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Research Article

Material Analysis, Restoration and Protection of Modern and Contemporary Architectural Relics

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ABSTRACT

This study explores the potential of Reinforcement Sleeve Concrete Grouting Connection (RSCGC) technology as an innovative solution for restoring modern architectural relics. With the degradation of materials such as concrete, steel, and prefabricated components in contemporary buildings, the study aims to evaluate how this advanced restoration method can enhance the structural integrity and longevity of modern buildings while preserving their historical and cultural value. This research utilizes the systematic review method, examining 21 peer-reviewed journal articles, case studies, and technical reports on restoration methods and prefabricated construction technology. The research aims to analyze the potential of RSCGC in enhancing material compatibility, structural reinforcement, and authenticity preservation. The case studies comprise theoretical implementations and actual instances, providing an overall insight into the effectiveness of the technology across various settings. An analytical framework was employed to group restoration techniques by their compatibility with contemporary materials and their capacity for increasing the longevity of contemporary building structures. The findings suggest that RSCGC offers significant advantages over traditional restoration methods, including improved structural durability, faster application times, and compatibility with modern construction materials. It also offers enhanced sustainability by reducing material waste and minimizing long-term maintenance costs. However, the study also identifies the need for more diverse case studies and long-term empirical data to fully assess the technology's effectiveness in various contexts. This study contributes to the growing body of knowledge on integrating advanced construction technologies into heritage conservation practices. It highlights the importance of modernizing restoration approaches to preserve modern architectural heritage, offering a potential paradigm shift in conservation strategies.

Keywords: Modern Architectural Relics, Reinforcement Sleeve Concrete Grouting Connection (RSCGC), Restoration Techniques, Prefabricated Concrete Technology, Structural Preservation.

INTRODUCTION

Modern and contemporary architectural remnants are becoming relevant in architectural conservation. These innovative buildings embody 20th- and 21st-century culture and history. Modern architecture uses new materials and technologies including reinforced concrete, steel frames, and glass facades (Xu, Y. Zhao, & C. Wu, 2022). While groundbreaking, these materials can be difficult to conserve (Dogan, Cuomo, & Battisti, 2023). These architectural remnants represent the social, political, and cultural factors that drove their design as well as technical advances (Chang, Wen, Yu, Luo, & Gu, 2022). Thus, preserving these buildings is essential for connecting to the past, understanding architectural evolution, and ensuring that future generations can appreciate their aesthetic, technological, and historical significance (Tian, 2020). Many modern architectural structures reflect important times in national or worldwide architectural history, therefore protecting them helps preserve cultural identity. The Sydney Opera House, Guggenheim Museum, and Le Corbusier's structures are global emblems of their civilizations (Vazzana et al., 2022). Modern architecture has specific obstacles that complicate its maintenance as it ages. These structures utilize concrete, steel, and glass, which last less than stone and brick (Tian, 2020). Moisture, temperature changes, and environmental chemical reactions cause concrete cracking and corrosion (Santhanam & Ramadoss, 2022). Air and water can corrode and degrade steel reinforcing and structure (Wierzbicka & Arno, 2022). Modernist glass facades can degrade from environmental exposure, causing discoloration, thermal stress, and fracture (Serrano, Kampmann, & Ryberg, 2022). Time worsens the deterioration of certain materials, making it harder to preserve aesthetic and functional integrity (Z. Feng, X. Luo, J. Wang, & S. J. Cao, 2022). This increased degradation drives the need to restore modern architectural artifacts, but it also challenges conservationists. The preservation of historic structures must reconcile their original design and usefulness with modern safety, accessibility, and sustainability norms (Chang et al., 2022).

Concrete, steel, and glass deterioration makes modern architecture restoration difficult. These materials are highly sensitive to environmental stress (Elliotis, 2022). Mid-century concrete fractures due to shrinkage, thermal expansion, and contraction, and water, chloride salts, and air pollution worsen it (Kang, Medvegy, & Y. Zhou, 2020). Modern buildings use steel for its strength and flexibility, however moisture and oxygen can corrode it (Kadaei et al., 2023). Modern curtain walls with huge windows can break owing to UV radiation, thermal expansion, and wind pressure. Traditional restoration is harder as these materials decay and impact building construction and appearance (Hsiao & Shen, 2023). Traditional restoration methods, used for millennia to preserve stone, brick, and timber buildings, may not meet modern standards. Modern architecture's sophisticated materials may make crack filling, surface restorations, and component replacement ineffective. Since material deterioration is often underestimated, concrete crack filling may only work initially (T. Li, Z. Li, & J. Cai, 2024). Surface fixes to steel buildings may hide the problem but weaken the material, causing more corrosion (Zeng et al., 2023). Restoration of modern architecture is difficult because replacing old materials or components may alter the building's appearance or history (T. Li et al., 2024). Traditional restoration methods generally emphasize aesthetics above structural integrity, which is crucial for keeping modern structures safe and viable for future generations (Vazzana et al., 2022).

Many modern architectural relics are difficult to restore, thus there is a rising interest in creating new, more effective solutions to meet their distinct concerns. Advanced building technologies including prefabricated concrete systems have been used to increase rehabilitation durability and efficiency (Chang et al., 2022). These technologies may enable structurally sound and attractive repairs and reinforcements that match modern building materials (Wierzbicka & Arno, 2022). RSCGC strengthens concrete buildings and extends their lifespan more than standard repairs (Feng et al., 2022). Conservationists may be able to preserve modern structures' historical, cultural, and architectural significance with new technology (Serrano et al., 2022). Although promising, new restoration technologies are difficult to integrate into conservation practices. Architectural conservationists may not know advanced building methods (Chang et al., 2022). Restoration specialists must be taught to use these new technologies, and integrating them into workflows may need major technical and regulatory modifications to conservation (Clini, Mariotti, Angeloni, & Muñoz Cádiz, 2024). Stakeholders who prefer conventional conservation methods or worry about the building's authenticity may oppose advanced restoration technology (Ye & Y. Lu, 2024). Researchers, policymakers, and conservationists must collaborate to establish standards and best practises for innovative architectural heritage conservation technology (Moreno et al., 2023).

Public art and post-industrial heritage have a changing function in urban renewal by bringing back forgotten spaces, building a sense of community belonging, and saving cultural identity (Zeng et al., 2023). These aspects design inclusive public places that facilitate social interaction and collective memory, making local identity and civic pride more robust (T. Li et al., 2024). Public art is used as a form of cultural expression, expressing the past and present stories of communities and stimulating creativity and participation (Tian, 2020). In addition, the reuse of post-industrial areas triggers socio-economic growth through tourism, investment, and new economic opportunities. Through the incorporation of artistic and heritage-based projects, cities are able to develop sustainable, lively urban spaces that reconcile historic preservation with contemporary innovation (Z. Feng et al., 2022).

This study investigates creative repair methods, including prefabricated concrete building construction with reinforced sleeve concrete grouting. This new method could change architectural conservation by making building repairs and strengthening more efficient and durable. For structural stability and design preservation, RSCGC uses precast concrete components and a unique grouting procedure to strengthen joints and connections. Modern architectural relic restoration procedures and RSCGC's ability to improve them are critically examined in this study. This study examines current technology to comprehend heritage conservationists' concerns and provide a better way to preserve modern architectural history. The durability, cost-effectiveness, and sustainability of RSCGC technology in modern building restoration are also highlighted. This research analyzes literature and case studies to establish architectural conservation and restoration techniques.

METHODOLOGY

Scope and Approach of the Review

Restoration methods for modern architectural relics, namely RSCGC technology, are examined. A complete systematic evaluation of 21 peer-reviewed publications and case studies covered theoretical and practical advances (Table 1). These sources were chosen using a comprehensive search approach in Scopus, Web of Science, and Google Scholar. Search terms: "modern architecture restoration," "prefabricated construction in heritage conservation," "concrete repair techniques," "structural grouting," and "sleeve grouting for concrete restoration." To represent modern advances and methods, 2000-2023 articles were selected. Included research and case studies addressed issues in recovering modern building materials including concrete, steel, and glass. Studies on prefabricated technologies, and new structural and aesthetic repair approaches were prioritized. Only peer-reviewed journal papers, conference proceedings, and thorough case studies were used to assure quality and relevance. Exclusion criteria excluded theoretical research without actual data, non-peer-reviewed sources, and works unrelated to prefabrication or the RSCGC. The selected sources cover simple repairs, large historical preservation efforts, and material science advances. Diversity helps contextualize restoration's challenges and opportunities. The results of the study were supported by case studies on new technology installation and efficacy.

Tale 1. Selection Criteria for Reviewed Literature

Criterion	Description
Time-frame	Literature published within the last 10 years to ensure relevance to current practices and technologies.
Relevance	Focus on restoration techniques, material challenges, and prefabricated construction methods in modern and contemporary architecture.
Peer-reviewed Status	Only peer-reviewed articles and case studies were included to ensure the reliability and credibility of sources.
Geographic Scope	Included studies from various geographical locations to capture a global perspective on restoration practices.
Technological Focus	Emphasis on studies that discuss emerging technologies like RSCGC and prefabricated components in restoration.

Framework for Analysis

The research uses a systematic approach in evaluating the application of Reinforcement Sleeve Concrete Grouting Connection technology in the restoration of contemporary architectural monuments. The approach is meant to incorporate a multidisciplinary approach, recognizing the interplay of material science, architectural preservation, and cultural heritage. The research methodology is framed by an extended review of literature, case studies, and hypothetical simulations of restoration methods. The analytical framework is organized in four major steps: (i) the multidimensional role of public art, (ii) post-industrial heritage and historical narratives, (iii) the combined effect of public art and heritage, and (iv) technical assessment of restoration technologies. These steps guarantee a thorough comprehension of how restoration methods are consistent with cultural, historical, and material conservation principles.

Step 1: The Multidimensional Role of Public Art

Public art is important to the formation of architectural relics' identity, specifically in contemporary and modern buildings. The initial component of this investigation is a step-by-step process of reviewing publications that talk about the convergence between public art and architectural conservation. Peer-reviewed works, urban planning theories, and case studies in the incorporation of public art on heritage sites are reviewed to evaluate its contribution during restoration. The research examines how public art adds to the aesthetic and cultural continuity of architectural remains. This involves a consideration of mural installations, sculptural components, and interactive art integrated into restored buildings to add to their historical value and community participation. Furthermore, literature on participatory art movements and their role in urban regeneration projects is examined to determine how artistic interventions affect the conservation of modernist buildings. By situating public art as both a functional and cultural aspect of restoration, the research lays a groundwork for assessing how

Reinforcement Sleeve Concrete Grouting Connection can be adopted in a manner that upholds artistic integrity.

Step 2: Post-Industrial Heritage and Historical Narratives

Historical narratives tend to be deeply rooted in contemporary and modern architectural remains, especially in post-industrial heritage places. The second step of the methodology is examining historical records, archives, and case studies of industrial and post-industrial architectural places evolving over time. This ensures that restoration methods are consistent with maintaining historical authenticity. A comparative case study analysis is done to analyze the restoration challenges of post-industrial heritage conservation to discuss challenges unique to this group of buildings. These are material degradation, structural weaknesses, and socio-cultural value of disused industrial areas. Literature involving adaptive reuse and the conversion of industrial remnants to cultural and artistic centers is utilized to investigate the ways in which restoration methods may enable both structural integrity and the preservation of history. The research assesses the role that Reinforcement Sleeve Concrete Grouting Connection can play in restoring large concrete and steel structures in post-industrial settings in a way that makes them robust while preserving historic integrity.

Step 3: The Integrated Impact of Public Art and Heritage

The third stage of the methodology combines findings from the earlier steps to evaluate the overall effect of public art and preservation of heritage on restoration practice. This entails the analysis of case studies in which public art has been employed to improve architectural restoration and analyzing how Reinforcement Sleeve Concrete Grouting Connection can facilitate such integration. Major points to consider in this process are the function of artistic interventions in strengthening cultural memory, the impact of restored heritage sites on cityscapes, and how restoration methods can be used to open sites up to the public. The research discusses how prefabricated concrete restoration techniques such as sleeve grouting can be used without compromising the artwork and cultural character of a site. This discussion encompasses documented projects in which prefabricated technologies have been employed in restoration projects that involve public art, including memorial buildings, cultural centers, and reused industrial buildings. Secondly, the research also takes into account how restoration methods can be modified to enhance ongoing public art projects. Through discussing urban heritage projects that combine preservation with artistic output, the research seeks to identify how Reinforcement Sleeve Concrete Grouting Connection can be presented as a method that corresponds with larger cultural conservation aspirations.

Step 4: Technical Analysis of Restoration Technologies

The fourth and last step in the methodology is a technical evaluation of restoration methods based on material compatibility, structural support, and long-term sustainability. Reinforcement Sleeve Concrete Grouting Connection is considered in the context of case studies examined, evaluating its use in restoring contemporary architectural monuments. This step includes

Material Compatibility Evaluation: Checking the chemical and physical characteristics of sleeve grouting materials to ensure that they can be integrated into current structures. This includes evaluating data on bonding strength, shrinkage resistance, and thermal expansion.

Structural Performance Evaluation: Checking load-carrying tests, seismic resistance research, and durability factors to gauge the efficacy of sleeve grouting in reinforcing degraded concrete elements.

Aesthetic and Heritage Factors: Analyzing the extent to which prefabricated concrete restoration methods can match initial design aspects with a view toward maintaining historical authenticity.

Case Study Comparisons: Comparative evaluation of restoration projects using comparable prefabricated methods to establish best practice and limitations.

By incorporating cultural, historical, and technical viewpoints, this approach guarantees that the assessment of Reinforcement Sleeve Concrete Grouting Connection is balanced between engineering efficacy and preservation of heritage. The systematic approach makes it possible to carry out an extensive analysis of how contemporary restoration methods can assist in the conservation of architectural remains while enhancing their historical and artistic value.

FINDINGS

Materials and Structural Challenges in Modern and Contemporary Relics

Modern architectural remains incorporate concrete, steel, glass, and prefabricated components. Concrete is popular due to its versatility, low cost, and ability to be molded into many patterns (T. Li et al., 2024). Over time, cracking, spalling, and weathering have affected its durability. Deterioration is caused by poor mix design, insufficient reinforcing coverage, and environmental stresses (Table 2). Steel is another significant part of modern architecture due to its structural flexibility and ability to support large structures (Zeng et al., 2023). However, it is highly susceptible to corrosion, particularly in environments with high humidity, pollution, or salt exposure. Traditional methods such as sandblasting or chemical treatments can affect its integrity and surface finish. Glass is an iconic element of modernist architecture, offering both aesthetic appeal and functional benefits (Santhanam & Ramadoss, 2022). However, its fragility and susceptibility to physical and chemical degradation pose significant restoration challenges. Restoration of glass in modern relics often involves replacing damaged panes, but sourcing glass with identical optical and material properties is challenging (Prince & Walters, 2022). Prefabricated components, often made of concrete, steel, or composite materials, became a hallmark of post-World War II architecture. However, the joints and interfaces between prefabricated units have proven to be points of weakness over time (Hsiao & Shen, 2023). Restoration of prefabricated structures necessitates innovative techniques to strengthen or replace deteriorated joints while ensuring compatibility with existing components (W. Zhou, Song, K. Feng, 2022). Addressing these challenges is essential for preserving the architectural and cultural legacy of modern and contemporary relics while ensuring their structural and functional viability for future generations (Elliotis, 2022).

Table 2. Summary of Material Challenges in Modern and Contemporary Architecture

Material	**Common Issues**	**Causes (Environmental, Structural Load)**	**Restoration Challenges**
Concrete	Cracking, Surface Erosion	Environmental exposure (moisture, freeze-thaw), Structural load from heavy use	Difficulty in matching aesthetic texture, Ensuring compatibility with original material
Steel	Corrosion, Fatigue, Rust	Environmental factors (moisture, salt), Structural stress over time	Treatment for corrosion without damaging integrity, Reinforcement of rusted components
Glass	Cracking, Breakage, UV Degradation	Environmental exposure (UV light, temperature changes), Structural impact	Replacement matching original style, Potential risk of thermal breakage or fracture
Prefabricated Components	Joint separation, Material fatigue	Poor installation, Lack of proper reinforcement, Movement of building	Ensuring structural integrity in joints, Compatibility with newer materials and techniques

Traditional Restoration Techniques

Architectural remnants have been restored using traditional methods for structural and aesthetic difficulties. Conservators generally start with surface repairs, strengthening, and crack filling to address material deterioration (Prince & Walters, 2022). However, applying them to current architectural artifacts often limits longevity, compatibility, and scalability. Localized damage in concrete and masonry constructions is often repaired using crack filling and patching. Cracks are sealed and surface continuity is restored using mortar, grout, or resin-based materials (Table 3). These fixes reduce water penetration and superficial damage, but they seldom sustain long-term environmental exposure (C. Xu et al., 2022). Repairs often fracture again, especially in buildings susceptible to dynamic loads or freeze-thaw cycles. Steel bars or epoxy injections are used to strengthen structures after considerable material deterioration. Epoxy resins are injected into fractures to connect broken parts and increase tensile strength, while steel reinforcements increase load-bearing capacity (W. Zhou et al., 2022). When using current repair materials with older building methods, compatibility concerns may develop. Steel reinforcements may have different thermal expansion characteristics than original materials, causing stress concentration and damage. Epoxy injections repair fractures but degrade over time due to UV and chemical deterioration. Large-scale restorations and complicated constructions are also difficult using traditional methods. Large-scale restoration is inefficient and expensive because of personnel and resource requirements. Many conventional repairs are intrusive, which might undermine architectural relics' historical authenticity and raise conservation ethics. These constraints have spurred the development of efficient, compatible, and sustainable repair methods.

Table 3. Comparison of Traditional and Modern Restoration Techniques

Technique	**Materials Addressed**	**Advantages**	**Limitations**
Crack Filling	Concrete, Stone, Brick	Cost-effective, Quick application	May not address underlying structural issues, Aesthetic inconsistencies.
Surface Repairs	Concrete, Masonry	Restores appearance, Minimizes further	A short lifespan of repair, May not restore structural integrity.

Technique	Materials Addressed	Advantages	Limitations
		deterioration	
Reinforcement	Steel, Concrete	Increases strength and stability, Long-term solution	May require structural modifications, Expensive and labor-intensive.
Patchwork Restoration	Concrete, Stone, Metal	Repairs specific areas with minimal disruption	May compromise original design, Matching with existing materials can be challenging.

Emerging Technologies in Restoration

RSCGC technology is an advanced solution used in prefabricated concrete construction to efficiently and securely join concrete components, particularly in restoration projects (Bi et al., 2024). This technique involves using specially engineered steel or composite sleeves that house the ends of reinforcement bars from adjacent prefabricated concrete elements (Prince & Walters, 2022). These sleeves are designed to ensure precise alignment and facilitate the transfer of structural loads between connected components, mimicking the continuous reinforcement found in traditional cast-in-place concrete construction (Z. Lu, B. Wu, & Sakata, 2023). Grooves or ribs increase the mechanical bond between the sleeve, reinforcing bars, and grouting material (Ding et al., 2024). This approach involves aligning and inserting reinforcing bars from each component into the sleeve, injecting high-strength grout, and curing the grout (Xie, Q. Liu, X. Wang, & C. Yang, 2023). This makes a durable joint that can endure tensile, compressive, and shear loads. RSCGC can create strong, long-lasting connections between prefabricated components, making it useful when normal repair methods fail (T. Wang, Y. Song, L. Wang, & Q. Han, 2024). The procedure requires careful planning and specialized personnel during grouting, higher initial costs, and ensuring that the restoration does not harm the building's historical and cultural significance (W. Zhou et al., 2022). Table 4 shows the details of prefabricated concrete technologies.

Table 4. Overview of Prefabricated Concrete Technologies

Technology Type	Applications	Benefits	Challenges
Prefabricated Panels	Wall construction, Facade restoration, Floor slabs	Quick installation, Consistency in quality, Cost-effective	Matching with original structure, Complex installation in older buildings
Reinforcement Sleeve Grouting	Joint reinforcement, Structural restoration	Enhances load-bearing capacity, Durable, Reduces maintenance	Compatibility with existing materials, Potential aesthetic issues in visible areas
Precast Concrete Beams and Columns	Structural reinforcement in modern and contemporary buildings	High strength, Faster assembly on-site, Reduced labor costs	Requires precise measurement and installation, Can be expensive
Precast Slabs	Floor and ceiling restoration	Reduces downtime, Easy to transport and install	Requires adaptation to building design and structure, Potential for misalignment during installation

Current Challenges in Restoration Practices

The study illustrates the challenges of recovering modern architectural antiquity owing to material structural deterioration and traditional restoration methods. Problems arise from prefabricated elements' interface and connection structural weakness. Architectural materials like reinforced concrete, steel, and glass decay differently. Thus, repairing and strengthening these materials is tough. Prefabricated concrete joints disintegrate owing to mechanical load, weather, and component age in modern buildings (Figure 1). Surface healing and fissure filling do not restore joint integrity, causing structural instability and degeneration (W/ Zhou et al., 2022). Furthermore, ancient-modern material exchanges are hard to reconstruct. Traditional materials and prefabricated components may cause poor bonding, thermal expansion, and mechanical incompatibility. These differences worsen structural defects and reduce remedy efficacy. Epoxy or cement-based repair adhesives cannot withstand dynamic loads or environmental stresses, making them unsuitable for modern architectural relics in tough urban or industrial environments, according to studies. Case studies show that improperly repaired joints cause most structural failures in restored structures, highlighting the need for better solutions (Ding et al., 2024). Traditional repair procedures fail sophisticated or large-scale contemporary architecture. Modernist structures with cantilevers, thin-shell constructions, and lengthy spans require new structural strengthening methods. Due to their restricted flexibility and visible shift, external prestressing and steel plate bonding may not work for certain designs. Large-scale restorations require fast, efficient methods that preserve the building's history. Traditional methods often fail to strike this balance, resulting in longer project schedules and poorer results (Z. Lu et al., 2023).

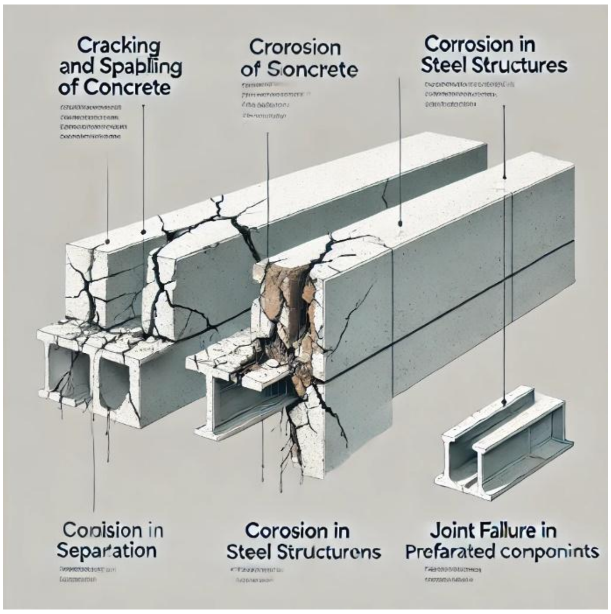

Figure 1. Structural Challenges in Modern Architectural Relics

Traditional approaches cannot control repair durability over time. Since crack filling and surface patching do not fix structural instability or material degeneration, they are often temporary fixes. Continuous pressures, embedded steel corrosion, or environmental exposure can cause reinforced concrete cracks. Recurrent damage weakens the building's structure, increasing maintenance costs and degradation. Research shows that these methods are inadequate in high-stress areas like load-bearing columns and beams, where repair failure might be disastrous (S. Wang et al., 2021). In addition to structural issues, architectural and aesthetic integrity are important. Modern architectural relics use fundamental materials and finishes like minimalist steel structures or bare concrete. Traditional repair methods, which include visible reinforcements or major material replacement, reduce a building's historical value and look. Modernist architecture's cultural importance can be greatly reduced by restoration approaches that prioritize structural performance and visual authenticity (Salameh, Touqan, Awad, & Salameh, 2022). Conventional restoration methods can have environmental concerns. These solutions need resource-intensive activities including non-recyclable adhesives and reinforcements, extensive demolition, and material replacement. These activities generate large amounts of carbon emissions and trash, which contradicts sustainable development goals. Research shows that typical restoration initiatives, especially for huge structures with a lot of resources and energy, are becoming more environmentally damaging (Della Torre, 2021).

Advantages of Prefabricated Concrete Technologies

Prefabricated concrete technologies improve application efficiency and structural durability for modern architectural artifact restoration. One of its biggest advantages is long-term structural reinforcement. Prefabricated concrete components blend into the existing structure, unlike conventional approaches that use transitory reinforcements or surface-level repairs (Figure 2). Controlled manufacturing assures the quality and endurance of these components. Research shows that prefabricated concrete parts are best for rebuilding badly degraded structures due to their load-bearing capability and environmental resilience. Prefabricated components improve structural performance and section lifespan in bridge rehabilitation case studies (Yuan et al., 2023). Traditional repairs are less lasting and harder to use than prefabricated options. Industrial components are ideal for large, time-sensitive projects since they reduce on-site labor and disruptions (T. Li, Z. Li, & Dou, 2023). Manual mending, formwork assembly, and curing can raise costs and project duration. However, the RSCGC and other novel connecting technologies allow speedy installation of prefabricated parts. This method blends new and old parts to hasten restoration and preserve structure. Prefabricated technologies save 40% more time than traditional processes, making them feasible (Bi et al., 2024). Precast concrete technologies are compatible with new and ancient building components, another benefit. High-performance concrete, composites, and lightweight aggregates are common in modern construction. Restoration techniques must match these materials' mechanical and chemical qualities for seamless integration. Prefabricated parts can be adjusted for restoration. Changing prefabricated component thermal expansion to match the original structure helps prevent stress-induced fracture or delamination.

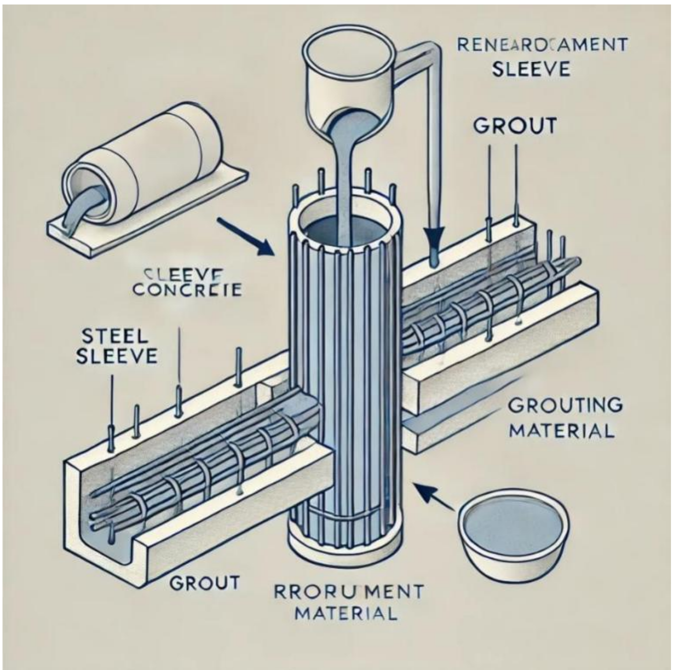

Figure 2. Schematic of Reinforcement Sleeve Concrete Grouting Connection

Research has shown that prefabricated technologies may handle compatibility difficulties in complicated projects with different material compositions (Prince & Walters, 2022). Due to their aesthetic versatility, prefabricated technologies are ideal for recovering modern architectural objects. Due to their simple forms or exposed concrete, many modern constructions are attractive, but any changes might harm their architectural integrity (Z. Lu et al., 2023). Prefabricated components can match the building's textures and colors to maintain its appearance. Case studies show that modernist heritage projects often use prefabricated materials to restore structures that look like the originals. Traditional methods can struggle to balance structural and aesthetic concerns, but prefabricated technology can (Xie et al., 2023). Prefabricated concrete technologies improve sustainable repair approaches as well as structural and cosmetic benefits. The controlled manufacture of prefabricated parts lowers material waste and energy usage, supporting sustainable growth. The extensive destruction and replacement of components during conventional restoration can generate a lot of trash (Della Torre, 2021).

Potential Applications

RSCGC can rehabilitate modern architectural artifacts with complicated structural issues, as proven by real-world and theoretical examples. This procedure may work for prefabricated concrete pieces with considerable deterioration when traditional repair methods fail. Restoring decades-old reinforced concrete bridges is one example. Reinforcement Sleeve Concrete Grouting can fix a large metropolitan bridge's joints and connections that are corroding steel reinforcements. Research reveals that firmly connecting new prefabricated pieces to older ones can restore load-bearing capability and increase building lifespan (Della Torre, 2021). It suits large residential and commercial buildings, notably modernist ones with cantilevers, spans, and thin-shell concrete constructions. Concrete prefabricated connections are frequently more vulnerable to structural stresses and environmental deterioration in these buildings. Traditional fracture repair and surface treatments don't fix structural concerns at these critical connections. Instead, the RSCGC easily integrates new components with the old structure to provide efficient reinforcement without damaging the building's architecture. A mid-20th-century office building with broken and rusty cantilevered concrete slabs may be restored. Technology may be more enduring and appealing than ancient approaches (Frangedaki et al., 2020). Protecting modern-material cultural heritage sites and monuments is another option. Time, weather, and negligence are eroding many mid-20th-century buildings created with cutting-edge materials and methods. Reinforcement Sleeve Concrete Grouting can preserve these places' beauty and heritage. A modernist art institution with massive concrete walls and beams that had rusted and fractured at vital points was repaired. Prefabricated concrete components with reinforcing sleeve grouting may protect building structure and design. Case studies show that this strategy discreetly incorporates new materials without affecting the design (Clini et al., 2024). Prefabricated concrete solutions like RSCGC help seismically damaged structures recover. Earthquakes can shift concrete structural joints, rendering standard restoration processes unusable due to the damage and complex stresses (Moreno et al., 2023). Since it strengthens and stretches critical joints, this method may be better in seismically active places (Ye & Lu, 2024). RSCGC may restore design integrity in a modern high-rise building with earthquake-induced joint displacement. Engineers can strengthen and earthquake-proof the building with prefabricated concrete components and advanced grouting. It reduces structural collapse risks by improving seismic resistance and rehabilitating earthquake-prone buildings (Frangedaki et al., 2020). Urban redevelopment, where historic structures and infrastructure must be restored, may benefit from this strategy. Urban regeneration schemes may restore neglected modernist or postmodernist buildings. Massive prefabricated concrete panels or exposed structural parts have eroded, especially at junctions. RSCGC technology can repair old structures to safety and usability standards while preserving their architecture (Moyano, Carreño, Nieto-Julián, Gil-Arizón, & Bruno, 2022).

The findings of this review demonstrate that both post-industrial heritage and public art have important but differential roles in promoting social cohesion, cultural regeneration, and identity for communities. Public art is a living site for conversation and expression, providing communities with the opportunity to discuss cultural histories, social problems, and shared memories. By incorporating art interventions into urban spaces, public art provokes conversations, promotes inclusivity, and fosters social cohesion between disparate communities. Through case studies, it is apparent that public art installations become agents of urban revitalization, converting abandoned areas into cultural spaces that draw attention and activity (T. Li et al., 2024). In addition, public art initiatives that involve the community promote civic pride and local identity, creating a sense of belonging and ownership (Tian, 2020). Conversely, post-industrial heritage has a more preservationist function, affirming historical continuity and community identity by preserving links to a common past. Industrial remnants, redeveloped as cultural or social spaces, act as a conduit for collective memory, connecting present and future with the past developments of their respective communities. It has been studied that adaptive reuse of industrial heritage, including converting abandoned factory buildings into museums, cultural institutes, or multi-use developments, maintains historical records while facilitating emerging modes of cultural and economic exchange (Z. Feng et al., 2022). This heritage conservation process promotes historical rootedness, reinforcing community identity by making the industrial past an apparent and relevant feature of the urban environment. The combination of public art and post-industrial heritage has an even deeper effect on social cohesion and cultural regeneration. Where art interventions are confronted with industrial heritage, the latter is fashioned into spaces both responsive to the past and sensitive to the current culture. As an example, huge public artworks within abandoned industrial areas tend to be connectors of the past and present, providing accessibility and reclamation to past spaces and eliciting reinterpretation and conversation (T. Li et al., 2024). This two-pronged strategy— where post-industrial heritage maintains authenticity and public art generates engagement—illuminates how both aspects, as different as they are, are important factors in cultural sustainability and community empowerment.

DISCUSSION

Modern architecture's unique materials make preservation difficult. When developed, reinforced concrete, steel, and glass were technologically advanced, yet they are now more environmentally degradable than stone, masonry, or wood. Modern buildings degrade concrete joints, steel reinforcing, and material interfaces. Complex structural and environmental links intensify these issues, requiring innovative solutions. When essential linkages and interfaces are disrupted, established restoration procedures for old structures built of traditional materials fail when applied to modern materials, the study found. Novel methods like RSCGC are needed to handle architectural leftovers. We found structural component deterioration at prefabricated element connections and interfaces in modern architecture repair. Mid-20th-century modern structures need specific connectors and sealants to link massive concrete panels, steel frames, and glass façade. Moisture, mechanical vibrations, and thermal expansion and contraction cause fractures, corrosion, and joint failure. Often undetected, degeneration at these connections can impair the structure's load-bearing capacity. Crack filling, surface treatments, and basic strengthening may not fix structural issues at these crucial intersections. Cosmetic repair may not address the core causes of degradation and may aggravate them (Frangedaki et al., 2020). The RSCGC technique can repair these structural defects. The RSCGC technique strengthens precast concrete component junctions and connections with an innovative reinforcing approach. Attaching additional reinforcement to the structure requires grouting reinforcement casings into joints using high-strength concrete. Prefabricated components and grouting solutions reinforce critical connections and strengthen buildings. This technology restores modern buildings precisely, long-lastingly, and effectively without altering their architecture. Moreno et al. (2023) indicate that this method has rebuilt large-scale reinforced concrete structures, improving load-bearing and preventing connection deterioration. One of the benefits of RSCGC is that it works with many current construction materials, as shown by this study. Modern structures use concrete, steel, glass, and synthetic materials, making structural integrity maintenance challenging. Traditional repair procedures may not work on mixed-material buildings. The RSCGC method may be adapted to the building's materials. Grouting and sleeve technologies can interact with concrete and steel while maintaining integrity in a reinforced concrete frame and steel or glass façade. RSCGC improves joint connections without harming materials (Della Torre, 2021).

Time and cost savings are further advantages of RSCGC over standard restoration procedures. Traditional restorations may be costly and time-consuming, especially for big or complicated modern structures. If the facility is still in use, the considerable on-site work needed for surface restorations, fissure fills, and strengthening may impede operations. These methods may also need non-standard materials or techniques, raising repair costs. RSCGC technique uses prefabricated units made in regulated industrial circumstances. On-site manufacturing is decreased, lowering labor costs and construction time. Prefabricated components' high quality and accuracy make fixes more durable, decreasing future maintenance demands. According to Clini et al. (2024), prefabricated components are made to precise specifications, eliminating the margin for mistake and speeding up the repair procedure. Another important consideration is restoration's environmental sustainability. Due to excessive usage of adhesives, patching materials, and structural component removal, traditional methods waste a lot of material. Even if they might be saved with technology, large parts of the original building must be rebuilt. This increases environmental impact and resource use. RSCGC and other precast concrete technologies save energy use and waste. Prefabricated components guarantee that only essential components are created, reducing waste. Because prefabricated components are made in controlled surroundings, they use fewer resources than on-site building. Ye & Lu, (2024) emphasize the importance of sustainable building in reducing the construction industry's carbon footprint. They believe broad implementation of prefabricated concrete technology might significantly reduce the environmental impact of large-scale rehabilitation projects. The restored structure's durability reduces the need for periodic material replacements and restorations, boosting its sustainability.

RSCGC's aesthetic benefits must be considered while restoring modern structures. Many contemporary structures, especially mid-20th-century ones, were minimalist due to exposed concrete, steel frames, and huge glass panels. Restoration that alters the original design may devalue these structures, which are prized for their architecture and culture. Traditional restoration may involve visible repairs or surface treatments that alter the building's appearance. Conversely, RSCGC permits structural improvements without disturbing the exterior. Studies show that prefabricated components that match the texture and finish of the original materials can support the building while keeping its appearance. Salameh et al. (2022) showed that prefabricated concrete components can blend with existing materials for repairs without affecting architectural character. Renovations of culturally significant buildings must preserve their aesthetics. In urban redevelopment and individual structures, RSCGC may retain current architecture. Some urban redevelopment sites have modernist and postmodern architecture. Preservation of these architectural elements preserves the city's history. In such cases, RSCGC may coordinate the restoration of several structures, saving money and time and maintaining the urban landscape. Studies show that urban regeneration using current restoration methods may revitalize entire regions while retaining their history and culture (Della Torre, 2021). RSCGC may be used in many district structures to reinforce essential links and interconnections without affecting architectural designs, conserving the built environment. The study indicates that RSCGC supports current architectural relic restoration which is a new approach to modern building restoration that balances aesthetics, efficiency, sustainability, material compatibility, and structural integrity. RSCGC is cheaper, longer-lasting, and more effective than traditional restoration methods, according to a study. This strategy sustains contemporary architecture from individual structures to metropolitan regeneration. The findings show that modern architectural artifacts must be restored using cutting-edge technologies to remain viable and culturally relevant.

This review provides inclusion and sustainability in public art and heritage works by promoting community-led initiatives in which local people influence artistic and preservation processes. It focuses on adaptive reuse methods that convert industrial remnants into inclusive cultural facilities, providing long-term relevance and environmental stewardship. Public art projects that facilitate social conversation are prioritized, encouraging inclusivity by reflecting multiple histories and identities. Sustainable materials and environmentally friendly restoration methods are promoted to reduce environmental footprint while maintaining historical integrity. Moreover, the review advocates policies that incorporate public art and conservation of heritage in urban planning to ensure public access and long-term cultural sustainability. The study can be applied to the rest of Europe and China by applying its principles to regional heritage architecture, urban planning policy, and cultural outreach strategy. Post-industrial European cities such as Manchester or Leipzig can use the model to adapt industrial monuments to new uses and incorporate public art to promote social integration. In China, rapidly urbanizing areas with historical industrial sites, such as Shanghai’s waterfront or Beijing’s old factory districts, could benefit from sustainable heritage conservation and community-driven artistic interventions. Cross-cultural case studies could further refine best practices for balancing modernization with historical continuity.

Policymakers and urban planners in both regions could use the research to develop inclusive and environmentally sustainable heritage restoration projects.

THEORETICAL AND PRACTICAL IMPLICATIONS

The results of this study affect the restoration business both practically and theoretically in architectural conservation. Conservation policies, practices, and outcomes are immediately affected by RSCGC technology. This study recommends integrating new technologies into conservation programs as a key practical guideline. Traditional restoration methods have centered on stone, masonry, and wood, but they cannot meet the demands of modern materials like concrete, steel, and prefabricated pieces. RSCGC technology can upgrade restoration methods to fit current building materials while keeping historical or aesthetic value. Modern urban structures, especially in mid-century architectural hotbeds, are important, therefore adding RSCGC into conservation efforts helps balance structural integrity and cultural relevance. Government agencies, historical groups, and industry stakeholders must incorporate modern technologies into preservation standards and laws. This would need architects, engineers, and repair professionals to learn how to use precast concrete components to strengthen modern building connections and interfaces, increasing their lifespan. The focus would shift from cosmetic treatments and crack filling to long-term damage prevention. Municipal and national conservation legislation may be changed to reflect the rising importance of sustainability in building restoration. RSCGC technologies, which use prefabricated components made in controlled factory settings, offer an environmentally friendly alternative to on-site construction as the building industry's environmental effect is studied. These conservation methods decrease material waste and restoration energy, speeding up the global shift toward sustainable building. RSCGC technology might significantly reduce repair time and expense. Precision engineering and prefabricated components speed application. Reduced on-site labor and materials save money with prefabricated components. Funding constraints may help public or community conservation programs. RSCGC-based medicines last longer, reducing future interventions and maintenance expenses. The prefabricated concrete technologies' long-term benefits outweigh their initial expenditures, resulting in lower lifetime maintenance costs than restorations. Another benefit of RSCGC is built environment sustainability. Modern restoration projects must be ecologically sustainable, hence RSCGC technology is used. Waste and resource use are reduced via controlled prefabricated component manufacture. Due to their high-strength concrete, modern buildings survive longer and require less maintenance. This minimizes resource use over time, helping the environment. RSCGC improves building structural integrity and addresses the rising need for green development and restoration.

This study implies that innovation and preservation may coexist with the correct technology, addressing the conservationist-modern building clash. Previous building restoration research employed traditional methods and materials to preserve aesthetics and history. This revolutionary research examines how modern architectural antiquities may be treated with newer building technology to extend their longevity and cultural and historical value. This study illustrates that advanced repair methods may coexist with modernist and postmodernist architecture, including materials and structures neglected in heritage preservation discussions. This study highlights structural engineering and material science in architectural conservation. The research recommends employing high-performance materials like precast concrete instead of original materials in restoration. In line with construction industry trends, modern materials are designed for durability, sustainability, and beauty. This new strategy follows suit. This study contributes to the theoretical question of how architectural conservation should adapt to modern society. Technology and cultural heritage are integrated into the research to better understand the preservation of modern and contemporary constructions for future generations. This study also shows how restoration approaches may be tailored to different materials, making a theoretical contribution. This research shows how multi-material contemporary structures can benefit from a more integrated and flexible restoration strategy, whereas most architectural conservation literature has focused on stone or masonry. The use of RSCGC technology, which can be adapted for glass, steel, and concrete, indicates a trend toward more thorough restoration techniques that recognize system and material interdependence. This insight is expected to affect architectural conservation and material science research, supporting creative, adaptive built environment restoration solutions. It also lays the groundwork for theoretical study on urban redevelopment and restoration integration. Urbanization and gentrification are threatening modern and contemporary buildings, especially post-industrial landscapes and mid-century modernist architecture. This study's focus on RSCGC may help preserve modernist and postmodernist areas and communities. Further studies might examine the wider effects of improved repair technologies on urban regeneration and revitalization. Given the rapid speed of urban growth, these technologies must be integrated into preservation efforts to maintain cities' historical identities and satisfy current demands.

CONCLUSION

This study reveals that RSCGC technology could manage material degradation in current architectural restoration. Traditional restoration methods might damage newer structures due to environmental factors. RSCGC may increase the resilience and lifetime of modern structures, especially prefabricated steel and concrete ones, according to the study. This strategy strengthens and protects old structures' cultural and historical significance. The article emphasizes incorporating cutting-edge building technology into conservation laws and practices. RSCGC may make restoration cheaper and more sustainable, removing the need for frequent repairs and extending the lifespan of modern architectural relics. The report recommends additional diversified case studies and long-term empirical evidence to evaluate RSCGC's efficacy. To overcome these difficulties, future research should widen case studies, undertake longitudinal evaluations, and examine this technology's economic and environmental implications. Finally, by combining conventional conservation procedures with current building processes, RSCGC might transform how we maintain modern architectural history and preserve these precious structures as examples of innovation and creativity.

Limitations and Future Directions

One weakness of the research is its limited case studies and peer-reviewed literature, which focuses on bigger commercial businesses. This study's 21 studies provide valuable insights into RSCGC applications in specific contexts, but they may not fully represent the diverse range of modern architectural relics, such as residential buildings or smaller, less conventional structures. These structures may have unique materials, historical significance, or structural attributes, making restoration difficult. Since case study results cannot be generalized to different structures, RSCGC technology may be limited. More case studies of building types, from simple residential buildings to culturally significant mid-century modern houses, may close this gap. Future research may show RSCGC's potential to preserve architectural structures in various contexts and materials. Another difficulty is the lack of empirical evidence regarding RSCGC technology's sustainability in restoration. The case studies illuminate the technology's early success but not its durability or long-term hazards. Long-term monitoring of RSCGC-restored structures would reveal the technology's efficacy amid seismic activity, humidity, and harsh weather. Traditional restoration methods and RSCGC might be compared over time to determine their cost-effectiveness, upkeep, and durability. Without long-term proof, the widespread usage of RSCGC technology has unknown effects. Future study should focus on longterm studies of RSCGC-restored structures. This will help develop best practices for using this technology in current architectural conservation and reveal material connection durability. This will prove the technology's merits conceptually and experimentally.

REFERENCE

Bi, Y., Yao, Z., Qin, Y., Kali, A., Chen, Q., & Niyazi, H. (2024). Seismic performance of precast concrete shear walls based on grouted corrugated metallic duct hybrid connection. *Construction and Building Materials*, *450*, 138576.

Chang, B., Wen, H., Yu, C. W., Luo, X., & Gu, Z. (2022). Preservation of earthen relic sites against salt damages by using a sand layer. *Indoor and Built Environment*, *31*(4), 1142-1156.

Clini, P., Mariotti, C., Angeloni, R., & Muñoz Cádiz, J. (2024). Architectural heritage digital representations for conservation strategies. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences—ISPRS Archives*, *48*(2), 111-118.

Della Torre, S. (2021). Italian perspective on the planned preventive conservation of architectural heritage. *Frontiers of Architectural Research*, *10*(1), 108-116.

Ding, M., Xu, W., Wang, J., Chen, Y., Fang, R., Zhou, D., . . . Sun, Y. (2024). Seismic performance and estimation of flexural bearing capacity of prefabricated engineered cementitious composite shell-reinforced concrete composite column with grouted sleeve connection. *Soil Dynamics and Earthquake Engineering*, *178*, 108430.

Dogan, E., Cuomo, F., & Battisti, L. (2023). Reviving urban greening in post-industrial landscapes: The case of Turin. *Sustainability*, *15*(17), 12760.

Elliotis, M. (2022). Retrofit, restoration and preservation of byzantine monuments: Assessment of natural degradation and evaluation of intervention options. *The Open Construction & Building Technology Journal*, *16*(1), doi:10.2174/18748368-v16-e2206271.

Feng, Z., Luo, X., Wang, J., & Cao, S. J. (2022). Energy-efficient preservation environment control for enclosed exhibition hall of earthen relics. *Energy and Buildings*, *256*, 111713.

Frangedaki, E., Gao, X., Lagaros, N. D., Briseghella, B., Marano, G. C., Sargentis, G. F., & Meimaroglou, N. (2020). Fujian Tulou rammed earth structures: Optimizing restoration techniques through participatory design and collective practices. *Procedia Manufacturing*, *44*(2019), 92-99.

Hsiao, T., & Shen, S. (2023). A study of digital architectural heritage preservation based on blockchain technology. *The Journal of Engineering*, *2023*(1), 1-17.

Kadaei, S., Nezam, Z., González-Lezcano, R. A., Shokrpour, S., Mohammadtaheri, A., Doraj, P., & Akar, U. (2023). A new approach to determine the reverse logistics-related issues of smart buildings focusing on sustainable architecture. *Frontiers in Environmental Science*, *10*, 1079522.

Kang, X., Medvegy, G., & Zhou, Y. (2020). Renaissance of the ruins — give modern functionality to rural architectural relics. *Pollack Periodica*, *15*(3), 220-231.

Li, T., Li, Z., & Cai, J. (2024). Antecedents and consequence of intra-organizational diffusion of prefabricated construction technology: A contingency theory perspective. *Engineering, Construction and Architectural Management*, *31*(7), 2932-2951.

Li, T., Li, Z., & Dou, Y. (2023). Diffusion prediction of prefabricated construction technology under multi-factor coupling. *Building Research & Information*, *51*(3), 333-353.

Lu, Z., Wu, B., & Sakata, H. (2023). Flexural performance of a fully-prefabricated concrete slab with double-grouted sleeve connectors: An experimental and theoretical study. *Engineering Structures*, *289*, 116266.

Moreno, M., Prieto, A. J., Ortiz, R., Cagigas-Muñiz, D., Becerra, J., Garrido-Vizuete, M. A., . . . Ortiz, P. (2023). Preventive conservation and restoration monitoring of heritage buildings based on fuzzy logic. *International Journal of Architectural Heritage*, *17*(7), 1153-1170.

Moyano, J., Carreño, E., Nieto-Julián, J. E., Gil-Arizón, I., & Bruno, S. (2022). Systematic approach to generate Historical Building Information Modelling (HBIM) in architectural restoration project. *Automation in Construction*, *143*, 104551.

Prince, R. C., & Walters, C. C. (2022). Modern analytical techniques are improving our ability to follow the fate of spilled oil in the environment. *Current Opinion in Chemical Engineering*, *36*, 100787.

Salameh, M. M., Touqan, B. A., Awad, J., & Salameh, M. M. (2022). Heritage conservation as a bridge to sustainability assessing thermal performance and the preservation of identity through heritage conservation in the Mediterranean city of Nablus: Heritage conservation as a bridge to sustainability. *Ain Shams Engineering Journal*, *13*(2), 101553.

Santhanam, K., & Ramadoss, R. (2022). Conservation & restoration of historic mortars at Alamparai fort with valley conical arch, Tamilnadu, India. *Construction and Building Materials*, *339*, 127619.

Serrano, T., Kampmann, T., & Ryberg, M. W. (2022). Comparative Life-cycle Assessment of restoration and renovation of a traditional Danish farmer house. *Building and Environment*, *219*, 109174.

Tian, C. (2020). 3D modeling and digital preservation of ancient architectures based on autoCAD and 3Dmax. *Computer-Aided Design and Applications*, *17*(S2), 100-110.

Vazzana, A., Higgins, O. A., Oxilia, G., Lugli, F., Silvestrini, S., Nava, A., . . . Benazzi, S. (2022). High-accuracy methodology for the integrative restoration of archaeological teeth by using reverse engineering techniques and rapid prototyping. *Journal of Archaeological Science: Reports*, *44*, 103511.

Wang, S., Xu, W., Wang, J., Xin, G., Chen, Y., Zhao, Z., & Bai, Y. (2021). Experimental research on anti-seismic reinforcement of fabricated concrete pier connected by grouting sleeve based on CFRP and PET materials. *Engineering Structures*, *245*, 112838.

Wang, T., Song, Y., Wang, L., & Han, Q. (2024). Experimental investigation of uncertain factors on the mechanical properties of half-grouted sleeve connected with large-diameter high-strength reinforcement. *Journal of Building Engineering*, *88*, 109087.

Wierzbicka, A. M., & Arno, M. (2022). Adaptation of places of worship to secular functions with the use of narrative method as a tool to preserve religious heritage. *Muzeológia a Kultúrne Dedičstvo*, *10*(4), 63-77.

Xie, L., Liu, Q., Wang, X., & Yang, C. (2023). Experimental study on seismic performance of precast concrete shear walls with defective and repaired grouted sleeve. *Structures*, *57*, 105071.

Xu, C., Zhao, Y., & Wu, C. (2022). 'Sustainable' recording and preservation of Zangniang stupa and Sangzhou Lamasery in Qinghai, China with heritage building information model. *Sustainability*, *14*(8), 4549.

Ye, H., & Lu, Y. (2024). Rebar-concrete bond behaviour in grouted sleeve connectors. *Construction and Building Materials*, *431*, 136487.

Yuan, M., Li, Z., Li, X., Luo, X., Yin, X., & Cai, J. (2023). Proposing a multifaceted model for adopting prefabricated construction technology in the construction industry. *Engineering, Construction and Architectural Management*, *30*(2), 755-786.

Zeng, J. J., Chen, S. P., Feng, P., Zhuge, Y., Peng, K. D., Dai, J. G., & Fan, T. H. (2023). FRP bar-reinforced ultra-high-performance concrete plates with a grouting sleeve connection: Development and flexural behavior. *Engineering Structures*, *287*, 116164.

Zhou, W., Song, S., & Feng, K. (2022). The sustainability cycle of historic houses and cultural memory: Controversy between historic preservation and heritage conservation. *Frontiers of Architectural Research*, *11*(6), 1030-1046.

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