Research Article GU J Sci, Part B, 12(3): 461-475 (2024)

Gazi University

Journal of Science

PART B: ART, HUMANITIES, DESIGN AND PLANNING

http://dergipark.gov.tr/gujsb

Conservation and Restoration of Historic Buildings: Application of Contemporary Addition Construction Techniques in the Case of Turkey

Furkan KARAÇOR[1,*], Mustafa DERELİ[2]

[1] *0000-0002-3165-7481, Necmettin Erbakan Üniversitesi, Fen Bilimleri Enstitüsü, Mimarlık A.B.D., Konya*

[2] *0000-0003-4678-873X, Necmettin Erbakan Üniversitesi, Güzel Sanatlar ve Mimarlık Fakültesi, Mimarlık Bölümü, Konya*

Article Info

Received: 03/07/2024
Accepted: 15/09/2024

Keywords

Conservation of Historic Buildings,
Restoration,
Contemporary Additional Construction Techniques,
Cultural Heritage,

Abstract

Historical buildings are important heritages reflecting the cultural identity and aesthetic values of societies. The conservation and restoration of these structures requires the integration of modern technologies as well as traditional methods. The aim of the study is to examine the process and results of the application of documentation and techniques used on selected buildings. The buildings considered within the scope of the study include Süleymaniye Mosque in Istanbul, Edirnekapı Mihrimah Sultan Mosque, Sultan Suyu Fountain in Konya, Sahabiye Madrasah in Kayseri and Payas Sokullu Mehmet Pasha Complex in Hatay. In the Süleymaniye Mosque, digital modelling and analysis was carried out with reverse structural engineering, and in the Mihrimah Sultan Mosque, the durability of wooden structures was increased with carbon fibre reinforced polymers (CFRP). Three-dimensional modelling was carried out with photogrammetry techniques at Sultan Suyu Fountain, and three-dimensional scanning and modelling techniques were used at Sahabiye Madrasah to digitise the structure. In Payas Sokullu Mehmet Pasha Complex, cracks between stone and marble blocks were filled with micro sandblasting technique. The advantages and evaluation of these techniques when applied correctly are also emphasised. The use of modern additional construction methods and documentation techniques in the conservation of historical buildings ensures that these buildings are carried to the future in a safe and aesthetically satisfying way.The safe transfer of these structures to the future will shed light on the next generations to obtain more detailed information about the present and the past.

1. INTRODUCTION

Historical buildings are important objects that reflect the past, cultural identity and aesthetic values of a society. In addition to being of great architectural and engineering value, these buildings are valuable heritages in terms of recognising societies, settlements and cultures and transferring them to future generations. The conservation and restoration of these structures has not been limited to the methods used in the past due to the lack of access to the materials of the past and the time and cost loss of applying the methods of the past. Today, all the possibilities of modern technology and construction techniques are tried to be integrated into these buildings in order to preserve the historical buildings inherited from the past. Contemporary extension techniques ensure both the preservation of historic buildings and their adaptation to today's living conditions [1-2]. These methods not only preserve the original texture and aesthetic value of the building, but also extend its lifespan by increasing its structural durability [3-4].

The restoration of historic buildings is of great importance not only for aesthetic reasons but also for the functionality and safety of the building [5]. In terms of aesthetics, a building should reflect its originality and the conditions of the period in which it was built. However, since the buildings are weakening statically day by day, these weaknesses should be eliminated without delay. The beginning of the conservation of buildings, both aesthetically and statically, dates back to the early 19th century [6]. Since then, the principles of conservation have been systematised, developed and spread across the world in an organised manner. Modern techniques used in the conservation and restoration of historic buildings have

* Corresponding author: furkankaracor97@gmail.com

become more effective with the integration of modern engineering and architectural practices [7]. Developing technology brings innovations to the field of restoration every day; these innovations are more effective in terms of cost and ease of application compared to the technologies of the past. However, rather than cost and ease of application, the restoration and conservation processes have made it easier to preserve the cultural and historical values of historical buildings and to carry these buildings to the future [8].

The basic principles adopted in restoration and conservation processes have been determined within the framework of international standards and guidelines. These principles aim to increase the effectiveness of the methods used in the conservation and restoration of historical buildings [9]. In the restoration process, taking care to protect the historical and cultural values of the building is critical for the successful realisation of the restoration [1].

In restoration works, it is essential to respect the original structure and provide protection with as little intervention as possible [10]. However, internal and external factors such as damages occurring over time, material deformations, natural disasters may jeopardise the safety of the structure. Under such circumstances, repairs restricted to restoring the building to its original state might not be adequate. One way to get around this annoying process is to use modern additional construction techniques. Modern addition construction techniques strengthen the structure and aid in maintaining its distinctive beauty and historical significance [11–13]. The innovations applied during the restoration process preserve the historical and cultural identity of the building and increase its physical stability. As a result, it is ensured that it is carried to the present day while preserving its historical significance and appearance. The restoration procedure guarantees the safe and visual preservation of the historic building. In addition, the modern methods used allow the process to proceed quickly and effectively [14].

The additional construction methods used provide different perspectives and application methods to continuous self-renewal and renovation works with the development of technology. These modern methods used in the restoration of historical buildings allow the current condition of the building to be analysed in detail, as well as ensuring that the necessary interventions are made in the most appropriate way [15]. When applied correctly, it virtually guarantees the building's lifespan and provides significant advantages for the restoration process [16–18].

Five significant historical Turkish buildings—the Payas Sokullu Mehmet Pasha Complex in Hatay, the Sultan Suyu Fountain in Konya, the Mihrimah Sultan Mosque in Edirnekapı, the Sahabiye Madrasah in Kayseri, and the Süleymaniye Mosque in Istanbul—will be the subject of this study's examination of the application of contemporary addition construction techniques.

The main purpose of the study is to investigate the methods of use of contemporary additional construction techniques used in the restoration of important historical buildings in Turkey. Their effects on structural conservation were analysed. The research is addressed in four main areas. How to proceed in future restoration works, the use of existing technology and how to improve the restoration processes are addressed. The role of contemporary extension techniques in the conservation of historic buildings is emphasised, while demonstrating the practical and effective aspects of these techniques. This will make it easier to guarantee the safe and aesthetic transfer of cultural heritage for future generations. The modern techniques used in the restoration of the studied buildings will serve as a template for future work aimed at the preservation and transmission of these historic buildings to future generations.

2. METHOD

This research looks into preserving five important historic buildings in Turkey while also utilizing contemporary building techniques. Hatay Payas Sokullu Mehmet Pasha Complex, Kayseri Sahabiye Madrasah, Konya Sultan Suyu Fountain, Istanbul Süleymaniye Mosque, and Edirnekapı Mihrimah Sultan Mosque are among the chosen structures that fall under the purview of this study. These structures were chosen because they are some of the last surviving examples in Turkey. A survey of the literature that concentrated on contemporary construction methods also influenced the choice. In the literature review,

the selected techniques and documentation methods and their reflections on historical buildings were extensively investigated. As a result of this research, relevant documentation and construction techniques were matched with a small number of buildings. On the matched buildings, the selection was made according to their regional and national value.

A total of four actions were involved in the procedure: 1. Review of Literature: An extensive study was carried out on both modern and traditional approaches to historic building restoration. The method involved gathering information from books, reports, academic journals, among other sources that provided valuable data related to the topic. 2. Case Analysis: Five historical buildings underwent a detailed case analysis where every aspect of the restoration technique was critically looked into, particularly how it impacted the structural and aesthetic value of the building. 3. Comparative Analysis: This was done by comparing results from different cases to ascertain benefits and applicability of each technique; this helps determine whether modern construction methods suit preservation of historic structures and their prospective use in future. 4. Conclusion and Recommendations: Drawing from the research results, conclusions and suggestions for upcoming restoration projects are offered. A focus on the significance of modern addition construction methods for historic building conservation and restoration is emphasized.

3. EXAMPLES FROM TURKEY

In this section, the structures of Süleymaniye Mosque in Istanbul, Edirnekapı Mihrimah Sultan Mosque, Sultan Suyu Fountain in Konya, Sahabiye Madrasah in Kayseri, and Payas Sokullu Mehmet Pasha Complex in Hatay are mentioned.

3.1. Süleymaniye Mosque in Istanbul

Süleymaniye Mosque is an Ottoman masterpiece completed in 1557 and built by Mimar Sinan [19]. The mosque is one of the most extreme points of architecture and engineering of the period it was built. However, over time, natural disasters, humidity, air pollution and other environmental factors have caused damage to various parts of the building [20]. Therefore, the restoration of the mosque has become inevitable. This restoration work was carried out by using a combination of various traditional and contemporary methods.

One of the important techniques used in the restoration of the Süleymaniye Mosque is reverse structural engineering. Reverse structural engineering enables the existing condition of the building to be digitally modelled and analysed [21]. In this way, weak points and damaged areas of the structure are identified and necessary interventions are made. Reverse structural engineering allows the restoration process to be carried out more precisely and safely [22]. A safe restoration is the top priority for a building such as Istanbul Süleymaniye Mosque, which is one of the most important building works of its period.

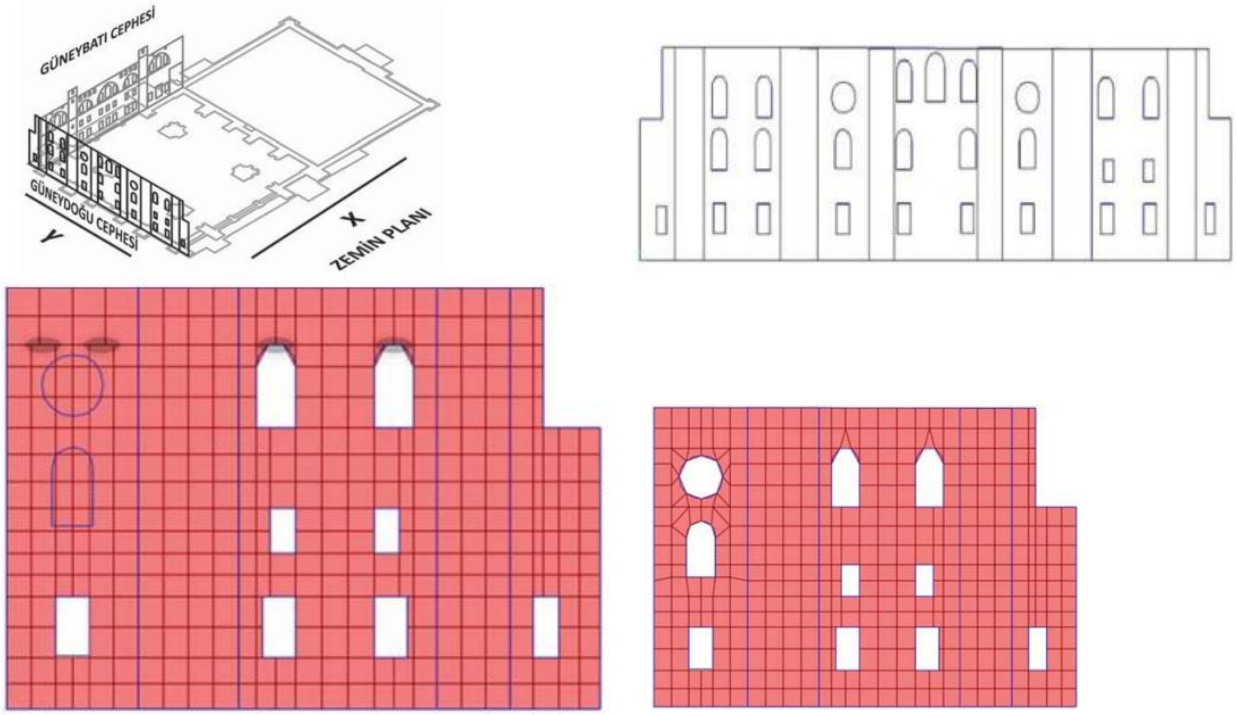


Figure 1. *Istanbul Süleymaniye Mosque two dimensional drawings and damage map prepared with AutoCAD and SAP2000 programmes* [23]

Two-dimensional plan and elevation diagrams of Istanbul Süleymaniye Mosque were initially prepared with AutoCAD and SAP2000 programmes [23]. These two-dimensional drawings were used as a basis for modelling. The study facilitated the transition to three dimensions as well as the planar detection of damaged points.

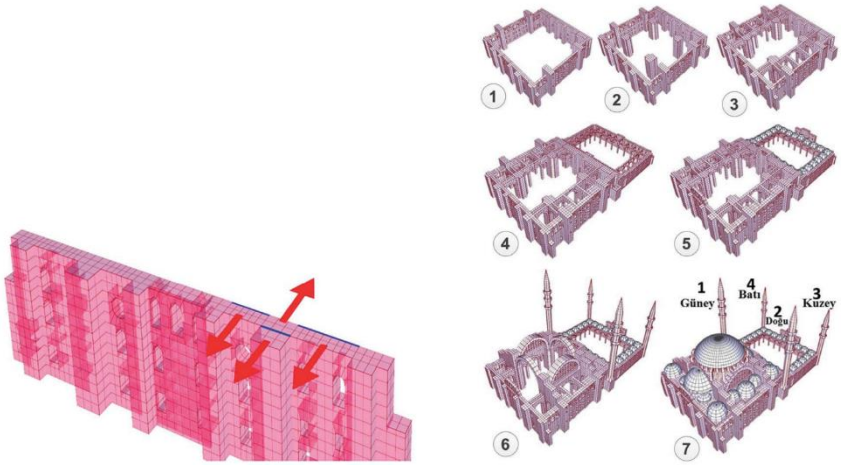
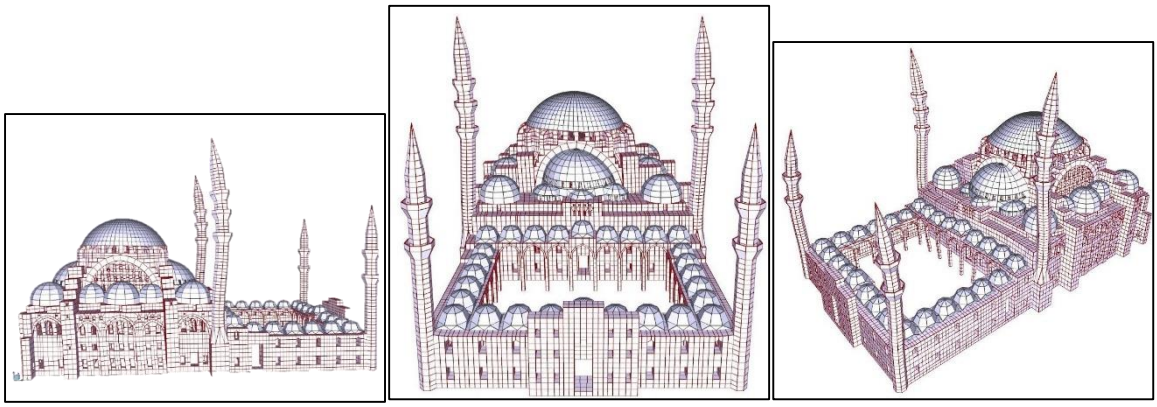


Figure 2. *Stages of solidification of two-dimensional shapes* [23]

After the creation of the two-dimensional shapes and the two-dimensional damage map, the transition from the second dimension to the third dimension was carried out [23]. These procedures are derived to predict which problems two-dimensional damages may cause in the real plane. The gradual realisation of the transition to these three dimensions is more effective than the extraction in a single piece in terms of determining the exact locations where the damage assessment can be performed.



(a) (b) (c)

Figure 3. *Istanbul Süleymaniye Mosque (a) X, (b) Y and (c) Z Axis Torsional Movement Torsion Prediction [23]*

In the last stage, three-way current damage and probable future damage were estimated from the three-dimensional shape [23]. The points that may be problematic in the future were predetermined with the reverse engineering study technique. As a result of the determination, the places that should be given importance in the restoration process were determined. In the intervention stages, this process will be followed from general to specific.

3.2. Edirnekapı Mihrimah Sultan Mosque

Edirnekapı Mihrimah Sultan Mosque, which reflects the elegant details of Ottoman period architecture and the mastery of Mimar Sinan, was built in the 16th century. However, over time, the wooden materials have worn out and jeopardised the integrity of the structure. Modern wood construction techniques and carbon fibre reinforced polymers (CFRP) play an important role in the preservation of such historical buildings [24]. Modern versions of timber construction techniques preserve the original texture of historic timber structures while increasing their durability [25-27]. Due to these features, the method is frequently used in sustainable conservation and restoration studies.

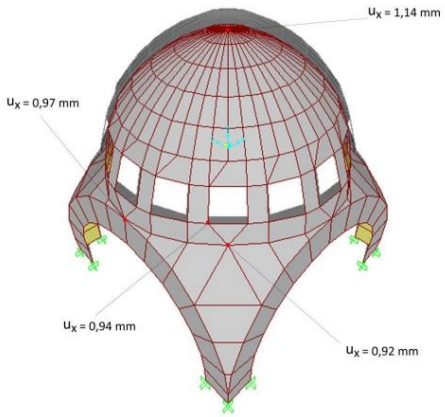


Figure 4. *Edirnekapı Mihrimah Sultan Mosque Dome, Arches And Pendentives As They Are Now And Their Displacement After CFRP Application [28]*

The amount of displacement in the current condition is higher than before the CFRP application and the biggest difference is at the pendentives [28]. Since the CFRP technique uses polymer material, it has increased stability as it reduces the amount of displacement and shrinkage. After the analysis process of the model is carried out, x- and y-directional measures are examined.

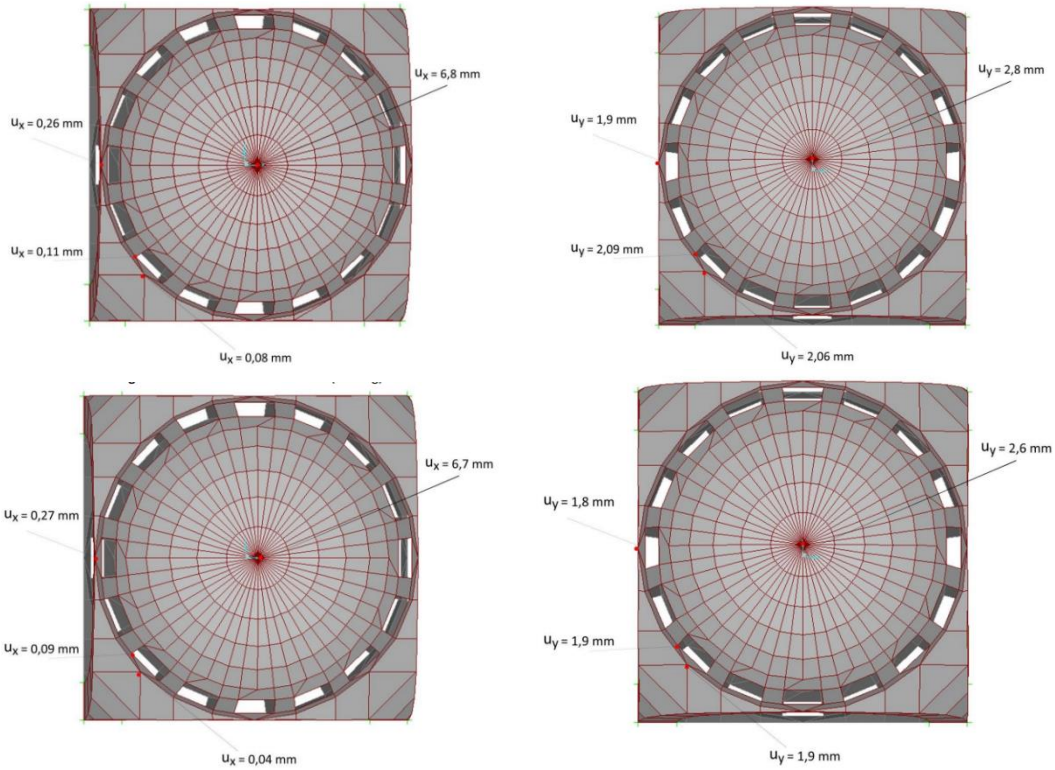


Figure 5. *X- and Y-directional Shifts of Edirnekapı Mihrimah Sultan Mosque Domes, Arches and Pendentives after Existing Conditions and CFRP Application [28]*

As a result of the comparison, a good improvement in x and y direction slip was observed after CFRP application [28]. The reduction of X and Y axis motion showed that CFRP application increased the stability in this analysis. Then the overall tensile and tensile forces are compared on the diagram.

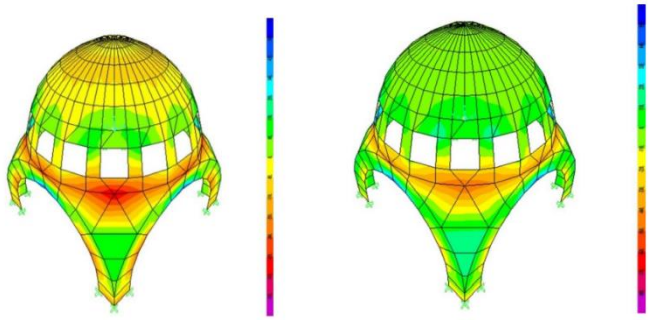


Figure 6. *Existing Condition And Tensile Force After CFRP Application [28]*

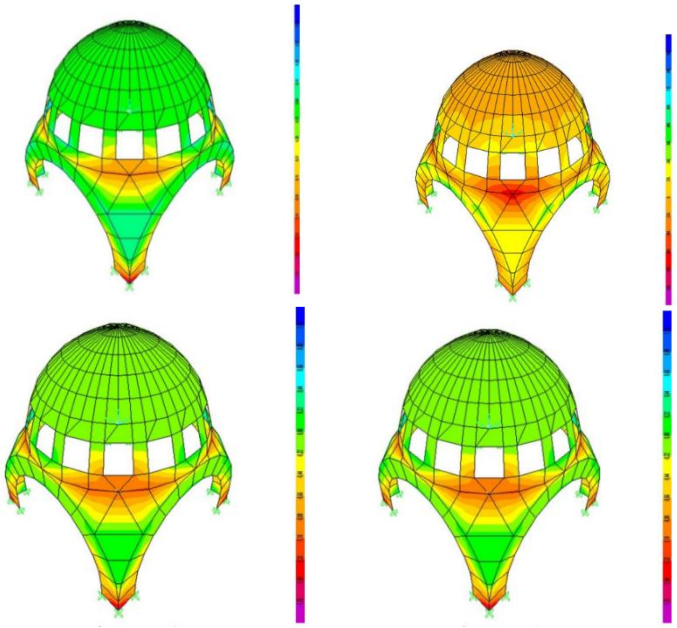


Figure 7. *Current Situation And Draft Forces After CFRP Application [28]*

After CFRP application, the push and pull forces in domes, vaults and pendentives became more stable. With the CFRP work, the building has become more seismically resistant while preserving its historical and aesthetic features [28]. Since the CFRP technique uses polymer material, it can be used more frequently in the repair of historical buildings in places with high earthquake risk, as it provides significant contributions to flexibility and durability properties.

3.3. Sultan Suyu Fountain in Konya

Taşkent Sultan Fountain is located in Taşkent district of Konya and was built during the reign of the Seljuk Sultan Alaeddin Keykubat, after the Sultan liked the quality of the water in this region [29]. The fountain bears the distinctive water structures features of Seljuk architecture. In the process, the structure was damaged by natural and human factors. During the restoration process, a three-dimensional template was created using photogrammetry techniques.

Photogrammetry is a technique used to create three-dimensional models of historical buildings and artefacts. This technique has been effective in precisely documenting and preserving the current condition of the Tashkent Sultan Fountain. Photogrammetry provides ease of application to the field part of the repair work to be carried out by analysing the current condition of historical buildings in a short time [30]. First of all, the necessary technical equipment for the study, namely a camera and an electronic rangefinder device, are identified [31].

Figure 8. *Current Situation And Draft Forces After CFRP Application [31]*

The materials to be used in the photogrammetry method are placed at the required points in certain sequences. Then, enough measurements and photographs of each point are taken to create a point cloud, which is then transferred to the computer environment and combined.

Figure 9. *Point Cloud of Konya Tashkent Sultan Fountain [31]*

With the point cloud extracted, it is easier to examine the current condition of the structure and to make modelling. In addition, with the improvement processes to be carried out on the extracted point clouds, it can also be a source for digital museum application.

3.4. Sahabiye Madrasah in Kayseri

Built in 1267 by the Seljuk vizier Sahip Ata Fahreddin Ali, it is a Seljuk architecture with a rectangular plan, courtyard and portico [32]. Over the years, it has suffered various damages due to climatic conditions, wars and changing country structures. In the light of modern techniques, restoration works were carried out by remaining faithful to the original architecture of the building. One of these techniques used is three-dimensional scanning and modelling technique.

Three Dimensional Scanning and Modelling allows the current condition of the building to be digitally documented and analysed [33]. Three-dimensional scanning allows all the details of the building to be precisely digitised. In this way, interventions to be made during the restoration process can be planned as they should be and reliably [34]. The process and materials of this technique are similar to those of photogrammetry. In the final stage of the process, the results extracted from the three-dimensional point cloud are made more detailed through modeling programs.

(a) (b)

Figure 10. *Kayseri Sahabiye Madrasah (a) 3D Scanning and (b) Model Created from Scanning [35]*

With the scanning process, the holistic state of the building can be seen from a single centre. Afterwards, by going to the plan, section and view from this holistic state to the places, it is possible to go to the special parts of the building that are damaged or damaged and to work on them.

3.5. Payas Sokullu Mehmet Pasha Complex in Hatay

The complex is thought to have been built towards the end of the 16th century of the Ottoman Period and was built by Vizier Sokullu Mehmet Pasha, one of the important statesmen of the period [36]. Until today, it has suffered deterioration due to occupations, natural disasters and especially climatic deformations. Restoration works have been carried out in this direction. In addition to the modern techniques used, micro sandblasting technique was used in certain areas.

Micro sandblasting is a technique that allows the filling of cracks and gaps between the stone and marble blocks of the building. This method is effective in small and sensitive areas and allows repairs to be made without damaging the original material of the building [3]. Micro sandblasting preserved the structural integrity and aesthetic value of Payas Sokullu Mehmet Pasha Complex and ensured its longevity [37].

Figure 11. *Process of Determining the Surface to be Micro Sandblasted [37]*

Suitable places of the structure are investigated for the micro sandblasting technique. During the research, first of all, places where the formation of micro natural organisms is not very intense are selected. After a certain area is selected, a small preliminary application is made. Afterwards, it can be continued after seeing the results of the application.

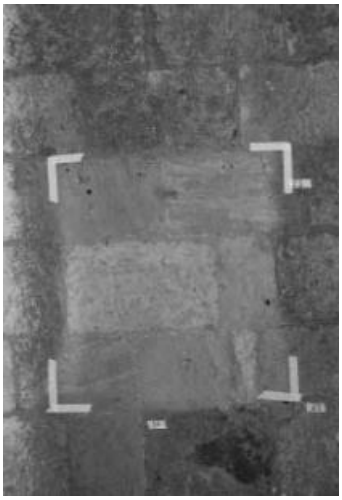


Figure 12. *Hatay Payas Sokullu Mehmet Pasha Complex Micro Sandblasting Technique [37]*

With the sandblasting process, the renovation work was carried out without deteriorating the chemical and physical properties of the building. In this way, the building did not lose its characteristics while returning to its original period shape.

4. ADVANTAGES AND EVALUATION OF MODERN SUPPLEMENTARY CONSTRUCTION TECHNIQUES

Because reverse structural engineering stays true to the original architecture, it makes it possible to restore historic buildings [2]. Through a thorough analysis of the building's current state, this technique makes it possible to make the essential adjustments in the most appropriate way [22]. Furthermore, this method aids in reducing potential hazards while the restoration is underway [21]. Using safe methods with a lower margin of error is one of the most important aspects of historic structure repair.

The application of modern timber construction techniques not only enhances the durability of historic timber structures but also does not compromise their original texture. Carbon fiber-reinforced polymers (CFRP) provide efficient reinforcement for timber constructions while retaining both the structural and visual aspects of the structure, which in turn allows easy adjustment of the building to modern living conditions because of its aesthetic qualities and strength . With such a system in place, there is no likelihood for structural failure or deterioration; refer to collapse as virtually impossible due to this reason.

Photogrammetry is a technique that creates 3D models of ancient edifices and relics. It ensures the preservation of their historical value and visual beauty while accurately documenting their condition—guaranteeing resilience and longevity [34]. Within the digital domain, photogrammetry allows for detailed scrutiny of these age-old constructions [30]. The photogrammetry method's quick application and accurate results help to minimize time lost during the restoration procedure.

An evaluation of the current state of the building can be achieved in a virtual environment through 3D scanning and modeling [34]. This will enable a more accurate and safe restoration process to be undertaken [17] also in future it can be applied for upcoming building maintenance and repair procedures [33]. The use of three-dimensional models helps in visualizing possible structural issues— which guides stakeholders on appropriate intervention strategies [18]. Simulating the procedures to be done to the laptop's structure in advance minimizes cost loss after assessing the deterioration, defects, and weak points of the computer's structure.

Micro-sandblasting can be used to fill cracks and gaps between a structure’s marble and stone blocks [38]. This method ensures the longevity of a building and preserves its structural integrity [3]. By focusing on preserving the original materials of a historic building, micro-sandblasting helps preserve the building’s aesthetic value [39]. By removing outdated structures, the building’s overall value and aesthetic appeal are preserved while also reflecting its grandeur. Modern addition construction techniques and restoration projects significantly improve the sustainability and preservation of historical buildings.

4.1. Suleymaniye Mosque Restoration

Digital modelling and CFRP reinforcement technologies were used in the restoration of the Süleymaniye Mosque to extend its structural life and preserve its important qualities. These techniques were carefully evaluated to ensure that the current condition of the historic building was completed with minimal damage within the scope of the work to be carried out. In particular, computer modelling preserves the historical texture of the building. It also allowed the upcoming maintenance and repair works to be planned more easily and effectively.

4.2. Edirnekapi Mihrimah Sultan Mosque Restoration

Photogrammetry and 3D modelling techniques were used during the restoration of the Kapımihri Mescidi Sultan Mosque in Edirne. These methods enabled the complex geometry of the building to be

comprehensively analysed and reported. They also helped to preserve the historical and architectural elements of the building. These methods are very effective in overcoming the difficulties encountered during the restoration of such complex structures.

4.3. Sultan Suyu Fountain Restoration

3D scanning and modelling technologies were used in the restoration of the Sultan Suyu Fountain. The methods used enabled a comprehensive assessment of the existing condition of the structure. These methods allowed the ancient fountain to be accurately restored without compromising its aesthetic and architectural features without compromising its decorative or architectural features.

4.4. Sahabiye Madrasa Restoration

LiDAR technology was used in the renovation of the Sahabiye Madrasa. The technology used was very effective in mapping the entire building and collecting all the necessary information for the restoration process. LiDAR technology accelerated the restoration process while preserving the historical and artistic aspects of the madrasah.

4.5. Payas Sokullu Mehmet Pasha Complex Restoration

Payas Sokullu Mehmet Pasha Complex was also restored using modern methods. The structural life of the historical building was extended and its artistic and historical importance was preserved. Digital modelling and CFRP reinforcement technologies were preferred within the scope of the restoration work in order to guarantee the long-term stability of the structure.

4.6. General Evaluation of Applied Techniques

The use of digital modelling and CFRP (Carbon Fibre Reinforced Polymer) reinforcement techniques in structural evaluations in restoration works increases the durability of the structure. Carefully examining the current condition of the structure with digital modelling guarantees that the restoration work to be carried out with the least damage and with the best accuracy. Comprehensive documentation is possible with photogrammetry and three-dimensional modelling techniques. This can help to preserve the exquisite subtleties and complex geometric systems of historic buildings. Three-dimensional scanning and modelling technologies are used in studies that require accurate and effective analysis of the current condition of the historic building. These methods help to preserve the structural integrity and aesthetic appeal of historic buildings. LiDAR (Light Detection and Ranging) technology makes it possible to precisely map buildings, making it easier to collect and analyse all the data needed for the restoration process.

Regarding the sustainability and conservation of historic structures, all of these approaches are in line with modern technology. The integration of modern technologies extends the structural durability and aesthetic value of historic buildings, extending their useful lives. This also enables more effective and efficient management of repair operations [40].

5. CONCLUSION

Historical buildings are the reflection of a society towards the past. The conservation and restoration of these buildings is important not only to preserve the integrity of the building, but also to reflect the traces of history in front of our eyes. Within the scope of this study, Istanbul Süleymaniye Mosque, Edirnekapı Mihrimah Sultan Mosque, Konya Sultan Suyu Fountain, Kayseri Sahabiye Madrasah and Hatay Payas Sokullu Mehmet Pasha Complex were analysed. Modern techniques used in the restoration processes of these buildings preserve their aesthetic and historical values, increase their structural durability and extend their service life.

Reverse structural engineering was used in digital modeling and analysis of the Süleymaniye Mosque to identify probable future stress areas in the structure beforehand. In order to fortify and toughen the wooden structures' earthquake resilience, carbon fiber reinforced polymer, or CFRP, was used in the Mihrimah Sultan Mosque through rigorous inspection of the ancient buildings' current condition. Photogrammetry techniques were applied for the current status determination and three-dimensional modelling of Sultan Suyu Fountain. Three-dimensional scanning and modelling techniques were used for the Sahabiye Madrasah. The micro sandblasting technique used to close the gap between the marble and brow blocks was used in Payas Sokullu Mehmet Pasha Complex.

All these contemporary restoration methods enhance the preservation of the historic building. They also provide significant benefits for restoration projects. Reverse structural engineering allows the project to be carried out both more precisely and more safely while identifying the weak points of the historic building. For buildings in seismically active areas, the CFRP method is preferred for both reliability and long-term durability. Photogrammetry allows restoration projects to be carried out quickly and efficiently. This is because it enables historical buildings to be digitally analysed in more detail. According to all these methods, the method that protects the original components of the building without compromising the structural and aesthetic integrity of the building and ensures its longevity is the micro sandblasting method.

As a result of the study, it sheds light on how the old buildings can be best preserved and repaired by using modern technologies. If these strategies and methods are applied correctly, historic buildings can maintain their structural preservation and visual satisfaction for decades. It also provides advantages in terms of speed of installation and cost of repair processes.

From this point of view, it is very important to use more careful and effective restoration methods for cultural treasures. The first step is to determine the weaknesses of the historical building. This step is very important to manage the restoration process of the building in a precise and safe way. As a result, CFRP should be used in high seismicity areas, Photogrammetry should be used in works that need to be fast and efficient, and micro sandblasting methods should be used for structural and aesthetic integrity.

REFERENCES

[1] Feilden, B. (2007). *Conservation of Historic Buildings*. London: Routledge

[2] Jokilehto, J. (2017). *A History of Architectural Conservation*. London: Routledge.

[3] D'Ayala, D. F., & Forsyth, M. (2007). What is conservation engineering?. *Structures & Construction in Historic Building Conservation*, 1-11. doi: 10.1002/9780470691816.ch1

[4] Roca, P. (2011). Restoration of historic buildings: Conservation principles and structural assessment. *International Journal of Materials and Structural Integrity, 5(2-3),* 151-167. doi:10.1504/IJMSI.2011.041932

[5] Feilden, B. M., & Jokilehto, J. (1993). *Management Guidelines for World Cultural Heritage Sites*. Roma: ICCROM.

[6] Kalčić, H. (2014). Eugène emmanuel viollet-le-duc and monument protection: A case study. *Urbani izziv, 25(2),* 130-142. doi:urbani-izziv-en-2014-25-02-005

[7] Ashurst, J., & Ashurst, N. (1988). *Brick, Terracotta and Earth.* Great Britain: Gower Technical Press

[8] Jokilehto, J. (1999). A century of heritage conservation. *Journal of Architectural Conservation, 5(3),* 14-33. doi:10.1080/13556207.1999.10785249

[9] ICOMOS, U. (1964). *The Venice Charter*. London: ICOMOS.

[10] Teutonico, J. M., & Matero, F. G. (Eds.). (2003). *Managing Change: Sustainable Approaches to the Conservation of the Built Environment.* 4th Annual US/ICOMOS International Symposium Organized by US/ICOMOS, Program in Historic Preservation of the University of Pennsylvania, and the Getty Conservation Institute 6-8 April 2001, Philadelphia, Pennsylvania (Vol. 4). Getty Publications.

[11] Forster, A., & Kayan, B. (2009). Maintenance for historic buildings: A current perspective. *Structural Survey, 27(3),* 210-229. doi:10.1108/02630800910971347

[12] Orbasli, A. (2008). *Architectural Conservation.* Oxford: Blackwell Science

[13] Van Balen, K. (2008). The Nara grid: An evaluation scheme based on the Nara document on authenticity. *APT Bulletin, 49(2),* 39-45.

[14] Remondino, F., & El-Hakim, S. (2006). Image-based 3D modelling: A review. *The Photogrammetric Record, 21(115),* 269-291. doi:10.1111/j.1477-9730.2006.00383.x

[15] Levy, M., & Salvadori, M. (2002). Why Buildings Fall Down: How Structures Fail. California: WW Norton & Company.fail.

[16] Boeykens, S., Santana Quintero, M., & Neuckermans, H. (2008). Improving architectural design analysis using 3D modeling and visualization techniques. *Digital Heritage: Proceedings of the 14th International Conference on Virtual Systems and Multimedia*, 67-73.

[17] Fassi, F., Fregonese, L., Ackermann, S., & De Troia, V. (2013). Comparison between laser scanning and automated 3d modelling techniques to reconstruct complex and extensive cultural heritage areas. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science*s, 40, 73-80. doi: 10.5194/isprsarchives-XL-5-W1-73-2013

[18] Rescic, S., Fratini, F., & Tiano, P. (2013). *Science and Technology for the Conservation of Cultural Heritage*. Florida: CRC Press

[19] Nejabati, A. (2020). Süleymaniye Cami'nin tamamlanması münasebetiyle Şah Tahmasb'ın, Sultan Süleyman'a gönderdiği tehniyet mektubu (1558 yılı). *Library Archive and Museum Research Journal, 1(1),* 1-16. doi:10.29228/lamre.46526

[20] Goodwin, G. (2003). *A History of Ottoman Architecture*. Baltimore: Johns Hopkins Press

[21] URL-1. *State of the art of research on historic structures in Italy. Dept. of structural engineering, Politecnico of Milan, Italy.* https://www.researchgate.net/profile/Luigia-Binda/publication/237440027_State_of_the_Art_of_Research_on_Historic_Structures_in_Italy/links/560af42408ae4d86bb14a9af/State-of-the-Art-of-Research-on-Historic-Structures-in-Italy.pdf Last Accessed: 02.07.2024

[22] Isikdag, U., Underwood, J., & Aouad, G. (2008). An investigation into the applicability of building information models in geospatial environment in support of site selection and fire response management processes. *Advanced Engineering Informatics, 22(4),* 504-519. doi: 10.1016/j.aei.2008.06.001

[23] Aslan, A., & Sahin, A. (2016). Karmaşık geometriye sahip tarihi yapıların modellenmesi için bir yaklaşım – Süleymaniye Camii örneği. *Yapı Dünyası 2016(1),* 44-53.

[24] Söğütlü, C., Yıldırım, K., TOGAY, A., Döngel, N., & Özköse, D. S. (2016). Restoration applications of wooden structures in Turkey. *Mugla Journal of Science and Technology, 2(2),* 181-186.

[25] Muratoğlu, A., Uysal, B., & Şeref, K. U. R. T. (2016). Restorasyonda ahşap yapı elemanlarının karbon fiber takviyeli polimerler (CFRP) ile güçlendirilmesi. *Selçuk-Teknik Dergisi,* 1219-1240.

[26] Sabuncu, A., & Özener, H. (2020). Mimari dökümantasyonda yersel lazer tarama teknolojisi kullanımı: tarihi sismoloji binası örneği. *Türk Uzaktan Algılama ve CBS Dergisi, 1(1),* 45-52.

[27] Wibowo, A. (2015). Conservation of wooden architecture: Willingness, support and tradition. *Procedia - Social and Behavioral Sciences, 184,* 388-393. doi:10.1016/j.sbspro.2015.05.107

[28] Öz, H., & Soyluk, A. (2023). Finite element analysis of strengthening method using carbon fiber reinforced polymer and glass fiber reinforced polymer in tensile zones of historical domed structures: Edirnekapi Mihrimah Sultan Mosque dome. *Journal of Architectural Sciences and Applications, 8(Special Issue),*487-509. doi:10.30785/mbud.1317703

[29] Kara, H. (2006). *Konya-Hadim ve Taşkent Türk Devri Yapıları*. Konya: Selçuk Üniversitesi Sosyal Bilimler Enstitüsü.

[30] Tanaka, E. (2015). Heritage destruction in context: The case of the Roman mosaics from Zeugma, Turkey. *International Journal of Heritage Studies, 21(4),* 336-353. doi:10.1080/13527258.2014.964287

[31] Ulvi, A., & Yiğit, A. Y. (2019). Kültürel mirasın dijital dokümantasyonu: Taşkent Sultan Çeşmesinin fotogrametrik teknikler kullanarak 3B modelinin yapılması. *Türkiye Fotogrametri Dergisi, 1(1),* 1-6.

[32] Akok, M. (1968). Kayseride Gevher Nesibe Sultan Darüşşifasi ve Sahabiye Medresesi rölöve ve mimarisi. *Türk Arkeoloji Dergisi,* 133-181.

[33] Barber, D., Mills, J., & Bryan, P. G. (2002). Laser scanning and photogrammetry-21th century metrology. *International Archives of Photogrammetry Remote Sensing and Spatial Information Sciences, 34(5/C7),* 360-366.

[34] Remondino, F. (2011). Heritage recording and 3D modeling with photogrammetry and 3D scanning. *Remote Sensing, 3(6),* 1104-1138. doi:10.3390/rs3061104

[35] Yakar, M., & Kocaman, E. (2017). Kayseri-Sahabiye Medresesi 3-boyutlu modelleme çalışması ve animasyonu. *International Journal of Engineering Research and Development, 10(1),* 133-138. doi:10.29137/umagd.419665

[36] Kızgın, E. E. (2021). Menzil külliyelerinde yer alan sibyan mektepleri. *Munzur Üniversitesi Sosyal Bilimler Dergisi, 10(1),* 34-62.

[37] Eskici, B., Akyol, A. A., & Kadıoğlu, Y. K. (2007). *Payas Sokullu Mehmet Paşa Külliyesi Yapı Malzemeleri, Bunlarda Görülen Bozulmalar ve Çözüm Önerileri.* 23. Arkeometri Sonuçları Toplantısı, 69-90.

[38] Brandi, C. (2005). Theory of restoration: Istituto centrale per il restauro.

[39] Castronovo, F., Lee, S., Nikolic, D., & Messner, J. I. (2014). Visualization in 4D construction management software: A review of standards and guidelines. *Computing in Civil and Building Engineering* , 315-322. doi:10.1061/9780784413616.040

[40] Kasapoğlu, M., Çakıcı, F. Z. (2023). Restoration in the Discipline of Architecture: A Bibliometric Analysis of Research Trends Since 2000. *Gazi University Journal of Science Part B: Art Humanities Design and Planning*, 11(4), 751-770.