
Key Challenges and Mitigation Techniques in the Management of Heritage Building Conservation Projects: A Systematic Review

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Abstract

Managing heritage building conservation projects is one of the complex challenges in the engineering field, due to the high historical and architectural value of these buildings. This study aims to identify the most prominent challenges affecting the management of heritage building conservation projects, with a particular focus on analysing the techniques and practices used to overcome these problems. A comprehensive systematic review was conducted to achieve these goals by studying the relevant published research. The methodology is based on using the PRISMA scheme to review these papers, where they are evaluated in each step of the scheme: identification, screening, eligibility, and inclusion. The selected keywords for this systematic review, such as conservation, restoration, rehabilitation, and management, reflect the intersection between project management and heritage building conservation, highlighting the current research trend in this field. The review process began by identifying 570 research papers in the last 5 years, which took into account the rapid development of modern technology such as artificial intelligence, 3d scanning tools, and HBIM and their integration with conservation management process. The research process ended by identifying 59 papers directly related to the topic. The influencing challenges were classified into five main categories: structural (31%), architectural (28%), management (26%), environmental (9%) and legal (6%). Moreover, advanced tools and techniques used in this field were also identified, such as Historic Building Information Modelling (HBIM) (44%), decision making tools such as the Analytical Hierarchy Process (AHP) (11%), and many other techniques. Together, the results provide a comprehensive vision for stakeholders and project managers in the field of heritage building conservation management, with an emphasis on adopting a multidisciplinary approach that combines advance technology and balanced and long-term practices. Additionally, it emphasizes the significance of maintaining a balance between modern interventions and preserving the historical value of the building, which represents a major challenge in the field of conservation. Although the study focused primarily on the active intervention phases, it offers an approach, based on the classification of key challenges and identification of mitigation tools, that can be extended to the post- intervention stage, particularly during periodic maintenance phase. This highlights the promising direction for future research aimed to ensuring the long-term effectiveness of conservation efforts.

1.0 INTRODUCTION

Heritage is a multidimensional and complex concept, with roots dating back to ancient times. Initially, it was limited to monumental physical structures, admired for their aesthetic, historical, and architectural value. Over time, this concept has evolved to become closely linked to law, human history, and a nation's culture, as well as to the innate human instinct to protect, preserve, and nurture all that is precious (Ursu, Chiriac, and Bostan 2022). Hence, heritage can be defined as the collective cultural elements deemed of significant value to a nation or humanity as a whole, encompassing both tangible and intangible aspects (Pérez-Guilarte, Gusman, and Lois González 2023).

Tangible heritage includes historical monuments, buildings, and tangible objects that represent artistic, historical, or cultural value, while intangible heritage includes traditions, celebrations, languages, and folklore that are passed down through generations and shape a community's identity (Obad Livingstone Banda et al. 2024). These two elements are interconnected, as a large portion of intangible cultural heritage is found in sites and monuments.

Among tangible heritage, heritage buildings occupy a particularly prominent place. They can be expressed as structures that carry significant historical, architectural, cultural, or social values. These structures include buildings that have withstood the vicissitudes of time, such as old houses, palaces, castles, markets, and other landmarks (Al-Sakkaf, Zayed, and Bagchi 2020). These buildings are considered an essential part of cultural heritage, representing a long history of human labor and architectural creativity and contributing to shaping a society's cultural identity (Nursanty, Rusmiatmoko, and Muhammad Fahd Diyar Husni 2023). Accordingly, heritage buildings are considered cultural assets that deserve protection and documentation, a point emphasized by numerous international conventions, such as the Venice Charter, which emphasizes the need to protect architectural heritage and pass it on to future generations in order to preserve this historical and artistic value (ICOMOS 1964).

In recent decades, researchers have emphasized that old buildings are not simply physical remnants of the past with historical or architectural significance. The societal value they hold must also be considered a crucial factor in heritage conservation decisions, particularly by involving the local community in the decision-making process (Rossitti, Oteri, and Torrieri 2025). This social dimension is an integral component of the cultural value of heritage.

Therefore, heritage buildings are complex entities that reflect both material and symbolic values. Their importance lies not only in their physical features but also in the meanings attributed to them over generations. Preserving them requires a deep understanding of their historical layers, cultural context, and their renewed significance in a rapidly changing world.

In addition, classification systems for such buildings vary between countries and organizations based on a set of specific criteria. According to (Al-Sakkaf, Zayed, and Bagchi 2020), heritage buildings can primarily be classified based on their type and value. Each main category is further subdivided into subcategories, as illustrated in Figure 1.

In Iraq, properties over 200 years old are classified as antiquities. Those less than 200 years old considered culture property if they hold historical, religious, or national significance, or national significance. Sites of important historical events are designated as historic sites, regardless of their age. (National Policy of Iraq N.55 2002). In contrast, countries such as Japan and Singapore, a new perspective has emerged for understanding heritage that focuses on the concept of “living heritage” and adopts what is known as “display-ness,” which combines present-day historical values with the institutional representation of the place (Lin 2024).

Over the years, relevant entities -such as governmental state boards and international organizations dedicated to historical affairs and the protection of cultural property- have cooperated to establish a body of law, regulations, and charters aimed to safeguarding and conserving heritage (ELDIB 2024).

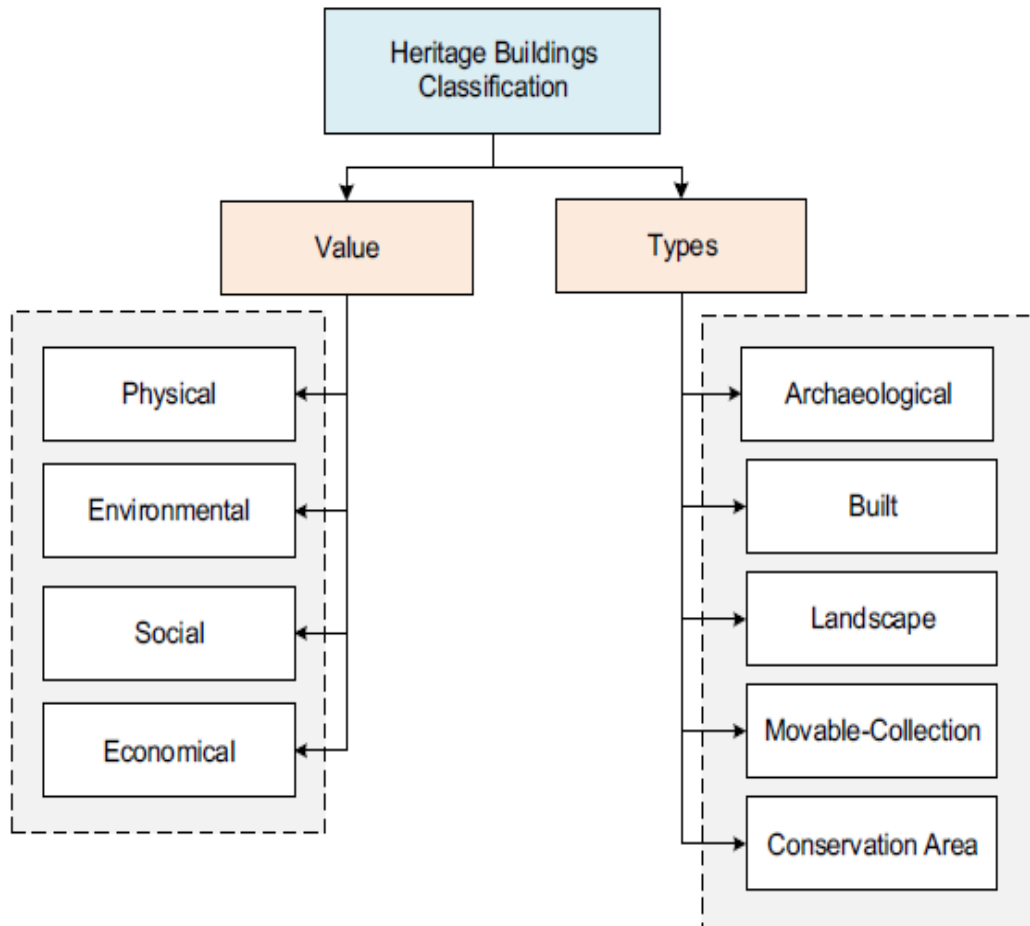


Figure 1. Heritage buildings classification (Al-Sakkaf, Zayed, and Bagchi 2020).

Among the most influential international charters that have laid down the general frameworks, principles and foundational concepts of conservation activities under various designations is Athens Charter (1931). This charter is considered the first international charter dedicated specifically to the conservation of heritage building, The Athens Charter emerged from a conference held in Athens in 1931, which brought together architects and experts specializing in conservation (International Council on Monuments and Sites (ICOMOS) 1931). Venice Charter (1964) is the second international conference of architects and technicians specializing in the conservation of historical buildings was held in Venice and issued this charter, which outlined clear guidelines concerning the principles of conservation, restoration and excavation (ICOMOS 1964). In addition, several other key international charter and documents have been developed such as Convention Concerning the Protection of the World Cultural and Natural Heritage, Paris, 1972 (UNESCO 1972), Declaration of Dresden on the "Reconstruction of Monuments Destroyed by War", Dresden, (1982) (ICOMOS 1982), Nara Document on Authenticity, Nara, 1994 (ICOMOS 1994), and Burra Charter, Burra, 2013 (Truscott 2014).

These charters have played a pivotal role in shaping the conceptual and practical understanding of heritage conservation. According to Burra charter 2013 "Conservation may, according to circumstance, include the processes of: retention or reintroduction of a use; retention of associations and meanings; maintenance, preservation, restoration, reconstruction, adaptation and interpretation. The concept of "restoration" has evolved across time and region According to article 19 in this charter, it is stated that "Restoration is appropriate only if there is sufficient evidence of an earlier state of the fabric" (Truscott 2014).

Despite the existence of international frameworks, many heritage buildings suffer from a severe deterioration resulting from several factors. For example, the building Saint Vincent de Paul School in Istanbul, built in 1883. originally housed an orphanage and it included a church, a monastery, and several other departments. The building was left for 28 years after the nuns left in 1924, resulting in significant deterioration.

Poor planned ill-considered structural modifications, such as re-division of the rooms, weakened the building's integrity and led to the collapse of parts of the roof and the walls. Exposure to harsh weather conditions, particularly the construction nearby concrete structures, further impacted the site by blocking the northern facade and its windows. In addition, earlier preservation efforts failed to consider the building's historical and structural value, which further accelerated its deterioration (Figure 2) (Doğan 2023).

Another prominent example is Khan Al-Shilan, established in 1899 in Najaf, Iraq. The building sustained significant deterioration as a result of prolonged exposure to humidity and harsh environmental conditions, with its first restoration efforts initiated in 2010. It can be said that the building restoration process was mandatory satisfactory, especially in light of the absence of a clear conservation plan and the limited expertise of the personnel involved in heritage restoration. This shortcoming ultimately resulted in the loss of some of the building's distinctive architectural features, either through their removal or inappropriate replacement. In addition, non-original materials were introduced under the pretext of the unavailability of materials similar to the original brushwork, despite the fact that such materials could have been locally produced using simple methods (Abid and Ameen 2023).

It can be said that the conservation management of heritage buildings projects faces numerous challenges, including balancing the requirements of modern use with historical value, as well as dealing with old materials and techniques that require meticulous maintenance (Aleksic et al. 2022). Although some ill-considered modifications made by users to buildings are minor, they lead to significant damage. Therefore, these modifications can contribute to structural problems, erasing historical identity and losing important architectural details (Hussein and Mousa 2024). The same is true for major changes, which have greater drawbacks (Doğan 2023).

Moreover, based on (Miran and Husein 2024), there are additional critical factors that lead to the deterioration of buildings and complicate the conservation management process, such as urban expansion, environmental conditions, and neglect. Urban expansion may expose buildings to pressure from infrastructure and modern projects, causing structural damage to buildings or their surroundings. On the other hand, environmental conditions such as climate change and humidity can contribute significantly to the erosion of the fundamental materials used in the construction of these buildings (Kotova et al. 2023). In addition, insufficient appreciation of the value of heritage leads to failure to take the necessary preventive measures to preserve these buildings. Thus, it is imperative to protect the heritage of ancient places and discover the relationships between the level of deterioration and types of buildings (Miran and Husein 2024).



Figure 2. Traces of the wooden structures at the rear facade of the main building; photo by H.A. Doğan. (Doğan 2023)

Consequently, to ensure the success of these projects, effective management is considered crucial, as it requires careful and efficient planning and management (Khan et al. 2022). Furthermore, to apply the modern techniques in order to deal with challenges facing the conservation process. Proper management preserves the architectural and historical values of the building and provides solutions to conservation problems (Guner and Benli 2019).

Therefore, this paper offers a systematic review to explore the main challenges facing the management of heritage building conservation projects and current techniques used to overcome them.

2.0 RESEARCH AIM

This study aims to identify and categorize the main challenges impacting the management of heritage building conservation projects, as well as explore the most common techniques for addressing them. Adopting a systematic review of the literature published over the past five years. The anticipated outcome is to provide a comprehensive and evidence-based approach that not only justifies current research trends but also supports stakeholders and decision-makers in improving implementation plans and management of heritage building conservation projects.

3.0 RESEARCH QUESTIONS

The study is guided by the following research questions

- What are the main challenges impacting the management of heritage building conservation projects?
- What are the most prominent techniques used to overcome these challenges?
- How do the results of the challenge and technique classification help guide the roles of stakeholders in managing heritage building conservation projects?

4.0 MATERIALS AND METHODS

The systematic review method is the approach followed in this research, for the purpose of identifying, verifying, and classifying the challenges influencing the management of heritage building conservation projects, in addition to identifying the techniques used to address them. This type of review was chosen based on its ability to conduct a comprehensive analysis of the existing literature, as it summarizes the evidence and provides an indication of its strength and direction, which ensures evidence-based results that identify the most prominent practices in any given field (Sharif et al. 2013). The systematic review follows the PRISMA (Preferred Items for Reporting Systematic Reviews and Meta-Analysis) method to provide a rationale and analytical approach to the review, planned in advance at an early stage (Moher et al. 2009). The PRISMA protocol greatly assisted in dealing with the variation in terminology across studies, and contributing to make decisions to include or exclude studies in a systematic and consistent manner.

In the literature of heritage building conservation, various terms are commonly used such as "heritage", "historic", and "old". While these terms carry different meaning, they are often confused, particularly due to different in classification systems, as well as legal and institutional frameworks across different countries. A similar overlap exists in the terminology used to describes conservation process, such as "restoration", "rehabilitation", and "preservation". Although each has a specific technical definition, their practical application are often overlaps, and projects employing these concepts are often face similar management challenges (Karimi et al. 2022) (Al-Sakkaf, Zayed, and Bagchi 2020). Therefore, this research relied on the use of verity of these terms to cover as many studies as possible, ensuring a comprehensive of the systematic review.

Scopus and Web of Science were selected as the primary sources for this systematic review due to their high academic credibility and strong scientific reputation. Both databases include high-impact research and adhere to strict indexing standards. To ensure academic rigor, the types of sources such as conference proceedings, which may not meet the same level of scientific precision were excluded. Although studies published in languages other than English are valuable, including them in the study would require significant translation efforts and could introduces discrepancies in analysis and data due to potential misunderstanding

or translation bias. Therefore, only studies published in English were included. A Boolean logic was used to broaden the search and ensure that important studies were not missed. Table 1 shows the databases and keywords used.

The search result showed that there were 570 potential research papers, including 325 articles from Scopus and 245 articles from Web of Science. Later on, the Ryan website was used to check duplicate articles and delete them. After excluding them, 470 articles remained. Reviewing primary research articles is more accurate in addressing the research questions raised, as they provide experimental results or direct case studies, which is more in line with the research objective. Consequently, non-articles, conference Papers were deleted and non-English language papers were deleted as well. After excluding them, 251 articles remained.

In the ensuing period, by reading the title and abstract of the remaining papers from the previous step, 154 papers that were not directly related to the management of heritage building conservation projects were excluded. Emphasis was placed on papers that dealt with topics such as conservation management, planning, execution, restoration, rehabilitation, and maintenance. However, studies that focused on specific technical aspects such as architectural and structural analysis without addressing management have been excluded. After we had 97 papers left, they were read more deeply by reading the full text. Therefore, 38 papers were excluded, and 59 papers were included in this research (Figure 3).

Once the paper identification process was completed, the full text of each paper was thoroughly reviewed to identify five main categories that impede the management of conservation projects. These categories included: structural challenges, architectural challenges, management challenges, environmental challenges, and legal challenges. Similar topics were combined to facilitate data collection, statistical analysis, and detailed discussion of the challenges in each category, as well as the techniques used to address these challenges.

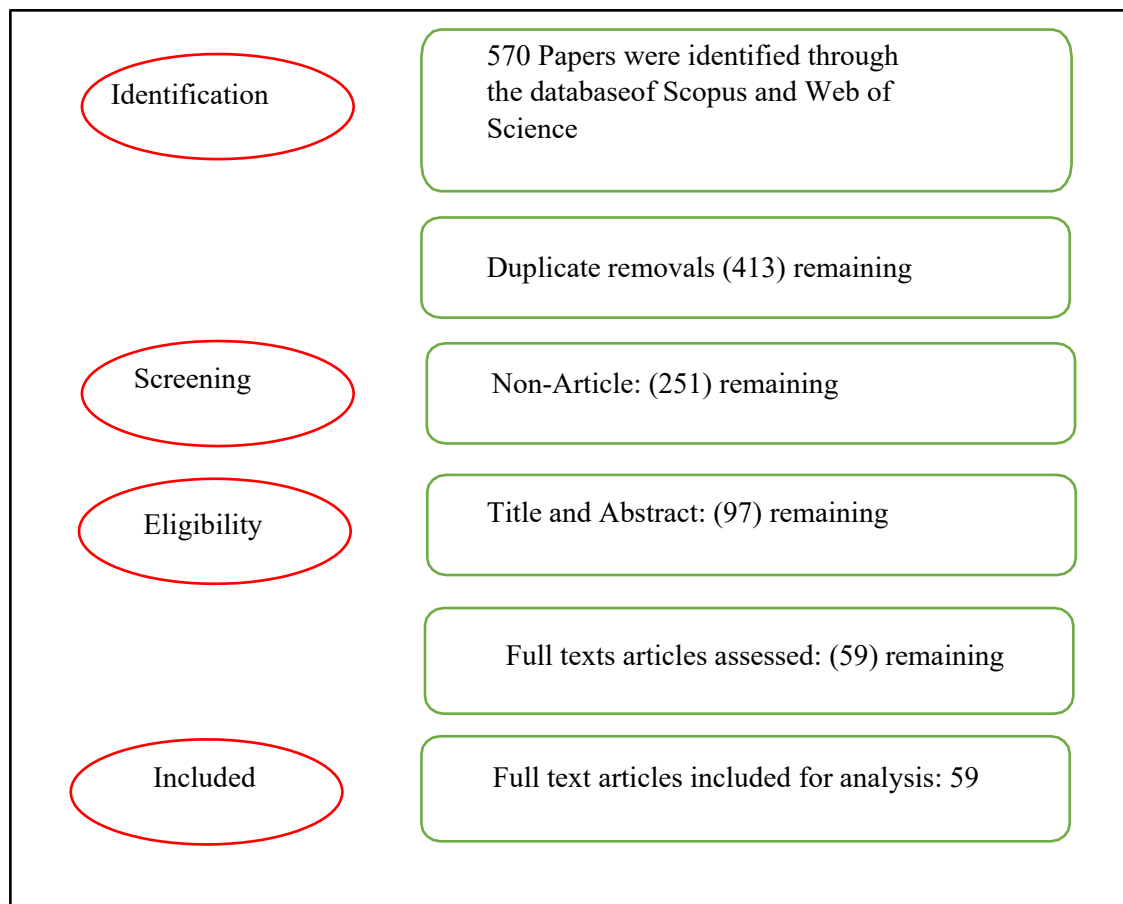


Figure 3. PRISMA flow diagram for inclusion of the articles during the review process.

Table 1. Databases and search keywords used for the systematic review.

N.	Database	Query Keywords
1	Scopus	TITLE-ABS (heritage AND buildings AND restoration) OR TITLE-ABS (historical AND buildings AND restoration) OR TITLE-ABS (conservation AND of AND heritage AND structures) OR TITLE-ABS (heritage AND building AND rehabilitation) AND TITLE-ABS (management) OR TITLE-ABS (challenges) OR TITLE-ABS (issues) AND TITLE-ABS (techniques) OR TITLE-ABS (strategies)
2	Web of science	TITLE-ABS (heritage AND buildings AND restoration) OR TITLE-ABS (historical AND buildings AND restoration) OR TITLE-ABS (conservation AND of AND heritage AND structures) OR TITLE-ABS (heritage AND building AND rehabilitation) AND TITLE-ABS (management) OR TITLE-ABS (challenges) OR TITLE-ABS (issues) AND TITLE-

5.0 RESULTS AND DISCUSSIONS

Through the systematic study of the published literature, five main categories of challenges were identified: structural challenges, architectural challenges, management challenges, legal challenges, and environmental challenges. In the same context, a set of techniques used in this field were identified. The five categories are as follows:

5.1 Structural Challenges

Table 2 presents the challenges under this classification, along with the techniques adopted in each study and the relevant charters and guidelines highlight these challenges. The following is a detailed explanation of these challenges:

The evaluation of the structural safety challenge was the most reported challenge at 27%, as it is essential to prevent buildings collapse under the current and future loads. The study conducted by (Agliata et al. 2023) on the Frattaminore building in Italy serves as an applied example of how HBIM modelling can be used to assess structural safety. Data were gathered through manual field surveys, laser measurements, and analysis of original construction documents. This information was then integrated to the HBIM environment to provide a framework for structural analysis, damage assessment, and identification of changes compared to the original design. Another tool is hierarchical risk map, which helped prioritize interventions and manage structural risk effectively (Ruiz-Jaramillo et al. 2020). Non-destructive geophysical technique (NDT) were also employed to evaluate the materials used in the structural elements, contributing significantly in their structural assessment (Matias et al. 2021). AHP (Analytical Hierarchical Process) was used as a technique to assist in the structural evaluation after studying the challenges affecting the deterioration of the walls of the old city of Salé and evaluating their weights, which contributed to classifying the walls according to their final weights (Multi-criteria analysis to assess conservation states of walls in Salé Medina in Morocco Elhachmi et al. 2020).

Meanwhile, the seismic risk assessment challenge obtained a percentage of 23%, which focused on studying the necessary measures to enhance the resistance of buildings exposed to earthquakes in areas with high seismic activity. Among the techniques used are: improve connections, reduce floor flexibility, and increase wall strength (Aleksic et al. 2022). Cladding of mud walls and floors with reinforced concrete and polymer fibres was also used, and steel elements were used to enhance vertical and horizontal connections (Maheri, Najafgholipour, and Zarandi 2023). A database was also created based on archaeoseismological investigations, which play a role in supervising and monitoring earthquake zones and developing plans to reduce disaster risks (Combey et al. 2021). The AHP technique was applied to 15 earthquakes - damaged churches to determine priorities of restoration intervention (D'Alpaos and Valluzzi 2020). The ground motion simulation technique using the Abaqus program was also used to simulate earthquakes and create potential earthquake records in the study area (Hoveidae, Fathi, and Karimzadeh 2021).

Understanding and evaluation building materials constituted 18% of the identified challenges in this category. In addition to the previous techniques that were used in evaluating the structural safety of the building, such as HBIM and NDT. Other techniques such as site investigation and conducting analyses related to humidity, groundwater and wind, were used to describe the materials of the dome of the study case and to know the reasons that led to its deterioration (Pizzigatti and Franzoni 2021). In another study, a comprehensive review of coastal defence structures was conducted, and the building materials used, such as stone, brick, and soil, were inventoried and their current condition was studied (Shao et al. 2023).

In order to know the correct interventions that are in line with the structural behaviour of the building, the understanding the structural behaviour played a good role with a rate of 14%. The visual identification was used to identify the building system and many distinctive architectural elements, such as decorations and mosaics, as well as windows and stairs, which helped in the conservation process of a building built in the old classical style to be reused as a restaurant (Prieto-Vicioso, Flores-Sasso, and Fernández-Flores 2022). The finite element model, along with numerical analyses and test results, provided a clear picture of the real structure's behaviour, including its response to earthquakes (Baggio et al. 2021). The HBIM technique was used to collect relevant data for the Flaminio Stadium in Rome. The finite element model FM was used to determine the response of the structure under different dynamic tests under operating conditions. This study provided an understanding of the structural behaviour of the stadium for the purpose of implementing a pre-maintenance strategy for the building (Di Re et al. 2021).

Enhancing structural safety challenge accounted for 9% of the total challenges forming this classification. One of the techniques used is the reconstruction of some structural parts that were eroded due to excavation in previous periods and left to suffer due to weather conditions, but these interventions are considered non-invasive and reversible (Nadali 2023). Additionally, the focus was also placed on the stability of the structure and the removal of the beams, affecting the strength of the internal wall and stairs in the Lugo Wall in Spain (Bailliet 2023). In the same note, the random interventions factor also accounted for 7%, indicating the negative impact of uncalculated interventions on structural safety. Previous conservation procedures were discussed, and weaknesses were identified to develop a comprehensive strategy for preventive conservation of the Moorish Pavilion (Coelho, da Silva, and Zouain 2020). The current status of maintenance plans and incorrect interventions that resulted in the loss of many existing structures were also studied, and the paper focused on the need to provide a comprehensive approach to maintenance within the framework of preserving cultural heritage (A. Cruz et al. 2022). Figure (4) shows the frequency of these challenge within the structural category, while Figure (5) shows the use of techniques across all these challenges.

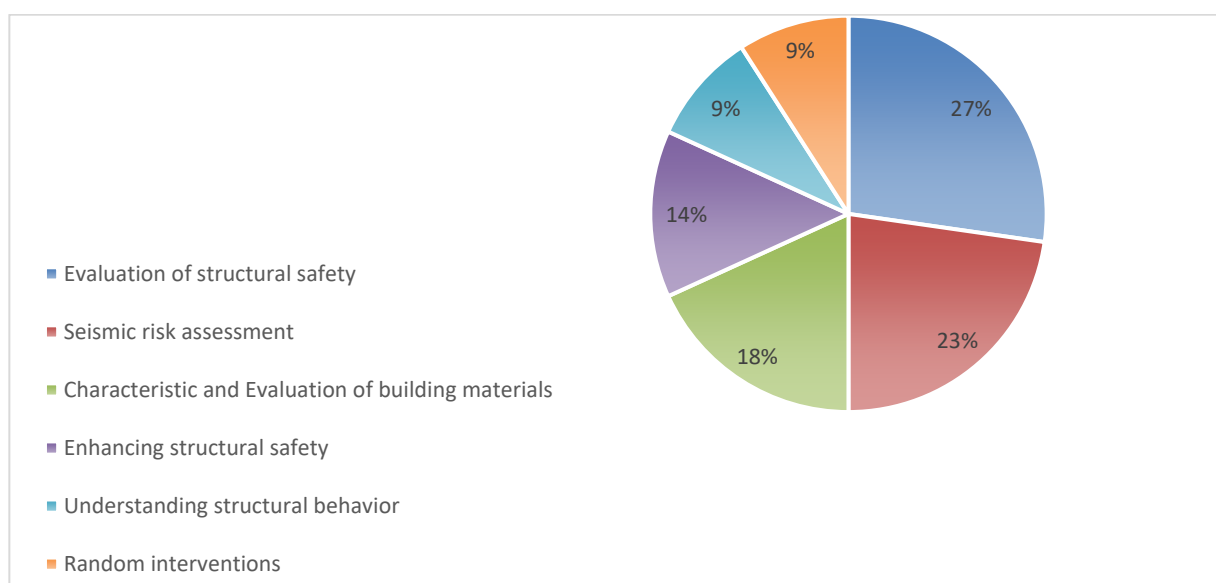


Figure 4. The frequency of challenges within the structural category.

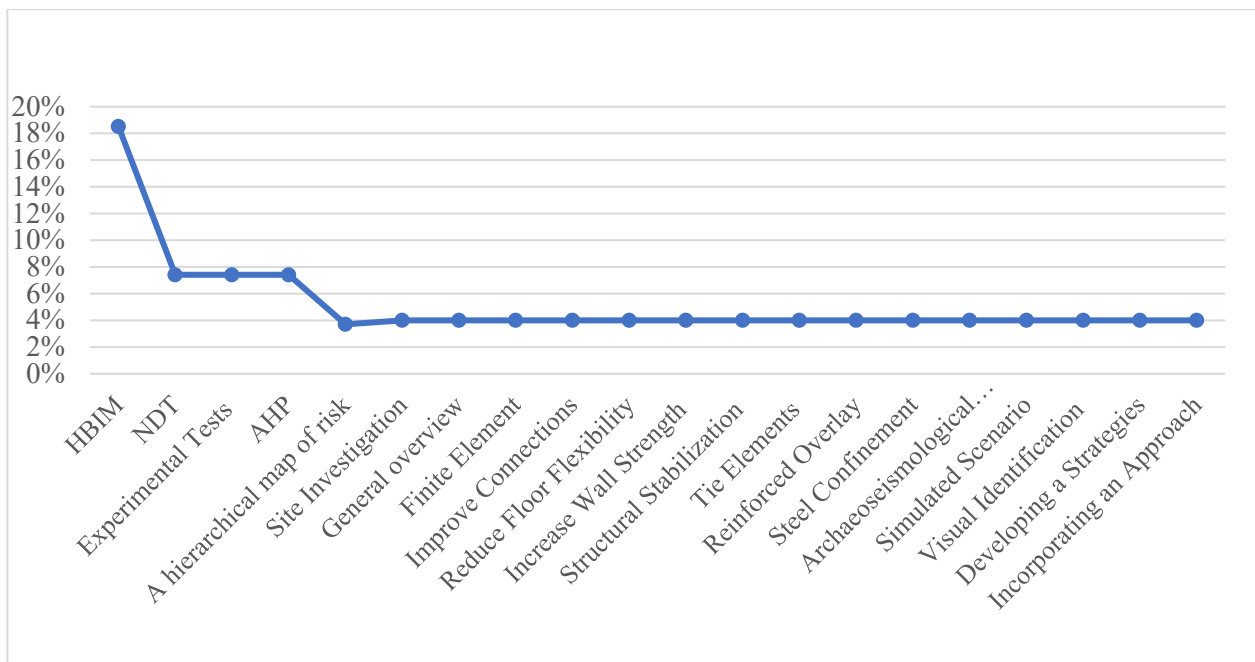


Figure 5. The frequency of techniques used across structural challenges.

Table 2. Challenges and techniques identified in the structural category.

Challenges	Charter and Guidelines	Author(s)	Technique
Evaluation of structural safety	ISCRASH guidelines 2025, Venice Charter Art. 10	(Agliaata et al. 2023) (De Falco et al. 2024) (Y. Cruz et al. 2024) (Matias et al. 2021) (Multi-criteria analysis to assess conservation states of walls in Salé Medina in MoroccoElhachmi et al. 2020) (Ruiz-Jaramillo et al. 2020)	HBIM (Agliaata et al. 2023), HBIM (De Falco et al. 2024), HBIM (Y. Cruz et al. 2024), High resolution NDT (Matias et al. 2021), AHP (Multi-criteria analysis to assess conservation states of walls in Salé Medina in MoroccoElhachmi et al. 2020) a hierarchical map of risk (Ruiz-Jaramillo et al. 2020)
Seismic risk assessment	ISCRASH guidelines 2025, ICOMOS Risk Preparedness Guidelines 1993	(Aleksic et al. 2022) (Maheri, Najafgholipour, and Zarandi 2023) (Combey et al. 2021) (D'Alpaos and Valluzzi 2020) (Hoveidae, Fathi, and Karimzadeh 2021)	Improve connections, reduce floor flexibility, increase wall strength (Aleksic et al. 2022), Reinforced overlay, steel confinement (Maheri, Najafgholipour, and Zarandi 2023), relational database based on archaeoseismological investigation(Combey et al. 2021), AHP (D'Alpaos and Valluzzi 2020), Ground Motion Simulation (Hoveidae, Fathi, and Karimzadeh 2021)
Characteristic and Evaluation of building materials	Venice Charter Art. 10, Bura Charter Art. 4	(Agliaata et al. 2023) (Matias et al. 2021) (Pizzigatti and Franzoni 2021) (Shao et al. 2023)	HBIM (Agliaata et al. 2023), High resolution NDT (Matias et al. 2021), Site Investigation (Pizzigatti and Franzoni 2021), General overview (Shao et al. 2023)
Understanding structural behavior	ISCRASH guidelines 2025	(Prieto-Vicioso, Flores-Sasso, and Fernández-Flores 2022) (Baggio et al. 2021) (Di Re et al. 2021)	Visual identification (Prieto-Vicioso, Flores-Sasso, and Fernández-Flores 2022), finite element, experimental tests (Baggio et al. 2021), HBIM, Finite Element (Di Re et al. 2021)

Enhancing structural safety	ISCRASH guidelines 2025, ICOMS Guidelines for Structural Interventions	(Bailliet 2023) (Nadali 2023)	Reconstruction (Nadali 2023), Structural stabilization (Bailliet 2023)
Random interventions	Bura Charter Art.3, Venice Charter Art. 9-10	(Coelho, da Silva, and Zouain 2020)(A. Cruz et al. 2022)	Developing comprehensive strategies for preventive conservation (Coelho, da Silva, and Zouain 2020), Incorporating a maintenance approach in the preservation (A. Cruz et al. 2022)

5.2 Architectural Challenges

Table 3 presents the challenges under this classification, the corresponding techniques applied in each research and the relevant charters and guidelines highlight these challenges. The following is an explanation of these challenges:

Accurate documentation emerged as the most prominent challenges in this category, as it constituted 68%, reflecting the impact of accurate documentation on the success of conservation project management. A notable technique employed to address this challenge is HBIM. For instance, (Alshwabkeh and Baik 2023) demonstrate a critical role of advanced techniques in achieving accurate documentation in heritage conservation projects. This study, conducted in Saudi Arabia at AlUla (a World Heritage Site), involved integration terrestrial laser scanning (TLS) was combined with high-resolution Photogrammetry to produce a detailed, realistic HBIM model that reflects the actual condition of the site, including cracks, signs of deterioration, and minor surface changes.

The research showed that its results would be useful in the field of heritage building projects (Alshwabkeh and Baik 2023). The laser scanner was also used and integrated with HBIM in other research such as (Rolfsen et al. 2023), as well as Photogrammetry (Sarhan and Abed 2021), parametric modelling (Liberotti and Gusella 2023), manual modelling (Karasaka and Ulutas 2023), and NDT (Solla et al. 2020) techniques that were all integrated with HBIM and showed distinctive results. Additional techniques include UAV and neural radiation for 3D reconstruction, offering high-quality outputs and improved efficiency in work implementation (Ge et al. 2024). Low-cost spherical cameras were used in another study, which is a camera that captures the scene at 360 degrees, although it gave less accurate results compared to other equipment and techniques. However, it can be used in the field of preparing virtual tours (Herban et al. 2022).

The second challenge in this category is the minimum intervention, making up 14%. When preserving a heritage building, the first step is to analyse the various intervention levels to determine the minimum level, aiming to achieve structural integrity while minimizing impact historical value (ICOMOS 2003). However, identifying the appropriate minimum intervention is a complex task, influenced by interrelated factors. Zhang and Dong (2021) presented a model that evaluates six key criteria: stakeholders, building typology, existing fabric, functional changes, potential problems, and conservation measures. The model also classifies interventions into progressive levels, such as preservation, renovation, restoration, consolidation, adaptive use, and new design. This allows for accurate decisions based on an analysis of structures and architectural elements within the context of use and functional requirements (ICOMOS 2003). Various techniques have been adopted to determine the appropriate minimum intervention. For instance, Non-invasive conservation techniques were applied to parts of the Tower Motrilja, successfully preserving its authentic architectural appearance without altering the building's original concept (Aleksic et al. 2022). Fuzzy logic and random forest were used in a study conducted in southern Chile to help decision makers avoid failure, uncertainty, and to prioritize the correct actions that guarantee the least intervention and the best results (Mendoza, Torres-González, and Prieto 2024).

Among the techniques used is the AHP technique, which was relied upon to create a decision-making tool called H-MCDM, a flexible tool to evaluate the best reuse strategy while taking into account the principles of preserving the architectural heritage (Maselli et al. 2024).

Identification of building units is the third challenge with 9% of the total research, expressing the description of general and precise details of the building parts. Due to the lack of drawings and plans for the case study, a visual inspection of the site was carried out in order to identify the structural units and determine the geometric characteristics, technical and technological details, so that a successful conservation methodology can be applied (Pizzigatti and Franzoni 2021). In addition, a neoclassical building was rehabilitated in the Dominican Republic (Prieto-Vicioso, Flores-Sasso, and Fernández-Flores 2022), where the work included the identification of structural units and the structural system and the restoration of the decorative elements and original colours of the walls.

However, the discovering building changes was rated at 5%, as natural and historical factors are assumed to cause architectural and building material changes. Terrestrial laser scanning and hyperspectral imaging technology was used to provide a comprehensive and flexible approach to detecting architectural and building material changes in these buildings, where signs of deformation were detected in the Beijing Tianningsi Tower in Beijing. It can be said that this technique provided an opportunity for chemical and physical evaluation of the materials and provided a scientific basis for research and preparation of a restoration plan (Zhang, Ma, and Gao 2021).

On the other hand, the potential of reversibility was rated at 5%, as this challenge indicates the ability to remove current changes to buildings in the future without architectural or structural distortion of the original building. In the city of Ebla in Syria, a non-invasive and reversible intervention technique was used by building parts of eroded walls with Mudbricks made of local raw materials to preserve what remains of the building and gain time to prepare a comprehensive restoration plan for the site (Nadali 2023). Figure 6 shows the frequency of these challenges within the architectural classification, while Figure 7 shows the use of techniques across all of these factors.

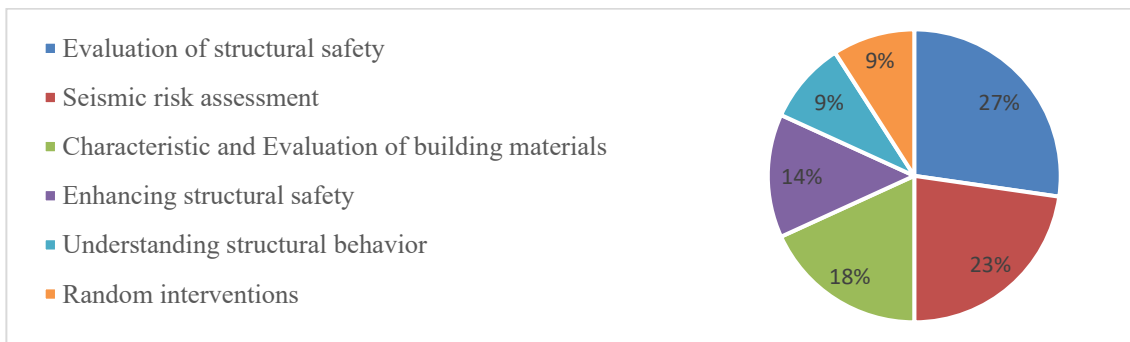


Figure 6. The frequency of Challenges within the architecture category

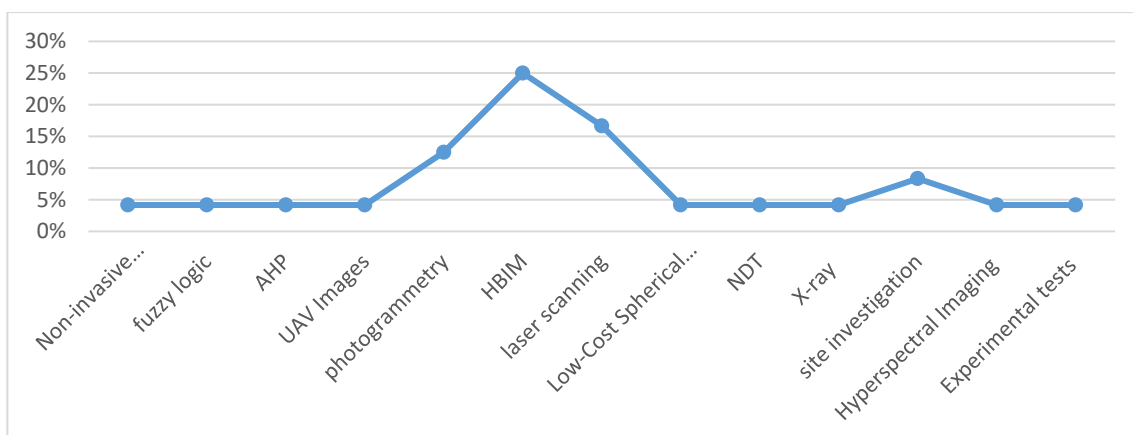


Figure 7. The frequency of techniques used across the architecture Challenges

Table 3. Challenges and techniques used in the architectural category.

Challenges	Charters and Guidelines	Author(s)	Technique
Accurate Documentation	Venice Charter Art. 16, Bura Charter Art. 5, PRINCIPLES FOR THE RECORDING OF MONUMENTS, GROUPS OF BUILDINGS AND SITES (1996),	(Ge et al. 2024) (Kallas and Napolitano 2023) (Alshwabkeh and Baik 2023) (Habib 2022) (Liberotti and Gusella 2023)(Karasaka and Ulutas 2023) (Sarhan and Abed 2021) (Herban et al. 2022) (Solla et al. 2020) (Rolfsen et al. 2023)	UAV Images and Neural Radiation(Ge et al. 2024), Photogrammetric survey (Kallas and Napolitano 2023), photogrammetry and laser scanning, HBIM (Alshwabkeh and Baik 2023), parametric modeling, HBIM (Liberotti and Gusella 2023), manual modeling and laser scanning, HBIM (Karasaka and Ulutas 2023), UAV Structure from Motion Photogrammetry, HBIM (Sarhan and Abed 2021), Low-Cost Spherical Cameras (Herban et al. 2022), NDT and BIM (Solla et al. 2020), laser scanning, HBIM (Rolfsen et al. 2023)
Minimum intervention	Bura Charter Art. 3, Venice Charter Art. 21, China Principles (Art. 21)	(Aleksic et al. 2022) (Mendoza, Torres-González, and Prieto 2024) (Maselli et al. 2024)	Non-invasive conservation technique(Aleksic et al. 2022) , fuzzy logic and random forest (Mendoza, Torres-González, and Prieto 2024), AHP (Maselli et al. 2024)
Identification of building units	Bura Charter Art. 6, Venice Charter Art. 6-7	(Pizzigatti and Franzoni 2021) (Prieto-Vicioso, Flores-Sasso, and Fernández-Flores 2022)	Site investigation (Pizzigatti and Franzoni 2021), Site investigation (Prieto-Vicioso, Flores-Sasso, and Fernández-Flores 2022)
Discovering building changes	Bura Charter Art. 26, Venice Charter Art. 11	(Zhang, Ma, and Gao 2021)	Terrestrial Laser Scanning and Hyperspectral Imaging (Zhang, Ma, and Gao 2021)
Potential of reversibility	ISCRASH guidelines 2025, Venice Charter Art. 10, China Principles Art. 21	(Nadali 2023)	Non-invasive intervention (Nadali 2023)

5.3 Management Challenges

Table 4 presents the challenges under this classification, the corresponding techniques applied in each research and the relevant charters and guidelines that highlight these challenges. The following is an explanation of these challenges:

Data management is one of the most important challenges, as its frequency in research reached 24%. This challenge contributes to improving the efficiency of the project and ensuring accuracy and success. HBIM technology has proven to be remarkably successful for this purpose, as it has been given in frequent usage. A systematic approach was applied to improve information transfer and reduce costs resulting from information loss from the initial stages to the facility management phase in old buildings (Pinti and Bonelli 2022). Another study focused on the capacity of the database and its role in managing cultural heritage structures by presenting an online database that integrates BIM modeling and related historical information (Castellazzi et al. 2023). The importance of integrating 3D digital documentation with facility management to overcome many challenges, such as financial losses and poor project control, using BIM technology, was discussed in the research (Khan et al. 2022).

Alignment with the sustainability challenge also constitutes a large percentage in this study, as it also accounted for 24% of this category. This challenge ensures that activities are consistent with global sustainability standards. One of the techniques used is AHP in the research (Cucco et al. 2023), which proposed a model based on evaluation indicators developed according to sustainability principles and hierarchical analysis algorithms. In the same context, the AHP technique was relied upon to create a decision-making tool called H-MCDM that uses seven economic, cultural, and social indicators, selected according to the sustainable development goals (Maselli et al. 2024). HBIM was used to integrate environmental considerations with geographical methods to provide broader knowledge about risk management in heritage building conservation projects (Prizeman et al. 2020). The research (Cinquepalmi and Tiburcio 2023) showed that catastrophic events can be mitigated, and conservation projects can be managed using digital techniques such as HBIM and Digital Twin, which provide valuable information that can be shared with stakeholders to preserve the building's value and ensure its compliance with sustainability criteria.

On the same side, essential data for decision makers accounted for 24% of the total management challenge classifications, as access to accurate data plays a crucial role in guiding intervention and ensuring successful conservation outcomes. Fuzzy logic and random decision forest methodologies were used to manage the important data obtained from experts and from the building itself, which helps decision makers in taking the right intervention measures (Mendoza, Torres-González, and Prieto 2024). The research [44] proposes an integrated framework based on a comprehensive literature review to include the digital twin in the management processes of heritage building conservation projects and suggests several recommendations for implementing this framework (Jouan and Hallot 2020). The research (Prieto 2021) aimed to include a new management system based on fuzzy logic (artificial intelligence) in order to manage important data from buildings and experts and informed stakeholder decisions. HBIM technology was also used for this challenge, where a 3D model was created containing functional, structural, architectural, and historical data, in addition to other data such as materials condition, and visual appearance (Al-Bayari and Shatnawi 2022).

Comprehensive knowledge of heritage assets is another challenge that accounted for 18% of this classification, as this knowledge allows for an accurate understanding of the cultural and historical value of buildings. Many studies have addressed the use of HBIM technology for this purpose, where models were created to manage large-scale assets (Giuliani et al. 2024). Other studies aimed to manage assets by developing digital models based on the HBIM techniques, which allows for better management of conservation projects (Moyano et al. 2022) (Piaia et al. 2021).

The ultimate challenge, which accounted for 12% in terms of frequency, is right stakeholder partnership, as these parties play an influential and critical role in the success of conservation projects. The research (Saba, Chanchí Golondrino, and Torres-Gil 2023) proposed a new plan using SWAT technology to ensure proper management in heritage site preservation efforts, as it revealed ambiguity in decision-making between the mayor's office and the Ministry of Culture, which hinder effective heritage conservation management projects. A web platform was developed to gather and manage data using tools such as 3dGIS, IOT, and a set of artificial intelligence techniques such as deep learning. This platform was used to provide an innovative tool for decision-makers to develop preservation plans (Lasorella, de-Dato, and Cantatore 2024). Figure 8 shows the frequency percentage of these challenges included in the management classification, while Figure 9 shows the use of techniques across all of these challenges.

It is worth noting that, although the concept of facility management (FM) is not directly referenced in this research, several of its associated tools, such as HBIM and Digital Twin, were actively featured among the solution techniques used to address the conservation challenges. These tools were particularly employed in area such as data management and decision making. The decision to focus on particular tools rather than theoretical frameworks was intentional and aligns with the main objective of this study.

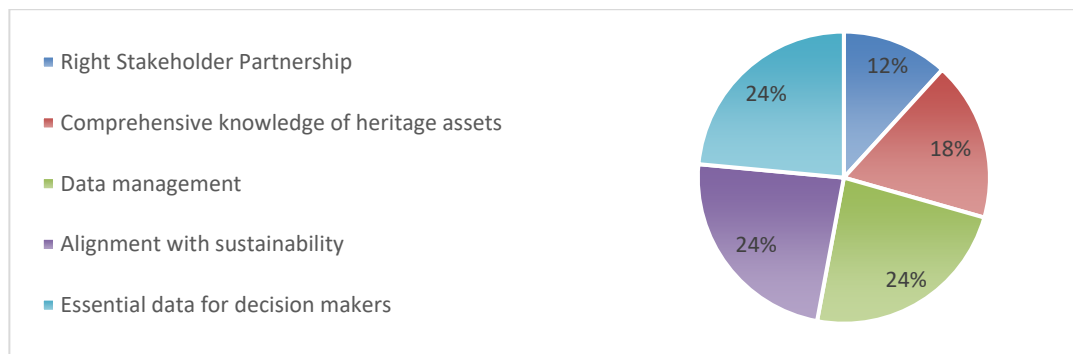


Figure 8. The frequency of challenges within the management category

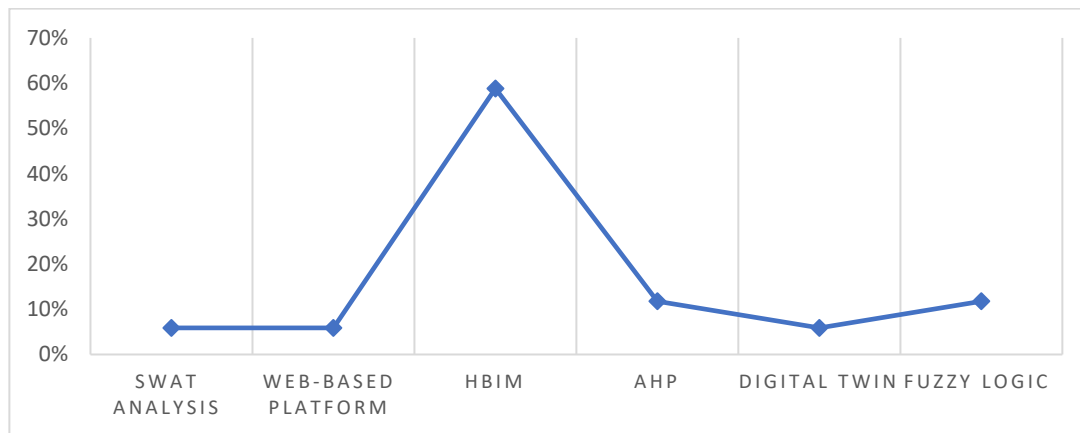


Figure 9. The frequency of techniques used across the management challenges

Table 4. Challenges and techniques used in the management category:

Challenges	Charters and Guidelines	Author(s)	Technique
Data management	ICOMOS Digital Documentation Principles, Burra Charter Art. 27	(Pinti and Bonelli 2022)(Castellazzi et al. 2023) (Khan et al. 2022)(Anaç and Arun 2024)	HBIM (Pinti and Bonelli 2022), BIM and Cloud-Based Solutions (Castellazzi et al. 2023), HBIM (Khan et al. 2022), HBIM (Anaç and Arun 2024)
Alignment with sustainability	ICOMOS Sustainable Development Goals Policy 2019, UN SDG 11.4	(Cucco et al. 2023) (Prizeman et al. 2020) (Cinquepalmi and Tiburcio 2023) (Maselli et al. 2024)	AHP (Cucco et al. 2023), HBIM (Prizeman et al. 2020), HBIM (Cinquepalmi and Tiburcio 2023), AHP (Maselli et al. 2024)
Essential data for decision makers	Burra Charter Art. 5, ICOMOS Heritage at Risk Reports	(Mendoza, Torres-González, and Prieto 2024) (Jouan and Hallot 2020) (Prieto 2021) (Al-Bayari and Shatnawi 2022)	Fuzzy logic and Random Forest (Mendoza, Torres-González, and Prieto 2024), Digital Twin(Jouan and Hallot 2020), Fuzzy system (Prieto 2021) , HBIM (Al-Bayari and Shatnawi 2022)
Comprehensive knowledge of heritage assets	ICOMOS Heritage at Risk Reports, Burra Charter Art. 5,26	(Giuliani et al. 2024) (Moyano et al. 2022) (Piaia et al. 2021)	HBIM Pipeline(Giuliani et al. 2024), HBIM (Moyano et al. 2022), HBIM (Piaia et al. 2021)
Right Stakeholder Partnership	Nara Documents 1994, ICOMOS Participatory Principle 2020	(Saba, Chanchí Golondrino, and Torres-Gil 2023) (Lasorella, de-Dato, and Cantatore 2024)	SWAT analysis (Saba, Chanchí Golondrino, and Torres-Gil 2023), WEB-BASED PLATFORM (Lasorella, de-Dato, and Cantatore 2024)

5.4 Environmental Challenges

Environmental Challenges affect the management of conservation projects by accelerating the deterioration of buildings, which requires the application of specialized maintenance techniques. They also increase the challenges related to adapting to climatic conditions and providing the necessary resources for sustainable protection. In table (5), all the items that fall under this category are displayed. The following is an explanation of these items:

Climate change stands out as the primary challenge in this classification, accounting for 57% of the research, due to its impact on conservation management, as it reflects the growing challenges related to climate and its association with the maintenance and protection of heritage sites. The mechanical forces and stability analysis techniques were used in order to assess the need for modifying the old concrete buildings requirements in terms of structure and function, as climate has affected these buildings negatively (Dias et al. 2021). Another paper proposed a risk-based approach that integrates the heritage value of buildings with the impact of climate change (Cunha Ferreira et al. 2023). The adaptive nature of this approach allows it to be applied to many ancient sites, especially in coastal areas. The multi-layer neural network (MLP) technique was used in the research (Bienvenido-Huertas et al. 2021) to predict the impact of environmental performance within a heritage church, contributing to assessing the impact of climate on the preservation of heritage elements. The study (Sámano Chong, Calderas, and Osnaya 2020) used organic examination as a technique to identify the relationship between environmental impact, architecture, and decorative elements to provide conservation solutions that reduce deterioration.

The second challenge is material lifecycle, which appeared in 29% of the studies, as it refers to the environmental impact of materials in the long term and how to choose sustainable materials with a low negative environmental impact. In the research (Fortuné and Donnet 2023), a case study of an old building was studied, and a systematic approach was proposed that takes into account to support stakeholders in making environmentally friendly, low-carbon, and economical rehabilitation decision. The project life cycle analysis (LCA) technique was used to compare two restoration and renovation models on an old building in Denmark in another paper (Serrano, Kampmann, and Ryberg 2022). The analysis showed that using old materials in the restoration is better as it preserves the old character of the building and has a lower environmental impact. The Sustainability of material used with the original materials is also an important challenge and received a percentage of 14% in this category. In the study (Maričić et al. 2023), the literature was reviewed, the original stones of Zagreb Cathedral were visited and described, and laboratory analyses were conducted in order to know the types of stones available and their potential use for reconstruction after the earthquake. Figure 10 shows the significance of the challenge included in the environmental classification, while Figure 11 shows the use of technologies across all these challenges.

Figure 10. The frequency of challenges within the environmental category

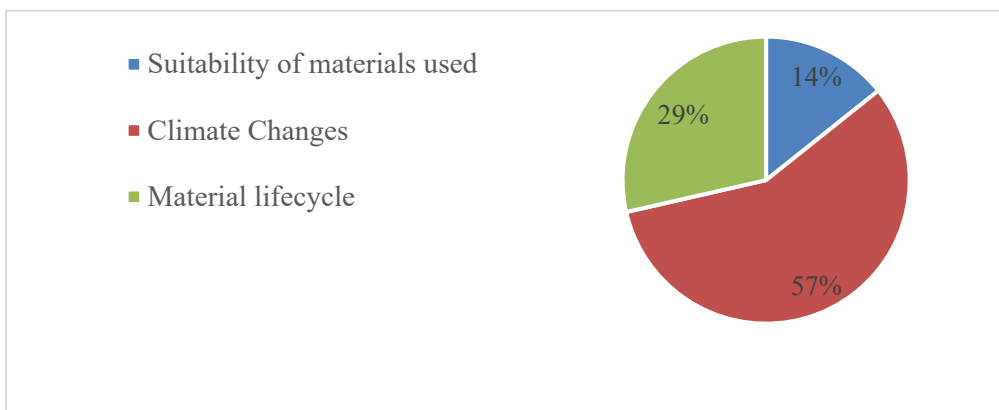


Figure 11. The frequency of techniques used across the environmental challenges

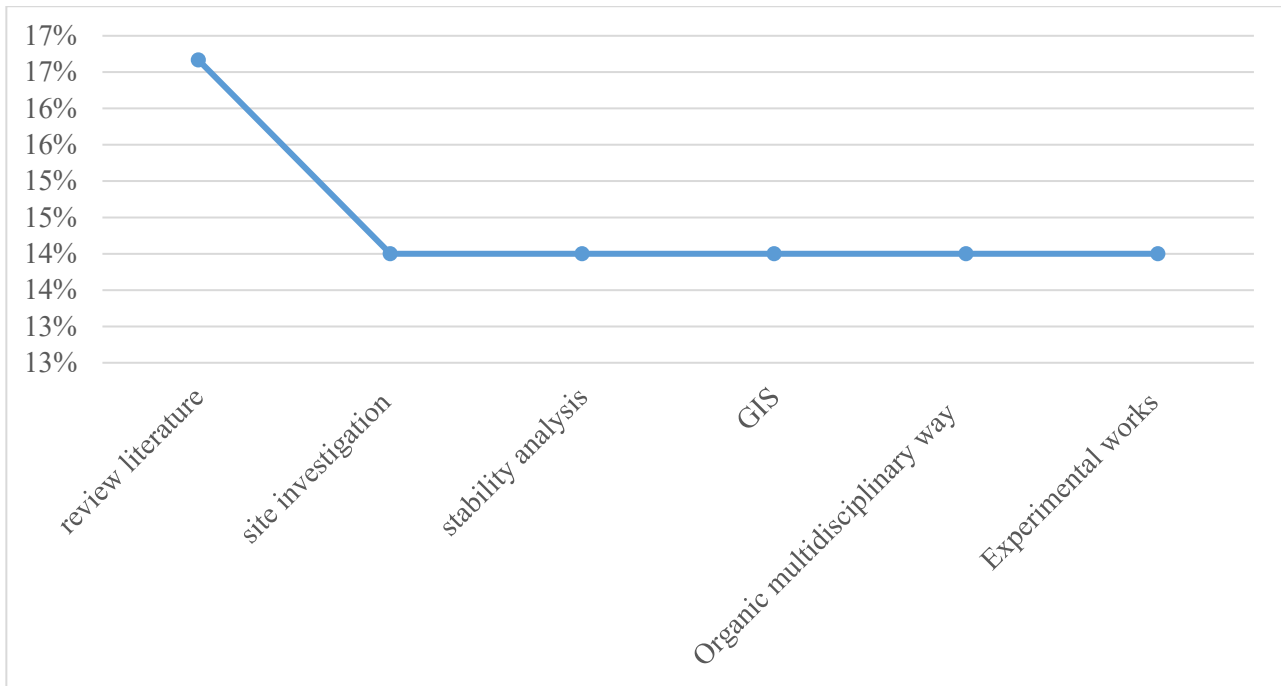


Table 5. Challenges and techniques used in the environmental category.

Challenges	Charters and Guidelines	Author(s)	Technique
Climate Changes	ICOMOS Climate Action Working Group (CAWG), UNESCO WH Guidelines Para. 132, 133	(Cunha Ferreira et al. 2023) (Dias et al. 2021) (Bienvenido-Huertas et al. 2021) (Sámano Chong, Calderas, and Osnaya 2020)	Mechanical forces and stability analysis (Dias et al. 2021), Risk Assessment and Vulnerability Analysis (Cunha Ferreira et al. 2023), MLP (Bienvenido-Huertas et al. 2021), Organic multidisciplinary way (Sámano Chong, Calderas, and Osnaya 2020)
Material lifecycle	ICOMOS Guidelines on Energy Efficiency and Sustainability in Heritage Building, 2022	(Fortuné and Donnet 2023) (Serrano, Kampmann, and Ryberg 2022)	Experimental works (Fortuné and Donnet 2023), LCA model (Serrano, Kampmann, and Ryberg 2022)
Sustainability of material used	ICOMOS Guidelines on Energy Efficiency and Sustainability in Heritage Buildings, 2022	(Maričić et al. 2023)	review of previously published literature, site investigation (Maričić et al. 2023)

5.5 Legal Challenges

Table 6 presents the challenges under this classification, the corresponding techniques applied in each research and the relevant charters and guidelines highlight these challenges. The following is an explanation of these challenges:

The alignment with conservation regulations challenge received 50% of the total studies in this category, as it requires conservation activities to comply with local and international laws. In a study conducted in Spain, it was proposed to create a passport for ancient buildings that integrates regulatory, financial, and informational tools, which helps in managing and planning the renovation of buildings in a manner that is consistent with conservation laws (Villarejo, Gámez, and Santamaría-López 2021). A single-storey building in Upper East Coast Road, Singapore, was selected for the study and analysis in the research (Quek and Rajeev 2023), and

it was found that the building suffers from structural damage and corrosion of columns, slabs, and foundations, so a hybrid approach was adopted using additives that comply with conservation law requirements.

Alignments with building codes were 50%, as the conservation of old buildings requires compliance with new building codes and requirements, although this may affect the original character of the building. A study was conducted at the University of Pavia, where a multidisciplinary strategy was presented to preserve the buildings, in accordance with modern standards. Suggestions for strengthening modifications were made after a comprehensive seismic safety analysis (Greco et al. 2021). The research (Garcia-Castillo, Paya-Zaforteza, and Hospitaler 2023) presented a comprehensive overview of the latest techniques used to combat fires in heritage buildings, and offers a solution for conservation instead of demolition, in accordance with current codes related to the safety of buildings in the face of fire.

Figure 12 shows the importance of the challenges included in the legal classification, while figure 13 shows the use of technologies across all of these challenges.

Figure 12. The frequency of challenges within the legal category.

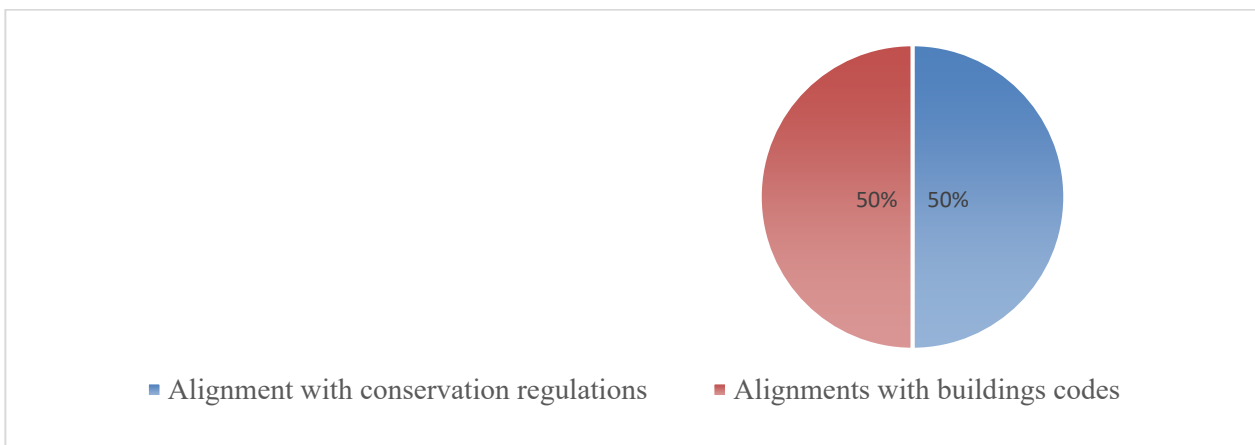


Figure 13. The frequency of techniques used across the legal challenge.

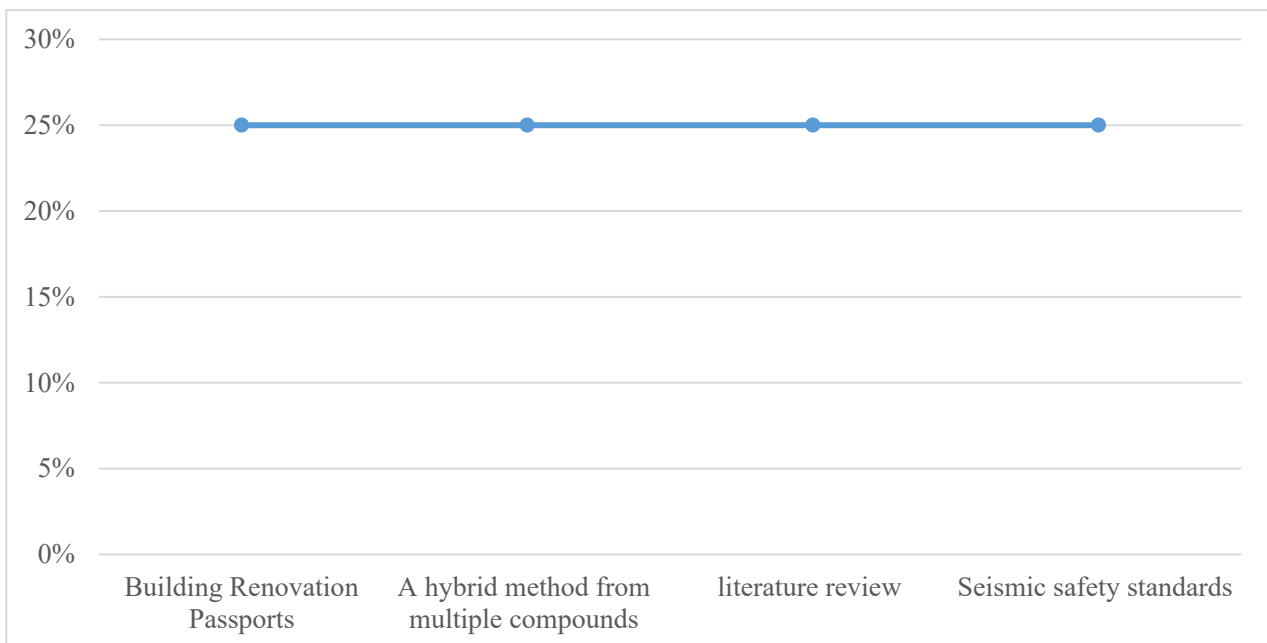


Table 6. The frequency of challenge within the legal category.

Challenges	Charters and Guidelines	Author(s)	Technique
Alignment with conservation regulations	The Operational Guidelines for the Implementation of the World Heritage Convention	(Villarejo, Gámez, and Santamaría-López 2021) (Quek and Rajeev 2023)	Building Renovation Passports (Villarejo, Gámez, and Santamaría-López 2021), A hybrid method from multiple compounds (Quek and Rajeev 2023)
Alignments with building codes	China Principles (Art. 19, 22), ISCARSAH (2024), Burra (Art. 15.3), UNESCO OG	(Greco et al. 2021) (Garcia-Castillo, Paya-Zaforteza, and Hospitaler 2023)	Seismic safety standards (Greco et al. 2021), literature review (Garcia-Castillo, Paya-Zaforteza, and Hospitaler 2023)

The research results indicated that structural challenges accounted for the highest percentage (31%), indicating their critical role in heritage building conservation projects management. Structural challenges affect management in terms of setting work priorities. When there are serious problems such as weak foundations or cracks in walls, priority should be given to ensuring the safety and stability of the building. Likewise, failing to conduct detailed structural studies can lead to delays and increased costs. In addition, dealing with structural challenges properly contributes to reducing risks during the conservation period, which enhances a safe working environment and improves long-term sustainability. It can be said that prioritizing structural aspect ensures the long-term stability of the building.

However, the architectural challenges followed closely at (28%), as they are considered an integral part of the process of preserving the historical and cultural identity of the building. It can be said that conservation project managers should recognize that heritage buildings are more than just physical structures, they are cultural icons, and conservation management involves ensuring that original architectural details of cultural significance are accurately preserved or restored. Therefore, they must consider how structural and architectural modifications affect the cultural and historical value of the building. Modern technologies such as 3D scanning or HBIM can support these efforts effectively. They also provide appropriate technical solutions that fit with the original design of the building and enhance its sustainability.

Furthermore, management challenges made up for 26%, reflecting the vital role played by effective management in the success of projects, as good management enhances the ability to make informed decisions and facilitate effective communication among the stakeholders. One of the effective management practices that directly impacts the success of a conservation project is data management. Collecting and documenting building about the conservation procedures is an essential part of effective management. Techniques such as HBIM help document the various stages of a project and ensure that decisions are based on accurate and up-to-date information.

Environmental challenges ranked fourth with 9%. Environmental challenges affect the management of conservation projects by accelerating the deterioration of buildings, which requires the application of specialized maintenance techniques. For instance, an applied study conducted on the University of Seville church highlight the value of AI tools to predict the environmental performance of interior heritage elements. This example supports the importance of environmental challenges in conservation management, as climate change can accelerate the deterioration of architectural and interior elements in heritage buildings. Based on these analyses, effective cooling and drying strategies can be applied to help preserve heritage elements and improve the internal environmental conditions of buildings (Bienvenido-Huertas et al. 2021). In the last stage, legal factors with a percentage of 6% indicating the need to adhere to local and international regulations and laws related to the preservation of cultural heritage. (Figure 14).

On the other hand, there were many techniques that affected conservation management processes and mitigated the impact of the aforementioned challenges. The most prominent techniques used in this context can be arranged as follows: HBIM (Heritage Building Information Modeling) emerged as the most widely used technique, representing 44% of application across all classifications. It was followed by the AHP

hierarchy, which accounted for 11%, followed by NDT at 9%. Then came: laser scanning, field visits, and laboratory experiments, each of which was used at 8%. Last but not the least, both fuzzy logic and photogrammetry accounted for 6% each (Figure 15). In addition to other techniques that were used in many studies.

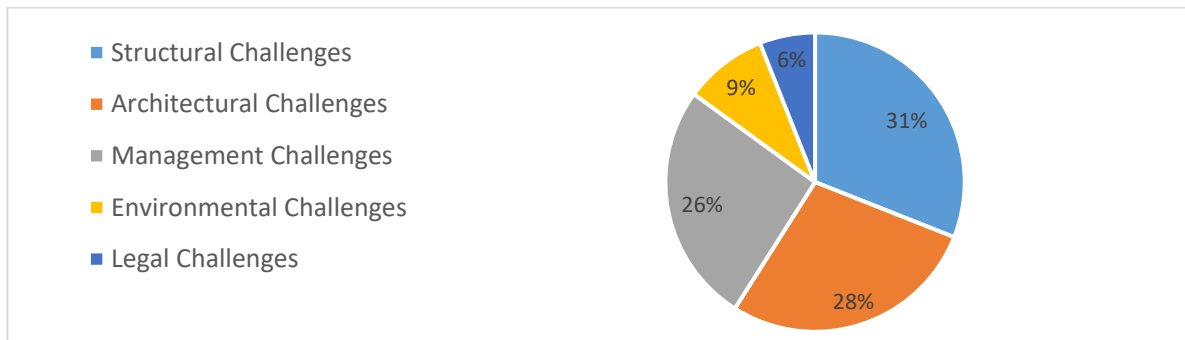


Figure 14. The frequency percentage of all categories.

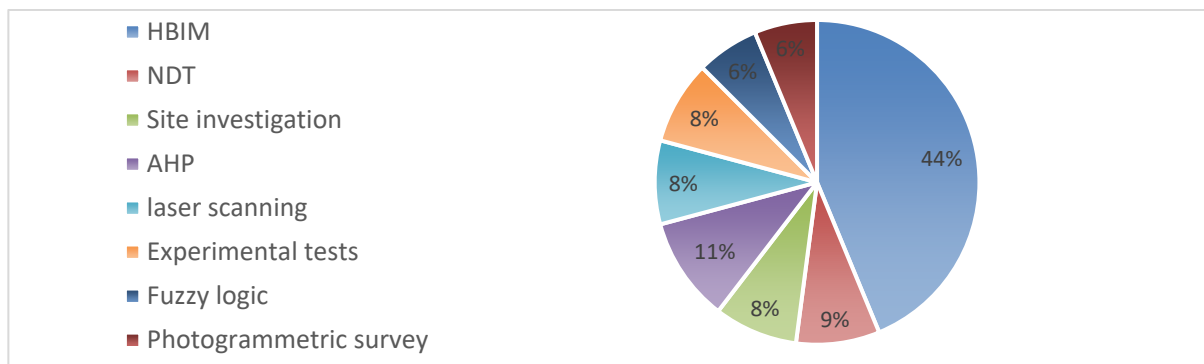


Figure 15. The frequency percentage of common techniques across all categories.

HBIM (Heritage Building Information Model) is one of the modern technologies that contribute to the conservation of cultural heritage, as it provides innovative solutions to a multitude of problems related to the management of heritage buildings, most notably accurate documentation. As a result, it provides comprehensive digital documentation through which decision-making can be improved based on accurate analysis of historical and architectural structures. It can be said that this technology plays an important role in the management of conservation projects as it develops facility management, structural analysis, virtual and augmented reality, and safety design (Universiti Teknologi Malaysia 2019). It is worth noting that this technology has been used since 2008 and is constantly evolving. It provides an opportunity for stakeholders to cooperate and communicate effectively, which ensures the design and management of successful restoration projects (Bastem and Cekmis 2022).

In the future, with the advancement of HBIM, it is expected that this technology will become a key tool in heritage building conservation projects alongside AI tools. HBIM can help reduce costs by improving planning accuracy, avoiding unnecessary modifications, and ensuring the preservation of historical identity. Moreover, it can accelerate process, minimize estimation errors, and improve the overall efficiency of conservation projects management.

Although HBIM technology has proven to be an effective digital tool in heritage building conservation projects, the results revealed that some traditional techniques still play a leading role in addressing many challenges, such as site investigation and experimental testing. The outcomes provided by these methods are often difficult to achieve through technology alone, making them essential for understanding and preserving the physical elements of heritage. Therefore, a balanced combination of HBIM technologies and traditional practices provides a more holistic and comprehensive approach in the context of conservation projects, ensuring a balance between technical innovation and the preservation of cultural continuity.

5.6 Impact of Results on Stakeholders

The research results indicate important impacts on the main stakeholders in heritage building conservation projects. For structural engineers and architects, the proportion of structural and architectural challenges constituted 31 and 27%, respectively, which are the highest proportions among all classifications. These percentages clearly reflect the need to focus on engineering - compatible design solutions that meet the structural needs of the buildings. The use of advanced technologies such as HBIM can help in assessing the risks associated with structural deterioration and providing sustainable solutions. In the same context, architects should find a balance between modern intervention and respect for the original design of the building, as well as attention to documentation, and tools such as laser scanning and photogrammetry offer essential support in this matter.

Project managers can also draw valuable insights from the findings, as the results show the importance of management challenges (26%), including making the right decisions and improving communication among all stakeholders. Managers can benefit from using techniques such as AHP (used by 11%) to improve the process of making complex decisions and systematically evaluating alternatives.

Additionally, government authorities should focus on mitigating damage caused by environmental challenges (9%) by applying techniques such as environmental scanning and laboratory experiments. They should also promote adherence to international conservation charters and guidelines, as legal challenges accounted for 6% only. Enacting consistent regulations aligned with international best practices can support long-term conservation efforts.

Finally, the findings of this study are not limited to practitioners but also extend to senior management bodies and institutions involved in heritage conservation. The classification adopted in the study, which encompass structural, architectural, management, environmental, and legal categories, along with their corresponding mitigation techniques, offer a multidimensional foundation aligned with the theoretical frameworks that underpin tools such as the conservation management plan (CMP) and the heritage impact assessment (HIA).

For example, Structural challenges contribute to the technical evaluation stage at the CMP and help assess the impact of the proposed intervention on the building structural integrity, while management challenges, such as data management and Right Stakeholder Partnership, facilitate coordinated decision making. Architectural, such as accurate documentation, minimal intervention, and reversibility, ensure the authenticity of intervention, and environmental, and legal challenges address risk mitigation and regulatory compliance (Ng 2021), (Johnston 2010).

6.0 CONCLUSIONS

This paper identified, classified, and analyzed the challenges affecting the management of heritage building conservation projects through a systematic review of published literature in Scopus and Web of Science. The research provides a structured understanding that helps researchers and stakeholders identify the core issued and explore appropriate techniques to address them.

The results showed that structural and architectural challenges represented the highest proportion, emphasizing the need to conduct technical evaluations of intervention proposals to preserve structural integrity while also preserving authenticity and historical value. Therefore, decision-making must strike a balance between these two categories to minimize structural risks and avoid cost overrun resulting from poorly informed decisions.

The high percentage of management challenges confirms that conservation projects success is not solely on technical knowledge. Instead, challenges such as effective data management, coordination among stakeholders, and structured decision making play a crucial role in ensuring efficient conservation management process.

In contrast, challenges related to environmental and legal classifications showed less frequency (9% and 6%). However, these factors remain important to ensure compliance with environmental standards, global and local legal regulations and should be taken into account when planning and managing conservation heritage projects.

In terms of the techniques used with the challenges affecting conservation projects, these results confirmed the importance of the diversity of techniques used in this field and highlighted the importance of benefiting from modern techniques such as HBIM, which obtained the highest percentage (44%) among all techniques, as it was used with structural, architectural, and management challenges to a large extent. It was followed by other techniques with varying percentages of 6-11 %.

The findings also indicate that the identified challenges are often interrelated and context dependent. This suggests that decision-making in heritage conservation projects involves complex interactions between multiple factors, which may not be fully captured through simplified or independent evaluation approaches.

Furthermore, the systematic methodological approach adopted in this study can also be beyond the active intervention phase to support the pre-intervention phases, such as maintenance and repair, as part of a long-term conservation strategy. Many of identified challenges, particularly structural, architectural, management challenges, serves as essential foundation of planning for future monitoring and maintenance activities.

RECOMMENDATIONS

Enhance the focus on the structural and architectural challenges to ensure the stability of structures and the preservation of historical identity, while maintaining a balance approach between authenticity and modern functional needs.

Expanding the scope of the future studies to include management challenges that have received limited attention in the current literature, such as resource allocation and building prioritization, due to their direct role in guiding planning and implementation process within heritage conservation projects.

Strengthen the legal and environmental dimensions of conservation projects by referencing relevant charters, such as Venice and Burra, as well as applicable national heritage protection laws. This would enhance compliance with regulatory frameworks and improve effective management of buildings conservation projects.

Broaden the technological landscape in future research. Although HBIM technology emerged as the most widely used tool in the current research review, future research is encouraged to broaden its scope by exploring other advance technologies, such as Digital Twin, and examining their integration with artificial intelligent.

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7.0 REFERENCES

- Abid, Sadiq Khalil, and Tamarah Ameen. 2023. "The Khan Al-Shilan: Appraising and Synthesizing Cultural Heritage Significance and Its Impact on Conservation Practices." *International Journal of Islamic Architecture* 12 (1): 189–209. https://doi.org/10.1386/ijia_00099_1.
- Agliata, Rosa, Dafne D'Aponte, Raffaella Lione, and Luigi Mollo. 2023. "HBIM Tools for Knowledge, Maintenance and Conservation of Concrete Built Heritage." *VITRUVIO-INTERNATIONAL JOURNAL OF ARCHITECTURAL TECHNOLOGY AND SUSTAINABILITY* 8: 98–105. <https://doi.org/10.4995/vitruvio-ijats.2023.19674>.
- Al-Bayari, Omar, and Nawras Shatnawi. 2022. "Geomatics Techniques and Building Information Model for Historical Buildings Conservation and Restoration." *EGYPTIAN JOURNAL OF REMOTE SENSING AND SPACE SCIENCES* 25 (2): 563–68. <https://doi.org/10.1016/j.ejrs.2022.04.002>.

- Al-Sakkaf, Abobakr, Tarek Zayed, and Ashutosh Bagchi. 2020. "A Review of Definition and Classification of Heritage Buildings and Framework for Their Evaluation Destructive Analysis-Based Testing for Cured-in-Place Pipe View Project Self Activated Floating Barriers(SAFB) View Project." 2nd International Conference on New Horizons in Green Civil Engineering, no. August: 1–5. <https://www.researchgate.net/publication/341160581>.
- Aleksic, Julija, Lejla Zecirovic, Danilo Dragovic, Branko Slavkovic, Jasmin Suljevic, and Jelena Bozovic. 2022. "Seismic Rehabilitation Techniques for Conserving and Managing Cultural Heritage of Old City Fortress in Novi Pazar." *APPLIED SCIENCES-BASEL* 12 (23). <https://doi.org/10.3390/app122312018>.
- Alshawabkeh, Yahya, and Ahmad Baik. 2023. "Integration of Photogrammetry and Laser Scanning for Enhancing Scan-to-HBIM Modeling of Al Ula Heritage Site." *HERITAGE SCIENCE* 11 (1). <https://doi.org/10.1186/s40494-023-00997-2>.
- Anaç, M, and G Arun. 2024. "HBIM Supported Archive Model." *JOURNAL OF THE FACULTY OF ENGINEERING AND ARCHITECTURE OF GAZI UNIVERSITY* 39 (1): 443–59. <https://doi.org/10.17341/gazimmfd.1175113>.
- Baggio, C, V Sabbatini, S Santini, and C Sebastiani. 2021. "Comparison of Different Finite Element Model Updates Based on Experimental Onsite Testing: The Case Study of San Giovanni in Macerata." *Journal of Civil Structural Health Monitoring* 11 (3): 767–90. <https://doi.org/10.1007/s13349-021-00480-1>.
- Bailliet, E. 2023. "Dignifying Building Heritage: Essential Interventions in the Wall of Lugo." *VLC Arquitectura* 10 (1): 181–205. <https://doi.org/10.4995/vlc.2023.17627>.
- Bastem, Sumeyye Sena, and Asli Cekmis. 2022. "Development of Historic Building Information Modelling: A Systematic Literature Review." *Building Research and Information* 50 (5): 527–58. <https://doi.org/10.1080/09613218.2021.1983754>.
- Bienvenido-Huertas, David, Miguel León-Muñoz, Juan Jesús Martín-del-Río, and Carlos Rubio-Bellido. 2021. "Analysis of Climate Change Impact on the Preservation of Heritage Elements in Historic Buildings with a Deficient Indoor Microclimate in Warm Regions." *Building and Environment* 200. <https://doi.org/10.1016/j.buildenv.2021.107959>.
- Castellazzi, G, E Cardillo, N Lo Presti, A M D'Altri, S de Miranda, G Bertani, F Ferretti, and C Mazzotti. 2023. "Advancing Cultural Heritage Structures Conservation: Integrating BIM and Cloud-Based Solutions for Enhanced Management and Visualization." *Heritage* 6 (12): 7316–42. <https://doi.org/10.3390/heritage6120384>.
- Cinquelpalmi, F, and V A Tiburcio. 2023. "Sustainable Restoration of Cultural Heritage in the Digital Era." *Vitruvio* 8 (2): 76–87. <https://doi.org/10.4995/vitruvio-ijats.2023.20545>.
- Coelho, C M T, E E C da Silva, and R S Zouain. 2020. "Moorish Pavilion: Preservation Challenges." *HISTORIA CIENCIAS SAUDE-MANGUINHOS* 27 (2): 565–82. <https://doi.org/10.1590/S0104-59702020000200015>.
- Combey, A, A Tricoche, L Audin, D Gandreau, C Benavente Escóbar, J Bastante Abuhadba, H Tavera, and M Á Rodríguez-Pascua. 2021. "Monumental Inca Remains and Past Seismic Disasters: A Relational Database to Support Archaeoseismological Investigations and Cultural Heritage Preservation in the Andes." *Journal of South American Earth Sciences* 111. <https://doi.org/10.1016/j.jsames.2021.103447>.
- Cruz, A, V Coffey, T H.T. Chan, and M Perovic. 2022. "Model for the Maintenance-Focussed Heritage Building Conservation." *Journal of Cultural Heritage Management and Sustainable Development* 12 (4): 309–20. <https://doi.org/10.1108/JCHMSD-09-2020-0127>.
- Cruz, Y, M Cabaleiro, B Conde, B Barros, and B Riveiro. 2024. "Methodology for the Integration of Structural Health Assessment of Masonry Bridges into HBIM." *International Journal of Architectural Heritage*. <https://doi.org/10.1080/15583058.2024.2342950>.

- Cucco, P, G Maselli, A Nesticò, and F Ribera. 2023. "An Evaluation Model for Adaptive Reuse of Cultural Heritage in Accordance with 2030 SDGs and European Quality Principles." *Journal of Cultural Heritage* 59: 202–16. <https://doi.org/10.1016/j.culher.2022.12.002>.
- Cunha Ferreira, T, X Romão, P M Freitas, and H Mendonça. 2023. "Risk Assessment and Vulnerability Analysis of a Coastal Concrete Heritage Structure." *Heritage* 6 (9): 6153–71. <https://doi.org/10.3390/heritage6090323>.
- D'Alpaos, C, and M R Valluzzi. 2020. "Protection of Cultural Heritage Buildings and Artistic Assets from Seismic Hazard: A Hierarchical Approach." *SUSTAINABILITY* 12 (4). <https://doi.org/10.3390/su12041608>.
- Dias, J M, A J Santos, A Pinto, A L Coelho, J Patrício, L Matias, M C Baião, and T O Santos. 2021. "New Performance Needs in Structural and Functional Rehabilitation of Heritage Buildings Due to the Climate Change." *Fib Symposium 2021*: 173–83. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85134843930&partnerID=40&md5=afd07eb3411b6fc6ec2a031eb14639fb>.
- Doğan, Huriye Armağan. 2023. "Reasons for Deterioration of Historical Buildings and the Significance of Memory in the Adaptive Reuse Process of Architectural Heritage: Case Study of Saint Vincent de Paul School in Istanbul." *Widomosci Konserwatorskie* 2023 (73): 24–33. <https://doi.org/10.48234/WK73ISTANBUL>.
- ELDIB, HASSAN. 2024. "National Architectural Heritage Conservation Acts and International Charters: Implementation on Amendment Legislation." *International Design Journal* 14 (5): 540–50. <https://doi.org/10.21608/idj.2024.293952.1151>.
- Falco, Anna De, Francesca Gaglio, Francesca Giuliani, Massimiliano Martino, and Vincenzo Messina. 2024. "An HBIM Approach for Structural Diagnosis and Intervention Design in Heritage Constructions: The Case of the Certosa Di Pisa." *HERITAGE* 7 (4): 1850–69. <https://doi.org/10.3390/heritage7040088>.
- Fortuné, I, and P Donnet. 2023. "Systemic Approach for a Controlled Rehabilitation of Heritage Buildings." *Materials Today: Proceedings* 85: 87–94. <https://doi.org/10.1016/j.matpr.2023.05.266>.
- Garcia-Castillo, E, I Paya-Zaforteza, and A Hospitaler. 2023. "Fire in Heritage and Historic Buildings, a Major Challenge for the 21st Century." *Developments in the Built Environment* 13. <https://doi.org/10.1016/j.dibe.2022.100102>.
- Ge, Y W, B X Guo, P S Zha, S Jiang, Z Y Jiang, and D M Li. 2024. "3D Reconstruction of Ancient Buildings Using UAV Images and Neural Radiation Field with Depth Supervision." *REMOTE SENSING* 16 (3). <https://doi.org/10.3390/rs16030473>.
- Giuliani, Francesca, Francesca Gaglio, Massimiliano Martino, and Anna De Falco. 2024. "A HBIM Pipeline for the Conservation of Large-Scale Architectural Heritage: The City Walls of Pisa." *HERITAGE SCIENCE* 12 (1). <https://doi.org/10.1186/s40494-024-01141-4>.
- Greco, A, V Giacometti, M Rota, I E Senaldi, and A Penna. 2021. "Integrated Strategies for Preserving and Enhancing the Historical Heritage of the University of Pavia." *Sustainability (Switzerland)* 13 (2): 1–25. <https://doi.org/10.3390/su13020783>.
- Guner, Aysun Ferrah, and Gulhan Benli. 2019. "Project Management in Conservation and Restoration of Historic Buildings." *SAR Journal* 2 (1): 24–30. <https://doi.org/10.18421/SAR21-04>.
- Habib, S. 2022. "Oudlājān Documentation Project: A Voluntary Challenge." *International Journal of Environmental Studies* 79 (2): 337–55. <https://doi.org/10.1080/00207233.2022.2033486>.
- Herban, S, D Costantino, V S Alfio, and M Pepe. 2022. "Use of Low-Cost Spherical Cameras for the Digitisation of Cultural Heritage Structures into 3D Point Clouds." *Journal of Imaging* 8 (1). <https://doi.org/10.3390/JIMAGING8010013>.

- Hoveidae, N, A Fathi, and S Karimzadeh. 2021. "Seismic Damage Assessment of a Historic Masonry Building under Simulated Scenario Earthquakes: A Case Study for Arge-Tabriz." *Soil Dynamics and Earthquake Engineering* 147. <https://doi.org/10.1016/j.soildyn.2021.106732>.
- Hussein, A T A, and T A H Mousa. 2024. "The Impact of Engineering Software on Documentation and Preserving Cultural Heritage: A Case Study of AL-Ghulitha Heritage Outpost in AL Muthanna Governorate." *Scholar Journal for Sciences & ...*, no. 3: 3–16. <https://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=27944549&AN=175953712&h=0NHJTodDtI5WBkzbnFvzd4%2FV8EDNT8mWHn4aXarQ84xmknPh5uzARhZ3hFOOuz3JGf72dulLq9n%2FOkO%2Fam3IKg%3D%3D&crl=c>.
- ICOMOS. 1964. "The Venice Charter 1964." *IInd International Congress of Architects and Technicians of Historic Monuments*, 1–4.
- . 1982. "Declaration of Dresden on the 'Reconstruction of Monuments Destroyed by War.'" *ICOMOS National Committee of the German Democratic Republic* 46 (2): 55. http://www.icomos.org.tr/Dosyalar/ICOMOSTR_en0824652001587379863.pdf.
- . 1994. "The Nara Document on Authenticity." *Knowledge Creation Diffusion Utilization* 309: 9–12. <http://whc.unesco.org/uploads/events/documents/event-833-3.pdf>.
- . 2003. "ICOMOS (2003) - ICOMOS Charter." *Princi*ICOMOS. (2003). ICOMOS (2003) - ICOMOS Charter. In 14^o Asamblea General Del ICOMOS. Zimbabwe (Ed.), *Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage* (p. 4). https://www.icomos.org/charters/structures_e.p, 4. https://www.icomos.org/charters/structures_e.pdf.
- International Council on Monuments and Sites (ICOMOS). 1931. "The Athens Charter for the Restoration of Historic Monuments." https://civvih.icomos.org/wp-content/uploads/2022/03/The-Athens-Charter_1931.pdf.
- Johnston, Chris. 2010. "Conservation Management Plans: Managing Heritage Places." *Heritage Council of Victoria's Technical Advisory Committee and Heritage Victoria* 3 (12): 55–60. http://www.dtpli.vic.gov.au/_data/assets/pdf_file/0003/219927/CMP_Guide_1278369664770.pdf.
- Jouan, P, and P Hallot. 2020. "Digital Twin: Research Framework to Support Preventive Conservation Policies." *ISPRS INTERNATIONAL JOURNAL OF GEO-INFORMATION* 9 (4). <https://doi.org/10.3390/ijgi9040228>.
- Kallas, J, and R Napolitano. 2023. "Image-Based 3D Modeling as a Damage Prioritization Tool for Historic Buildings in Post-Disaster Areas: The Case of the 2020 Beirut Blast." *Journal of Cultural Heritage* 62: 314–21. <https://doi.org/10.1016/j.culher.2023.06.007>.
- Karasaka, Lutfiye, and Neslisah Ulutas. 2023. "Point Cloud-Based Historical Building Information Modeling (H-BIM) in Urban Heritage Documentation Studies." *SUSTAINABILITY* 15 (13). <https://doi.org/10.3390/su151310726>.
- Karimi, Farzaneh, Nima Valibeig, Gholamhossein Memarian, and Aliakbar Kamari. 2022. "Sustainability Rating Systems for Historic Buildings: A Systematic Review." *Sustainability (Switzerland)* 14 (19). <https://doi.org/10.3390/su141912448>.
- Khan, Muhammad Shoaib, Muhammad Khan, Mushk Bughio, Bushra Danish Talpur, In Sup Kim, and Jongwon Seo. 2022. "An Integrated HBIM Framework for the Management of Heritage Buildings." *BUILDINGS* 12 (7). <https://doi.org/10.3390/buildings12070964>.
- Kotova, Lola, Johanna Leissner, Matthias Winkler, Ralf Kilian, Stefan Bichlmair, Florian Antretter, Jürgen Moßgraber, et al. 2023. "Making Use of Climate Information for Sustainable Preservation of Cultural Heritage: Applications to the KERES Project." *Heritage Science* 11 (1): 1–18. <https://doi.org/10.1186/s40494-022-00853-9>.

- Lasorella, Margherita, Pasquale de-Dato, and Elena Cantatore. 2024. "WEB-BASED PLATFORM TO COLLECT, SHARE AND MANAGE TECHNICAL DATA OF HISTORICAL SYSTEMIC ARCHITECTURES: THE TELEGRAPHIC TOWERS ALONG THE MADRID-VALENCIA PATH." *VIRTUAL ARCHAEOLOGY REVIEW* 15 (30): 123–40. <https://doi.org/10.4995/var.2024.20341>.
- Liberotti, R, and V Gusella. 2023. "Parametric Modeling and Heritage: A Design Process Sustainable for Restoration." *SUSTAINABILITY* 15 (2). <https://doi.org/10.3390/su15021371>.
- Lin, Francis Chia Hui. 2024. "Crafting Theories about Living Heritage: The Postcolonial Condition of Contemporary Asian Architecture and Urbanism as an Asian 'Display.'" *Journal of Asian Architecture and Building Engineering* 00 (00): 1–12. <https://doi.org/10.1080/13467581.2024.2412134>.
- Maheri, M R, M A Najafgholipour, and S Zarandi. 2023. "Seismic Rehabilitation of URM Heritage-Listed Namazi School Building Using Multiple Retrofitting Techniques." *JOURNAL OF BUILDING ENGINEERING* 79. <https://doi.org/10.1016/j.jobe.2023.107782>.
- Maričić, A, Z Briševac, P Hrženjak, and H Jezidžić. 2023. "Natural Building Stone in the Construction and Renovation of the Zagreb Cathedral." *Rudarsko Geolosko Naftni Zbornik* 38 (3): 29–42. <https://doi.org/10.17794/rgn.2023.3.3>.
- Maselli, G, P Cucco, A Nesticò, and F Ribera. 2024. "Historical Heritage-MultiCriteria Decision Method (H-MCDM) to Prioritize Intervention Strategies for the Adaptive Reuse of Valuable Architectural Assets." *METHODS* 12. <https://doi.org/10.1016/j.mex.2023.102487>.
- Matias, M, F Almeida, R Moura, and N Barraca. 2021. "High Resolution NDT in the Characterization of the Inner Structure and Materials of Heritage Buildings Walls and Columns." *CONSTRUCTION AND BUILDING MATERIALS* 267. <https://doi.org/10.1016/j.conbuildmat.2020.121726>.
- Mendoza, M, M Torres-González, and A J Prieto. 2024. "Machine-Learning Algorithms in the Service Life Prediction of Facility Management: Approach in Southern Chile." *JOURNAL OF PERFORMANCE OF CONSTRUCTED FACILITIES* 38 (2). <https://doi.org/10.1061/JPCFEV.CFENG-4572>.
- Miran, Fenk D., and Husein A. Husein. 2024. "Evaluating Deterioration Causes and Defect Patterns in Heritage Buildings: A Comprehensive Analytical Approach." *International Journal of Architectural Heritage*, no. June. <https://doi.org/10.1080/15583058.2024.2367690>.
- Moher, David, Alessandro Liberati, Jennifer Tetzlaff, and Douglas G. Altman. 2009. "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement." *BMJ (Online)* 339 (7716): 332–36. <https://doi.org/10.1136/bmj.b2535>.
- Moyano, J, E Carreño, J E Nieto-Julián, I Gil-Arizona, and S Bruno. 2022. "Systematic Approach to Generate Historical Building Information Modelling (HBIM) in Architectural Restoration Project." *Automation in Construction* 143. <https://doi.org/10.1016/j.autcon.2022.104551>.
- Multi-criteria analysis to assess conservation states of walls in Salé Medina in Morocco Elhachmi, D, L Bahi, L Ouadif, Y Bahi, and A Ait Errouhi. 2020. "Multi-Criteria Analysis to Assess Conservation States of Walls in Salé Medina in Morocco." *International Journal of Advanced Research in Engineering and Technology* 11 (4): 147–54. <https://doi.org/10.34218/IJARET.11.4.2020.016>.
- Nadali, D. 2023. "How to Deal with Adobe Architecture in the Ancient Near East: The Case of Ebla in Syria." *Heritage* 6 (2): 1856–70. <https://doi.org/10.3390/heritage6020099>.
- National Policy of Iraq N.55. 2002. "Law No.55 of 2002 for the Antiquities & Heritage of Iraq," no. 55: 1–20. <https://www.cemml.colostate.edu/cultural/09476/pdf/iraq-antiquities-law-2002.pdf>.
- Ng, Junn. 2021. "Importance of Heritage Impact Assessment in Infrastructure Projects." *The Ingenieur* 85 (March): 6–14. <https://doi.org/10.5281/zenodo.14267724>.

- Nursanty, Eko, Djudjun Rusmiatmoko, and Muhammad Fahd Diyar Husni. 2023. "From Heritage to Identity: The Role of City Authenticity in Shaping Local Community Identity and Cultural Preservation." *Journal of Architecture and Human Experience* 1 (2): 131–50. <https://doi.org/10.59810/archimane.v1i2.17>.
- Obed Livingstone Banda, Lazarus, Chigonjetso Victoria Banda, Jane Thokozani Banda, and Tapiwa Singini. 2024. "Preserving Cultural Heritage: A Community-Centric Approach to Safeguarding the Khulubvi Traditional Temple Malawi." *Heliyon* 10 (18): e37610. <https://doi.org/10.1016/j.heliyon.2024.e37610>.
- Pérez-Guilarte, Yamilé, Inês Gusman, and Rubén Camilo Lois González. 2023. "Understanding the Significance of Cultural Heritage in Society from Preschool: An Educational Practice with Student Teachers." *Heritage* 6 (9): 6172–88. <https://doi.org/10.3390/heritage6090324>.
- Piaia, E, F Maietti, R Di Giulio, O Schippers-Trifan, A Van Delft, S Bruinenberg, and R Olivadese. 2021. "BIM-Based Cultural Heritage Asset Management Tool. Innovative Solution to Orient the Preservation and Valorization of Historic Buildings." *INTERNATIONAL JOURNAL OF ARCHITECTURAL HERITAGE* 15 (6): 897–920. <https://doi.org/10.1080/15583058.2020.1734686>.
- Pinti, Lidia, and Serena Bonelli. 2022. "A Methodological Framework to Optimize Data Management Costs and the Hand-Over Phase in Cultural Heritage Projects." *BUILDINGS* 12 (9). <https://doi.org/10.3390/buildings12091360>.
- Pizzigatti, C, and E Franzoni. 2021. "The Problem of Conservation of XX Century Architectural Heritage: The Fibreglass Dome of the Woodpecker Dance Club in Milano Marittima (Italy)." *Journal of Building Engineering* 42. <https://doi.org/10.1016/j.jobe.2021.102476>.
- Prieto-Vicioso, E, V Flores-Sasso, and G Fernández-Flores. 2022. "Reuse, a Challenge for the Preservation of 20th Century Heritage. The Royal Bank of Canada, Santo Domingo, Dominican Republic." *Communications in Computer and Information Science* 1645: 207–22. https://doi.org/10.1007/978-3-031-20302-2_16.
- Prieto, A J. 2021. "Fuzzy Systems in the Digital Management of Heritage Timber Buildings in South Chile." *BUILDING RESEARCH AND INFORMATION* 49 (8): 878–92. <https://doi.org/10.1080/09613218.2021.1889350>.
- Prizeman, O, C Pezzica, A Taher, and M Boughanmi. 2020. "Networking Historic Environmental Standards to Address Modern Challenges for Sustainable Conservation in HBIM." *Applied Sciences (Switzerland)* 10 (4). <https://doi.org/10.3390/app10041283>.
- Quek, J, and R Rajeev. 2023. "Restoration Works to Existing Heritage Conservation Building at Upper East Coast Road, Singapore." *Lecture Notes in Civil Engineering* 319: 1–11. https://doi.org/10.1007/978-981-19-9394-7_1.
- Re, P Di, E Lofrano, J Ciambella, and F Romeo. 2021. "Structural Analysis and Health Monitoring of Twentieth-Century Cultural Heritage: The Flaminio Stadium in Rome." *SMART STRUCTURES AND SYSTEMS* 27 (2): 285–303. <https://doi.org/10.12989/sss.2021.27.2.285>.
- Rolfesen, C N, A K Lassen, S M Lein, and E Z Zabrodina. 2023. "The Use of HBIM and Scanning in Cultural Heritage Projects." *EWork and EBusiness in Architecture, Engineering and Construction - Proceedings of the 14th European Conference on Product and Process Modelling, ECPPM 2022*, 285–92. <https://doi.org/10.1201/9781003354222-37>.
- Rossitti, Marco, Annunziata Maria Oteri, and Francesca Torrieri. 2025. "The Social Value of Built Heritage: An Interdisciplinary Discourse." *Built Heritage* 9 (1). <https://doi.org/10.1186/s43238-025-00173-4>.
- Ruiz-Jaramillo, J, C Muñoz-González, M D Joyanes-Díaz, E Jiménez-Morales, J M López-Osorio, R Barrios-Pérez, and C Rosa-Jiménez. 2020. "Heritage Risk Index: A Multi-Criteria Decision-Making Tool to

- Prioritize Municipal Historic Preservation Projects.” *FRONTIERS OF ARCHITECTURAL RESEARCH* 9 (2): 403–18. <https://doi.org/10.1016/j.foar.2019.10.003>.
- Saba, M, G E Chanchí Golondrino, and L K Torres-Gil. 2023. “A Critical Assessment of the Current State and Governance of the UNESCO Cultural Heritage Site in Cartagena de Indias, Colombia.” *Heritage* 6 (7): 5442–68. <https://doi.org/10.3390/heritage6070287>.
- Sámamo Chong, M, I F Calderas, and M L D Osnaya. 2020. “Organic Relationship between Architecture and Decorative Elements: Challenges in the Conservation of the Aztec Skull Altar, Mexico City.” *Studies in Conservation* 65: 276–79. <https://doi.org/10.1080/00393630.2020.1780856>.
- Sarhan, H R, and F M Abed. 2021. “The Feasibility of Using UAV Structure from Motion Photogrammetry to Extract HBIM of the Great Ziggurat of UR.” *Iraqi Journal of Science* 62 (11): 4518–28. [https://doi.org/10.24996/ij.s.2021.62.11\(SI\).31](https://doi.org/10.24996/ij.s.2021.62.11(SI).31).
- Serrano, Teddy, Thomas Kampmann, and Morten W. Ryberg. 2022. “Comparative Life-Cycle Assessment of Restoration and Renovation of a Traditional Danish Farmer House.” *Building and Environment* 219 (May). <https://doi.org/10.1016/j.buildenv.2022.109174>.
- Shao, M, X Liang, Y Wang, Z Wang, and L Li. 2023. “An Overview of Some Traditional Materials Used in Linear Fortification Structures in Coastal Regions of China: Implications for Their Analytical Study and Conservation.” *Bulletin of Engineering Geology and the Environment* 82 (12). <https://doi.org/10.1007/s10064-023-03477-w>.
- Sharif, Mohammad O., Fyeza N.Janjua Sharif, Hesham Ali, and Farooq Ahmed. 2013. “Systematic Reviews Explained: AMSTAR-How to Tell the Good from the Bad and the Ugly.” *Oral Health and Dental Management* 12 (1): 9–16.
- Solla, Mercedes, Luisa M S Goncalves, Gil Goncalves, Carina Francisco, Ivan Puente, Paulo Providencia, Florindo Gaspar, and Hugo Rodrigues. 2020. “A Building Information Modeling Approach to Integrate Geomatic Data for the Documentation and Preservation of Cultural Heritage.” *REMOTE SENSING* 12 (24). <https://doi.org/10.3390/rs12244028>.
- Truscott, Marilyn Claire. 2014. “Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance (1999).” *Encyclopedia of Global Archaeology*, 1078–82. https://doi.org/10.1007/978-1-4419-0465-2_1046.
- Universiti Teknologi Malaysia. 2019. “4 Th International Conference on Water Resources,” 855.
- UNSECO. 1972. “UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANISATION CONVENTION CONCERNING THE PROTECTION OF THE WORLD CULTURAL Adopted by the General Conference at Its Seventeenth Session English Text.” *Heritage*, no. november.
- Ursu, Viorica, Natalia Chiriac, and Ina Bostan. 2022. “Heritage—Polysemantic Analysis of the Concept: Criteria, Forms, Definitions, and Particularities.” *OALib* 09 (06): 1–28. <https://doi.org/10.4236/oalib.1108934>.
- Villarejo, P, R Gámez, and Á Santamaría-López. 2021. “Building Renovation Passports in Spain: Integrating Existing Instruments for Building Conservation, Renovation and Heritage Protection.” *Energy Policy* 157. <https://doi.org/10.1016/j.enpol.2021.112506>.
- Zhang, X, R Ma, and R Gao. 2021. “Detection of Changes of Ancient Buildings from Terrestrial Laser Scanning and Hyperspectral Imaging.” *Scanning* 2021. <https://doi.org/10.1155/2021/3760592>.