop more sustainable solutions. This paper investigates the evolution of AM with a focus on its applications in architecture and construction. After outlining the current state of the art, it examines key technologies, materials, and development trends, highlighting growth patterns, emerging production models, and existing challenges. The study also evaluates the economic and environmental impact of

3D printing in construction, with particular attention to circular economy principles and carbon emission reduction. A comparative analysis of selected case studies is conducted to assess different implementation strategies, alongside the presentation of a research-based design case study focused on the use of AM in emergency housing contexts. The results indicate that 3D printing represents a promising approach for the construction sector, offering advantages in terms of design flexibility, waste reduction, and potential sustainability. However, its large-scale adoption is still constrained by high costs, limited regulatory standardization, and the current maturity of materials and technologies.

KEYWORDS

ADDITIVE MANUFACTURING, CONSTRUCTION SECTOR, 3D PRINTER, AFFORDABLE HOUSING, INNOVATIVE ARCHITECTURAL TECHNOLOGY

OLIVE PIT-BASED ECO-MATERIALS FOR 3D-PRINTED FAÇADE SYSTEMS: RESEARCH GAPS AND DEVELOPMENT PROSPECTS

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Climate change and ecosystem degradation represent two closely interconnected global crises that compel the scientific and technical community to rethink production models and technological solutions, steering them toward sustainable, efficient, and high-performance processes and materials. The most recent research lines explore the valorization of agro-industrial waste, of both plant and animal origin, to produce bio-based materials aimed at reducing carbon emissions and improving thermo-physical and mechanical performance. This paper presents a state-of-the-art review on the use of olive pits (olive stones) as a bio-based aggregate or filler in materials suitable for façade components. Olive pits, a by-product of the olive oil industry, represent an abundant lignocellulosic resource with promising thermal, acoustic, and lightweight properties. Existing studies have primarily investigated their incorporation in bio-composites, lightweight concretes, insulation panels, and polymer-based materials, highlighting benefits in terms of reduced density, improved

thermal performance, and enhanced sustainability. However, applications in architectural envelopes remain limited and largely unexplored. The review identifies a significant knowledge gap concerning the development of 3D printable materials incorporating olive pits for the fabrication of modular façade components. Additive manufacturing offers new possibilities for customized geometries, material optimization, and circular design strategies, yet no systematic research has addressed the rheological behavior, printability, mechanical performance, and durability of olive pit-based mixtures for large-scale façade applications. By outlining current material formulations, processing techniques, and performance data, this study establishes a research framework for future experimentation on 3D-printed façade modules containing olive pits. This research is developed within the MICS PNRR project, “Circular Design for Natural Fibers,” contributing to circular economy strategies and the valorization of agro-industrial residues in sustainable building systems.

KEYWORDS

OLIVE STONE, OLIVE PIT, FAÇADE, BUILDING ENVELOPE, CIRCULAR ECONOMY

PARAMETRIC TOWERS AND ROBOTIC CONSTRUCTION USING AN INDUSTRIAL MANIPULATOR

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The increasing demand for complex and customized architectural geometries has intensified the need for construction processes capable of translating parametric design into precise and efficient physical fabrication. This study investigates the automated construction of parametric towers using an industrial robotic manipulator, integrating parametric modeling, robotic programming, and experimental structural evaluation. Eight parametric towers composed of modular bricks were designed and assembled using an ABB IRB1200 robotic arm, with explicit definition of geometry, Cartesian pick-and-place trajectories, and workspace constraints. The research evaluates structural stability under eccentric loading, self-supporting capacity, assembly time, and the influence of brick geometry and trajectory planning on construction performance. Results demonstrate that geometric symmetry, center-

of-gravity alignment, and interlocking between elements are critical determinants of load-bearing capacity, while assembly efficiency is strongly influenced by the initial placement and orientation of bricks as well as the optimization of intermediate trajectory points. Despite limitations related to material choice and gripper performance, the findings confirm the feasibility of automated parametric construction using industrial robotic equipment, even within constrained workspaces and with relatively conventional hardware. The study contributes experimental evidence on the interdependence between parametric geometry, robotic motion planning, and structural behavior, providing a replicable framework for advancing robotic fabrication in architectural and construction contexts, particularly in developing and resource-constrained environments.

KEYWORDS

PARAMETRIC DESIGN, INDUSTRIAL ROBOT, AUTOMATED CONSTRUCTION

PARAMETRIC LIFE CYCLE ASSESSMENT OF DOUBLE-CURVED SURFACE PRODUCTION: MAPPING ENVIRONMENTAL COMPETITIVENESS DOMAINS

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This study investigates how the global warming potential (GWP) in producing double curvature architectural cladding panels (and other type of analogue objects) can vary as a function of geometric scale across different manufacturing typologies for complex double-curved surfaces. A parametric dataset of 288 validated geometries was generated by systematically varying a generative setup based upon a flexible boundary of production, defined as Bounding Box (BBOX). GWP was assessed through a cradle-to-gate Life Cycle Assessment

(LCA). The analysis compares conventional processes (CNC milling, 3D printing) with adaptive mould systems for the production of shell and surface-based products. Results reveal distinct environmental competitiveness domains, where embodied carbon depends not only on process type but also on geometric configuration. The study highlights the value of parametric LCA as a decision-support tool for early-stage design, enabling environmentally informed selection of manufacturing technologies.

KEYWORDS

LIFE CYCLE ASSESSMENT, PARAMETRIC DESIGN, DIGITAL FABRICATION, SUSTAINABLE MANUFACTURING, LCA

FROM PRE-DECONSTRUCTION AUDIT TO DIGITAL PRODUCT PASSPORT: OPERATIONAL TOOLS FOR STEEL COMPONENTS REUSE

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The construction sector is called upon to profoundly rethink its operational models in order to meet the demands of the circular economy and reduce environmental impacts. In this context, the reuse of steel building components represents a high-potential strategy, but it is still strongly limited by the loss of information throughout the building's life cycle. This paper, developed as part of the Project of Significant National Interest, funded by Next Generation EU, "ST3P+L. Buildings and Circular Economy. Steel from production to post-production. Law and responsibility issues," starting from the evolution of the pre-demolition audit towards a deconstruction and reuse oriented audit, proposes an operational procedure aimed at the identification, characterization, and preliminary assessment of steel components, supporting the selection of the most suitable post-production protocols.

The pre-deconstruction audit model constitutes the basic information asset of the Digital Product Passport (DPP), which EU Regulation 2024/3110 (CPR) also requires for used and remanufactured products, ensuring its reliability. Indeed, structuring the model as an interoperable tool allows communication with open BIM software and with the DPP, ensuring traceability, information continuity, and valorization of recoverable components. Validation of the model on a case study demonstrates how the integration between pre-deconstruction audits and DPP allows decommissioned components to be transformed from potential waste into documented resources, concretely enabling reuse and access to secondary materials markets.

KEYWORDS

REUSABILITY ASSESSMENT, OPERATIVE TOOLS, STEEL COMPONENTS, PRE-DECONSTRUCTION AUDIT, DIGITAL PRODUCT PASSPORT (DPP)

ASSESSING THE EFFECT OF DOMAIN TRAINING ON LLM RELIABILITY FOR BUILDING REGULATION INTERPRETATION

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The digital transition of the automated verification phase of a project's compliance with building regulations is a key issue for the European Union. Preliminary work to be carried out in order to move towards automation is the interpretation of building regulations written in natural language. This paper analyses the impact of sector-specific training for the construction industry on the ability of Large Language Models (LLMs) to interpret building regulations and translate them into Information Delivery Specifications (IDS) that are computer-interpretable and aligned with the Industry Foundation Classes (IFC) schema. Three LLMs (Grok, Gemini, Claude) were evaluated in configurations with and without training, using a structured workflow for extracting regulatory requirements, mapping IFC entities, and

formalizing IDS. Six normative articles related to health, hygiene, and accessibility were tested, including both articles used as training examples and unseen articles, allowing for the evaluation of learning effectiveness and generalization. Each normative article was processed five times per model, for a total of 180 runs, allowing for the evaluation of both output accuracy and stability. The results show that trained configurations significantly outperform untrained baselines and reduced variability between repeated runs. The results confirm that domain grounding through IDS examples is a critical factor in achieving reliable and reproducible regulatory formalization, supporting the scalable adoption of LLM-based compliance tools in digital workflows for building permit issuance.

KEYWORDS

DIGITAL BUILDING PERMITS, AUTOMATION OF COMPLIANCE, LARGE LANGUAGE MODELS, IFC, IDS

THE INFLUENCE OF BUILDING STOCK CHARACTERIZATION, ASSUMPTIONS, AND MODELS ON LCA RESULTS: A CRITICAL ANALYSIS

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Life Cycle Assessment (LCA) is one of the most widely accepted and applied methods for evaluating the environmental impacts of products and processes. However, the building sector exhibits substantial differences compared to other industrial sectors, primarily due to the complexity of buildings as integrated systems, along with temporal dynamics related to distinct material lifecycles and spatial contributions. First of all, the quality, accuracy, and level of detail in building characterization directly affect the reliability of the results. Furthermore, the use of incomplete, outdated, or generalized data, such as average emission factors, standardized consumption values, or simplified typological schemes, can yield approximate estimates that do not accurately reflect the existing building stock, thereby reducing the usefulness of the results for decision-making processes. This article, through a

critical review, aims to identify and evaluate the main factors influencing LCA outcomes, with the objective of mapping knowledge gaps in the field and highlighting the challenges and opportunities for developing a robust LCA model. The study specifically investigates how building stock characterization, databases, EPDs, functional units, inventory elements, system boundaries, material durability, and analysis periods affect the final results. To this end, these aspects are investigated both through a literature review and using parametric BIM models of residential buildings from previous studies conducted in Bologna. The results highlight significant sources of uncertainty, emphasizing that meaningful comparisons between distinct LCAs are challenging. Consequently, LCA can be correctly interpreted and used to compare different studies only when all such background information is communicated transparently.

KEYWORDS

LIFE CYCLE ASSESSMENT, UNCERTAINTY IN WBLCA, REVIEW, BIM, BUILDING STOCK CHARACTERIZATION, SUSTAINABILITY

THE PRINCIPLES OF UNIVERSAL DESIGN IN UNIVERSITY CAMPUSES: DESIGN STRATEGIES AND APPLICATIONS

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The inclusiveness and physical-cognitive accessibility of spaces is essential to architectural know-how. These characteristics are crucial in any context, but especially in those related to education and training, which are fundamental rights of every citizen. In this regard, recent European data show a degree of "inaccessibility" to university and school courses for students with disabilities. The reasoning behind this phenomenon is possibly due to a widespread lack of adequate support tools, as well as the presence of physical and cognitive barriers in several school and university buildings. In view of this, the paper addresses the issue of overcoming physical and cognitive barriers in university architecture,

starting from the definition of Universal Design (UD) and its guiding principles. It then presents a research methodology aimed at proposing and verifying the effectiveness of design solutions to improve and overcome architectural barriers. This methodology, which analyzes a number of best practices, is applied to a case study. The validity of this application is then verified by direct comparison with the UD's goals and the provision of an evaluation checklist. Research developments involve implementing the established methodology in other case studies in order to validate its exportability and replicability.

KEYWORDS

UNIVERSAL DESIGN, ACCESSIBILITY, UNIVERSITY CAMPUSES, INCLUSION STRATEGIES

FROM ACCESSIBILITY TO EXPERIENCE: AN EMERGING PARADIGM FOR DESIGNING INCLUSIVE MOUNTAIN ENVIRONMENTS

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Accessibility in mountainous regions is an increasingly important issue. The 2030 Agenda and the UN recommendations for sustainable mountain development provide a framework for considering accessibility and inclusion as an integral part of territorial policy quality, rather than an additional dimension. In this context, the barriers present in the mountain environment, whether natural, infrastructural, sensory, communicative, or cultural, should not be considered as isolated obstacles. Instead, they represent a multilevel, interconnected system that limits access and full participation for people with disabilities, as well as anyone else with specific needs. Given this complexity, the question

arises: what does it mean to make the mountains truly accessible to all today? By analysing projects and initiatives, this paper identifies participatory processes and interconnected design levels for inclusive natural environments that prioritise people, with the aim of transforming mountains from places to visit into places to enjoy. Trails and natural areas become meeting places where disability is no longer a barrier to participation in experiences. A paradigm shift is required that takes a holistic, integrated approach to transforming mountain locations from simple visitor infrastructure into contexts of wellbeing and social inclusion.

KEYWORDS

MOUNTAIN ENVIRONMENT, BARRIERS, ACCESSIBILITY, EXPERIENCE

FROM CONVENTIONAL TO ADAPTIVE GREEN ROOF DESIGN: A COMPARATIVE APPLICATION OF A SITE-RESPONSIVE FRAMEWORK TO AN EXISTING BUILDING

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This paper presents a site-responsive methodology for vegetation selection in green roof retrofits. The framework integrates macroclimatic, solar, structural, and wind-related constraints through parallel filtering applied to a broad Ellenberg-based dataset, followed by a final intersection that defines a coherent and feasible design space. The approach avoids hierarchical bias among constraints and provides a transparent, reproducible decision process. Its application to the SS. Annunziata historical hospital in Naples illustrates

how microclimatic variability and serviceability-driven structural limits significantly influence species admissibility, even within the same macroclimatic context. Rather than delivering a single predefined solution, the method generates a constrained yet flexible set of vegetation options that designers can refine according to biodiversity, maintenance, or landscape objectives. Overall, the framework supports adaptive, technically robust green-roof design for existing buildings.

KEYWORDS

ADAPTIVE GREEN ROOF DESIGN, VEGETATION SELECTION, SITE-RESPONSIVE FRAMEWORK, ELLENBERG INDICATOR VALUES, RETROFIT OF EXISTING BUILDINGS

DEVELOPMENT OF A RENOVATION PASSPORT FOR SCHOOL BUILDINGS: THE RERoadS PROJECT

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The Renovation Wave and the revised Energy Performance of Buildings Directive (EPBD 2024/1275) explicitly promote the development of the Building Renovation Passport (BRP) as key instrument to enable staged and data-informed renovation strategies. While the scientific literature on school building retrofit is extensive, the operational translation of the BRP concept into the school sector remains limited. This paper presents the methodological framework and first results of "RE-RoadS - Renovation and Education Roadmaps for healthy and resilient School buildings towards carbon neutrality", a research project aimed at developing and validating the first School Building Renovation Passport (SBRP) for the Italian context. The project approach integrates a modular Digital Building Logbook (DBL), the definition of reference school archetypes, and

the development of Renovation Roadmaps based on synthetic performance indices. Particular attention is devoted on the integration of indoor environmental quality (IEQ), users' behaviour, and education-oriented actions within the renovation planning process. The methodology is tested through pilot school buildings, combining desk-based analyses, monitoring campaigns, and stakeholders' engagement. Results demonstrate the potential of the SBRP to support prioritisation of interventions, guide staged renovation strategies, and enhance decision-making processes for local authorities and public bodies. Beyond energy efficiency, RERoadS contributes to advancing a holistic, user-centred vision of sustainable school renovation aligned with EU policy objectives and long-term climate neutrality goals.

KEYWORDS

BUILDING RENOVATION PASSPORT, DIGITAL BUILDING LOGBOOK, RENOVATION ROADMAP, SUSTAINABLE SCHOOL BUILDINGS, SCHOOL IEQ

AI-DRIVEN DESIGN AND CONSTRUCTION IN THE BUILDING PROCESS: AN EXPERIMENTATION WITH TEXT-TO-IMAGE MODEL AT UNISA CAMPUS

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The paper investigates the role of Artificial Intelligence (AI) in the AEC (Architecture, Engineering, Construction) supply chain, with a specific focus on the use of Text-to-Image models during the early concept-design phase. Unlike a general survey on AI applications, the contribution of the study is a structured workflow for testing whether prompt-based image generation can support the preliminary visualization of an architectural intervention within an existing university campus. The working hypothesis is that a progressive prompt-engineering protocol, moving from open-ended descriptions to contextual and performance-oriented constraints, can increase the contextual coherence and communicative effectiveness of the generated outputs, while still requiring expert validation for constructability, regulatory compliance and spatial consistency. The

protocol was tested on the concept design of a new university gym at the Fisciano Campus of the University of Salerno through Midjourney. The outputs were assessed using a multi-criteria visual audit based on prompt compliance, material and morphological coherence with the campus, functional legibility, spatial plausibility and constructability risk. The results show that contextualized prompts improved the alignment with the architectural identity of the campus, whereas performance-oriented prompts generated more innovative but less technically reliable configurations. The paper therefore clarifies the scientific contribution of Text-to-Image AI as a preliminary design and communication tool, not as a substitute for structural, regulatory or energy-performance or any other aspects concerning the feasibility of the project.

KEYWORDS

ARTIFICIAL INTELLIGENCE, GENERATIVE DESIGN, TEXT-TO-IMAGE MODEL, PROMPT ENGINEERING, UNISA CAMPUS

PROTOTYPING AN INNOVATIVE TEXTILE COMPONENT FOR SMART ENVELOPES

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This research presents the development and prototyping of an innovative textile component for smart architectural envelopes. Addressing the need to create lightweight, adaptable and easily assembled structures in fragile contexts, this studio integrates parametric design, digital fabrication and responsive architectural components. Through parametric script, the study resolves the geometric irregularities inherent in hexagonal-mesh geodesic domes, optimizing the surface to allow the use of standardized textile modules on double-curvature surfaces. The article details the methodological approach used to optimize geodesic

geometries, the design of a modular smart component for dynamic shading, and the fabrication process using 3D printing for custom nodes. The main results consist of the validation of a real scale prototype based on custom nodes, aluminium profiles and textile components. The system integrates motorized sliding curtain modules, preferred over folding mechanisms for their superior wind resistance. The resulting prototype demonstrates the feasibility of creating self-sufficient and reversible architectural systems that improve environmental comfort while minimizing the physical impact on the surrounding environment.

KEYWORDS

TEXTILE ARCHITECTURE, GEODESIC DOME, PARAMETRIC DESIGN, 3D PRINTING, LIGHTWEIGHT SMART SHADING SYSTEM

ACCESSIBILITY AND INCLUSIVE DESIGN FOR PARKS AND OUTDOOR SPACES: PRINCIPLES, ANALYSIS AND METHODOLOGICAL APPROACHES FOR SUSTAINABLE CITIES

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Urban parks play a fundamental role in improving quality of life, promoting health, social interaction, and environmental sustainability. However, their benefits can only be fully realized when these spaces are designed to be inclusive and accessible to everyone, including persons with disabilities, older adults, and people with temporary mobility limitations or families moving with strollers or tourists with luggage. In this context, inclusive design becomes essential to ensure equal opportunities for participation in public life. The importance of accessible urban parks is strongly aligned with the objectives of the United Nations 2030 Agenda for Sustainable Development, particularly Goal 11, which promotes inclusive, safe, resilient, and sustainable cities. Accessible green spaces contribute to reducing inequalities, fostering social cohesion, and enhancing well-being for all citizens. Likewise, the United Nations Convention on the Rights of Persons with Disabilities emphasizes the right to access public environments

on an equal basis with others, recognizing accessibility as a prerequisite for inclusion and autonomy. To effectively achieve these objectives, it is crucial to adopt an objective method for assessing accessibility levels before the design phase begins. A standardized and evidence-based evaluation allows planners to identify barriers, establish measurable priorities, and develop interventions that respond to real user needs. Without objective measurement, accessibility risks remaining an abstract principle rather than a practical and verifiable outcome. The paper presents a methodology for surveying and analysing parks and green spaces aimed at defining intervention priorities to improve their use by weak users. The parameters and criteria were applied to seven green areas in the city of Pavia, with the aim of providing the municipal administration with the basis for planning concrete interventions to create an inclusive environment.

KEYWORDS

ACCESSIBILITY, INCLUSIVE DESIGN, PARK, SOCIAL SUSTAINABILITY, AGENDA 2030

EXPLORATORY ANALYSIS OF INFORMATION REQUIREMENTS FOR SUSTAINABILITY ASSESSMENT IN E-PROCUREMENTS: THE CASE OF ENVIRONMENTAL RATING SYSTEMS

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The construction sector is currently undergoing a profound transition aimed at the digitalization of the building process and the improvement of the energy and environmental performance of the built environment, both existing and newly constructed. In this context, public administrations, in coordination with design and control bodies, are required to reorganize and innovate authorization procedures, achieving benefits in terms of efficiency, transparency, and quality, particularly in inspection and verification activities.

The research analyzes the integration between environmental sustainability assessment systems and

the Digital Building Permit (DBP), with the objective of defining BIM-supported workflows and structuring interoperable data throughout the entire building lifecycle, also in connection with Digital Building Logbooks. Starting from an environmental rating system information requirements, processes, and control rules are mapped, proposing semantically enriched BIM models mapped in the IFC format, suitable for supporting automated checking routines and enhancing sustainability control across the different phases of the building process.

KEYWORDS

ENVIRONMENTAL RATING SYSTEM, BUILDING INFORMATION MODELLING (BIM), IFC, DIGITAL BUILDING LOGBOOK, CODE CHECKING

BIO-BASED MATERIALS: METHODOLOGICAL FRAMEWORK FOR THE SUPPLY CHAIN ANALYSIS

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The decarbonization of the construction sector is considered crucial for achieving climate neutrality, set as a target by 2050, and requires greater control over the carbon emissions embedded in buildings. To reduce the carbon footprint of buildings, one possible strategy is the replacement of conventional materials with alternatives that have low embodied carbon. Building on this premise, the study addresses the topic of bio-based materials as innovative examples of low environmental impact solutions for construction. In particular, following a review of the state of the art - which highlighted the fragmentation and dispersion of available literature on these materials and the biological resources usable for their manufacture - the research

proposes a classification. The aim of this classification is to systematize information from highly diverse scientific fields and to reconstruct an integrated perspective linking biological resources and the supply chains from which they originate, in order to highlight aspects of circularity, opportunities, risks, and other factors guiding the selection of resources, by-products, and residues for the experimentation of new materials or to better understand their potential applications in construction. In this way, the study aims to contribute to providing methodological tools useful for promoting and supporting the use of innovative, low-environmental-impact materials in the construction industry.

KEYWORDS

BIO-BASED MATERIALS, CIRCULARITY, DECARBONIZATION, SUPPLY CHAIN, EMBODIED CARBON

DRAWING AND DESIGN. DIGITAL TECHNOLOGIES

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Since the 1990s, drawing within the field of architectural design and construction has undergone a profound transformation. The advent of digital technologies has significantly altered the methods of representation, streamlining processes, increasing accuracy, and expanding the expressive possibilities of architectural projects. However, these tools have not only impacted the way ideas are presented but have also influenced the manner in which projects are conceived and developed.

Despite the growing adoption of three-dimensional modelling, visualisation, and simulation software, analogue drawing continues to play a relevant role, particularly in the early stages of a project, where conceptual exploration and spontaneous creativity are crucial. Hand sketches allow for the experimentation

with ideas, the establishment of spatial relationships, and the immediate communication of intentions—elements that are often less fluid in digital environments. In this context, it is pertinent to examine the different types of drawing employed in architecture according to the stage of the project they represent: from conceptual sketches to construction drawings, including diagrams, perspectives, and digital models. Each type has been influenced differently by digital technologies, enhancing certain functions and transforming workflows, collaboration, and communication with clients and professionals. This analysis allows for an understanding of how digitalisation does not replace traditional drawing but complements it, creating a hybrid ecosystem in which manual creativity and technological precision converge.

KEYWORDS

DIGITAL DRAWING, CREATIVE PROCESS, DIGITAL TWIN, GRAPHIC ADVANCES, DESIGN SOFTWARE

ADDITIVE MANUFACTURING IN RESIDENTIAL CONSTRUCTION: A COMPARATIVE SURVEY 3D-PRINTED HOUSING PROJECTS IN SOUTHERN GERMANY

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This paper presents a comparative analysis of three residential buildings constructed using large-scale, on-site concrete additive manufacturing in southern Germany between 2021 and 2026. The study focuses on completed projects intended for permanent residential use, including a multi-family building in Wallenhausen, a single-family house in Witzighausen, and a subsidized multi-family housing project in Vöhringen. The selected cases employ different technological configurations, including gantry-based systems and vehicle-mounted mobile printers, enabling a comparison of current implementation approaches in residential concrete 3D printing. The analysis is structured around three main dimensions: the additive manufacturing system, the construction

process, and the resulting architectural configuration. Particular attention is given to the interaction between printed and non-printed components, the degree of hybridization with conventional construction methods, and the treatment of printed materiality within established residential typologies. The results show that, in all three cases, concrete additive manufacturing is applied in combination with traditional construction techniques, with printed elements primarily used for vertical load-bearing structures. The study contributes to the documentation of current practices in residential concrete 3D printing and provides a comparative overview of technological and architectural strategies emerging from recent built examples.

KEYWORDS

ADDITIVE MANUFACTURING, RESIDENTIAL BUILDINGS, 3D CONCRETE PRINTING, HYBRID CONSTRUCTION, BUILT CASE STUDIES, GERMANY

VALUE CHAINS: CIRCULAR ECONOMY, ENVIRONMENTAL SUSTAINABILITY AND INDUSTRIAL SYMBIOSIS

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The current European legislative framework encourages the adoption of circular and environmentally friendly production processes. One of the most widely applied strategies is the recovery of materials from supply chains other than those in which they will be reused. This action promotes the development of industrial symbiosis processes, capable of combining waste reduction and sustainable growth. Circular economy, environmental sustainability, and industrial symbiosis are the key principles that have guided the activity presented here, which reports some of the results of industrial research

developed in collaboration with Laterlite Spa (Melilli, Syracuse, Italy). The aim of the study is to investigate the possible use of by-products from the brick production and the stone supply chain in the production of premixed plasters. The development of the various mix designs tested provides a starting point for defining the procedure for incorporating by-products from other supply chains into industrial manufacturing. This would generate a value chain integrating environmental, social, and economic principles into every stage of the production process.

KEYWORDS

CIRCULAR ECONOMY, INDUSTRIAL SYMBIOSIS, INDUSTRIAL PROCESS, BY-PRODUCTS

PATCHWORK CLADDING: FAB_TIL MATERIAL EXPERIMENTS AND FULL-SCALE PROTOTYPES FROM TEXTILE WASTE

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Building on the results of the first phase of research—focused on the development of a composite reinforced with acrylic textile waste—the FAB_TIL project explores the transition from the laboratory to full scale, presenting the design, production, and validation of a regenerative architectural cladding system applied to a 1:1 experimental pavilion. The research integrates material design, experimentation, and prototyping, combining bio-based polymer matrices and textile waste reinforcements through an optimized manual lamination process. The methodology includes analysis of production cycles, mapping of pre-consumer waste streams, fabrication of test specimens using polymer matrices (epoxy, bio-based, recyclable), preliminary analyses, standardized tests (UNI/EN/ANSI), and

morpho-constructive optimization. The results highlight the technical and productive feasibility of the material, showing good mechanical and waterproof performance and effective integration between matrix and reinforcement. This article focuses on the cladding prototyping phase. Critical issues identified in durability tests (UVA exposure and freeze–thaw cycles) guide future phases toward surface treatments and process industrialization. The research demonstrates the technical and aesthetic validity of a lightweight, modular architectural skin, proposing a design model capable of extending the life of production offcuts, in which material, process, and language converge into a single narrative and constructive infrastructure

KEYWORDS

PATCHWORK, UPCYCLING, CIRCULAR DESIGN, COMPOSITE MATERIALS, TEXTILE ARCHITECTURE

REGULATORY FRAMEWORKS AND TECHNICAL PROTOCOLS FOR THE REUSE OF STRUCTURAL STEEL IN THE CIRCULAR ECONOMY: TOWARDS A CE MARKING PATHWAY

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The transition to a circular economy in the construction sector demands a comprehensive reassessment of regulatory and technical frameworks governing the reuse of building products, particularly structural steel. This paper examines the evolving European normative landscape, with specific reference to Regulation (EU) 2024/3110 on construction products and the recently published technical specification CEN/TS 1090-201:2024, which for the first time introduces harmonized provisions for the reuse of structural steel components. Building upon the four attestation protocols established by the CEN/TS and the complementary French Recommendations Professionnelles, the research proposes two additional protocols, Protocol E (reuse with downgrading) and Protocol F (refunctionalisation), designed to broaden the operational scope of steel

recovery beyond the boundaries imposed by current standards. The paper further investigates the pathways for achieving CE marking of reclaimed structural steel, identifying the European Technical Assessment (ETA) procedure, via the development of an appropriate European Assessment Document (EAD), as the most viable current route. A proposed framework for the essential characteristics, assessment methods, and Factory Production Control plan is presented, drawing on analogies with existing EADs for recycled construction products. The paper concludes by identifying critical regulatory gaps, including the absence of provisions for seismic zones and the lack of harmonized technical specifications for non-structural applications, and calls for coordinated European action to fill these lacunae.

KEYWORDS

CIRCULAR ECONOMY, STRUCTURAL STEEL REUSE, CEN/TS 1090-201, CE MARKING, EUROPEAN ASSESSMENT DOCUMENT, CONSTRUCTION PRODUCTS REGULATION

DIGITAL TECHNOLOGIES FOR THE BUILT ENVIRONMENT: A BIM-BASED DECISION SUPPORT SYSTEM FOR AUTOMATED CONSTRUCTION MATERIAL SELECTION

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In response to the growing need for building design in which digitalization processes enable the materials selection, the present study proposes a BIM-based workflow for the automated selection of construction materials. The approach integrates Autodesk Revit, Dynamo, and Microsoft Excel to automate material-related verification of regulatory requirements and parameter import into BIM. Verification of performance criteria is conducted by developing a custom Excel Calculator. This calculator is optimized using VBA macros that facilitate sheet compilation and automate the reading of compliance results. The automated creation and compilation of parameters and values derived from the Excel Calculator are imported into BIM via Dynamo parametric scripts, enabling the automatic generation of shared parameters, ensuring process interoperability. The workflow is validated through a nursery school case study, where the automated

evaluation of wood, concrete, and steel is conducted in accordance with CAM 2025 requirements. Although focused on CAM, the parametric core enables scalability to other compliance frameworks. The results show that process automation enables iterative material-based assessment, allowing exploration of alternative solutions and identification of more sustainable configurations. In addition, the structured integration of data within BIM environment enables the automatic extraction of informational outputs to support design decisions. In this context, the proposed workflow addresses companies' need for digitized tools to support material selection. Overall, the work highlights how academic research and professional practice can contribute to the development of digital tools applicable to real design processes and oriented toward improving sustainability in the construction sector.

KEYWORDS

BUILDING INFORMATION MODELING, VISUAL PROGRAMMING LANGUAGES, PARAMETRIC OPTIMISATION, ENVIRONMENTAL IMPACTS, SUSTAINABLE BUILDINGS

EVALUATING DIGITAL BUILDING PERMIT TO-BE SCENARIOS THROUGH PROCESS SIMULATION AND MINING

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Despite increasing efforts towards the digitalisation of building permit procedures, the design of Digital Building Permit processes remains strongly dependent on contextual conditions, including local organisational structures, regulatory interpretations and operational practices. Existing to-be process models are often either overly generic or closely linked to specific case studies, which limits their usefulness as instruments to support municipal in making decisions. This paper proposes a transferable framework for the evaluation and adaptation of digital building permit workflows in contexts where structured execution data are not yet available. The framework combines as-is BPMN modelling grounded in domain expertise, process simulation based on to-be business information and process mining applied to synthetic event logs generated via “what-if” to-

be scenarios. In doing so, it enables the systematic examination of process variability and organisational sensitivity across multiple scenarios. Through an illustrative application, the study demonstrates how municipalities can explore alternative digital configurations, assess their structural and temporal implications, and progressively refine process designs before implementation. In particular, the framework makes it possible to evaluate in advance the introduction of automated regulatory checking technologies and the redistribution of human workload within the process, prior to deployment in real operational contexts. By balancing contextual adaptability with methodological consistency, the proposed approach contributes to more robust and informed digital transformation strategies in heterogeneous public sector environments.

KEYWORDS

DIGITAL BUILDING PERMIT, BPMN, PROCESS SIMULATIONS, PROCESS MINING

USERS' SPACE PERCEPTION OF COMPLEX BUILDINGS: AN AI-SUPPORTED SENTIMENT ANALYSIS TO DETERMINE BEST PRACTICES IN DESIGNING SHOPPING MALL LAYOUT

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Spatial perception and wayfinding are fundamental components of users' experience in complex buildings, as they influence orientation, comfort, and the overall quality of the experience. In shopping malls, characterized by high spatial complexity and intense levels of use, wayfinding plays a particularly significant role, being closely related to cognitive mapping processes and to the configurational characteristics of the built environment. This paper investigates users' perceptions of space and wayfinding in shopping malls through an AI-supported sentiment analysis of online reviews. The study examines seven shopping malls located in the city of Rome and its metropolitan area, including both indoor and outdoor typologies, selected as case studies. For each case study, a dataset of 4000 reviews was collected from Google Maps and analyzed using automated sentiment analysis techniques to assess overall user satisfaction. The analysis was subsequently re-fined through a targeted filtering

of wayfinding-related content, based on a data-driven selection of keywords derived from users' spontaneous language. The results indicate that, in indoor shopping malls, sentiment related to wayfinding is consistently lower than overall sentiment, identifying orientation as a latent critical factor within an otherwise positive experience. By contrast, outdoor malls exhibit higher levels of positive wayfinding-related sentiment, suggesting that intuitive layouts, visual continuity, and recognizable landmarks support more effective spatial understanding. The study contributes to the growing literature backing up the potential of AI-supported sentiment analysis as a valuable tool for investigating spatial perception across large datasets and for supporting research on wayfinding in complex commercial environments. The study aims at deriving the main influencing factors affecting wayfinding and perception, as a preliminary step towards complex buildings' design throughout human-centric lenses.

KEYWORDS

SENTIMENT ANALYSIS, AI, USERS' PERCEPTION, WAYFINDING, SHOPPING MALL LAYOUT

SMALL CLT CONDOMINIUMS: ARCHITECTURE AND INDUSTRIALIZATION FOR THE DENSIFICATION OF CONSOLIDATED URBAN FABRICS THROUGH PUBLIC-INTEREST HOUSING IN LATIN AMERICA

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Latin American cities are currently shaped by the intersection of two structural crises: a persistent housing deficit and the growing impacts of climate change. In consolidated urban fabrics, these pressures are intensified by regulatory constraints, fragmented land ownership, and the high social costs associated with displacement and peripheral expansion. Conventional housing policies—largely based on large-scale developments or relocation programs—have proven insufficient to address these challenges in an integrated manner. In this context, industrialized timber architecture—particularly cross-laminated timber (CLT)—offers an architectural and technological strategy to enable controlled densification within existing neighborhoods, including areas with difficult access and limited construction logistics. Building on the Chilean case, this research examines the small

condominium typology designed for 9 × 18 m urban plots, widely distributed through mid-twentieth-century housing programs. Through architectural design, digital simulations, DFMA methodologies, and the construction of a full-scale mockup, the study explores how modular CLT systems can respond to these demands by combining adaptable design, factory-based quality control, and high productivity. Rather than proposing timber urbanism through large, district-scale developments, the research advances a bottom-up approach based on incremental interventions capable of densifying without displacement. The results suggest that small CLT condominiums can operate as replicable domestic infra-structures, integrating architectural quality, construction efficiency, and environmental performance, and contributing to more just, resilient, and sustainable cities.

KEYWORDS

TIMBER ARCHITECTURE, CLT, INDUSTRIALIZED HOUSING, MODULAR CONSTRUCTION, URBAN DENSIFICATION

SUSTAINABLE DEVELOPMENTS FOR A HUMAN SCALE ARCHITECTURE

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The contribute aims to provide an overview of current issues related to technological progress in close relation with the circularity of processes and products. Subsequently, will be considered the environmental sustainability connected to the green and digital transition in the building construction sphere. The design of inclusive, resilient, regenerative and circular living spaces appear as a tool to address the challenges of ongoing climate change, thanks to an integrated and multidisciplinary approach based on the use of digital technologies, adaptive design and circular resource management that focuses on reuse rather than landfill disposal. The paper intends to investigate issue related to urban metabolism as a model for the

analysis of the flows of matter and energy within cities, where, through the metaphor of a " living organism ", it possible to understand all the activities of a city in a single model, with the objective of improving its efficiency. In this scenario, digitalization plays a crucial role, through the adoption of artificial intelligence and technologies such as computer vision, machine learning and data analytics, it is possible to integrate and analyze in real time the data coming from BIM platforms and CDE environments. In this direction the design process goes beyond the concept of passive sustainability and includes climate assessment, computational parametric design, life cycle analysis of materials and urban mining strategies.

KEYWORDS

CIRCULAR ECONOMY, DIGITAL TRANSITION, ARTIFICIAL INTELLIGENCE

SUSTAINABLE CONSTRUCTION THROUGH 3D PRINTING WITH STABILIZED EARTH MATERIALS.

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The construction sector is a major contributor to global greenhouse gas emissions and solid waste generation, with significant impacts arising from material production as well as associated energy and water consumption. In this context, 3D printing applied to construction has emerged as an innovative technology with the potential to reduce material waste, improve construction efficiency and expand design flexibility. Nevertheless, traditional materials, often high in cement content, still pose challenges in terms of environmental sustainability. This study advances research on stabilized earth-based materials by analysing how composition and extrusion parameters influence final performance. The paper is organized into two main sections: the first provides a critical re-view of the literature, examining how composition, additives and water content significantly influence both mechanical properties and

the printability of the mixtures. Building upon this theoretical foundation, the second part introduces an experimental methodological framework designed to bridge the gap between material design and structural production. The research conducts a systematic comparison between two mixture families, one cement-free and one cement-based, each maintaining a constant 8% stabilizer content. Furthermore, the methodology evaluates the impact of two distinct extrusion methods, with and without the use of compressed air, to provide a comprehensive assessment of their influence on the material's structural behaviour. By combining a critical review with an experimental workflow, the study aims to identify and evaluate low-impact material solutions and to contribute to the advancement of sustainable, locally adaptable construction practices through 3D printing with earth-based materials.

KEYWORDS

3D PRINTING, ADDITIVE MANUFACTURING, 3D PRINTED EARTH, STABILIZED EARTH, SUSTAINABILITY

DESIGN FOR DISASSEMBLY AS A DRIVER OF CIRCULAR TRANSITION IN THE CONSTRUCTION SECTOR

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The construction sector is one of the largest consumers of natural resources and a major contributor to global waste generation and greenhouse gas emissions. In response to these challenges, the transition toward circular economy models has become a strategic priority within international and European environmental policies. In this context, Design for Disassembly (DfD) emerges as a key design approach aimed at extending the life cycle of buildings, facilitating the selective disassembly of components, and enabling the recovery and reuse of materials. This paper presents an overview of the theoretical

foundations, design principles, and operational strategies associated with DfD, highlighting its potential role as a driver of circular transition in the construction sector. After outlining the environmental impacts of construction activities and the challenges related to construction and demolition waste management, the study discusses the main design principles, life-cycle considerations, and stakeholder roles involved in DfD implementation. Finally, selected international case studies are examined to illustrate the opportunities associated with the adoption of disassembly-oriented design strategies.

KEYWORDS

DESIGN FOR DISASSEMBLY, LIFE CYCLE ASSESSMENT, CIRCULAR CONSTRUCTION, SUSTAINABLE BUILDING DESIGN, CONSTRUCTION & DEMOLITION WASTE



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