İSTANBUL UNIVERSITY PRESS

Journal of Technology in Architecture Design and Planning
JTADP 2023, 1 (2), 111–118
DOI: 10.26650/JTADP.23.004

RESEARCH ARTICLE

Science and Technology in Architectural Conservation: The Role of Scientific Research on Traditional Building Materials and an Evaluation of Conservation Laboratories

Işıl POLAT PEKMEZCİ[1]

[1]İstanbul Technical University, Faculty of Architecture, İstanbul, Türkiye

ABSTRACT

Cultural assets are at risk of decay due to natural processes, poor environmental controls, disasters, human activity, neglect, and even certain conservation treatments. Science and technology are crucial for comprehending historical building materials and their deterioration. Experienced professionals should execute these activities using proper methodologies and appropriate equipment and techniques. The field of conservation science has made significant progress since the first half of the 20th century and continues to advance. Some institutions have now reached their 50th anniversary since their establishment. In the face of these positive developments, these institutes have also encountered challenges. This study aims to make a recent assessment of the importance of conservation laboratories in terms of architectural conservation, as well as the necessity of the global exchange of knowledge and valuable data that have been gained through the efforts of former institutions.

Keywords: Conservation science, instrumental analysis, architectural heritage, conservation laboratory

1. Introduction

Historical building systems typically incorporate a variety of materials with varying properties. In addition to material properties, the long-term performance of a building is also affected by factors such as its location, design, and workmanship. Assessing the properties and level of deterioration of materials is essential for adequately safeguarding historic structures and undertaking effective restoration practices. Collaborative interdisciplinary studies need to be conducted to achieve this purpose. The experts and professionals collaborating in the conservation and restoration field use various factors to determine the appropriate interventions for preserving and restoring artifacts. These factors include the physical and architectural characteristics of the artifact, its current state of preservation, the properties of the materials used in its construction, and the extent of deterioration present in the building or area being investigated. Thus, this field seeks contributions from individuals with diverse expertise to restore and execute projects, to address building-related issues, and to develop solutions. The Venice Charter (ICOMOS, 1964) was the first to recognize the significance of preserving original materials while utilizing modern techniques based on scientific data and long-term experience. The charters adopted in subsequent years have placed an even greater emphasis on pre-conservation investigations, sampling for analysis, and non-destructive testing, as well as an emphasis on carrying out material conservation in accordance with such current standards as the Charter for the Protection and Management of Archaeological Heritage" (ICOMOS,1990), Charter on the Protection and Management of Underwater Cultural Heritage (ICOMOS,1996), and Principles for the Preservation of Historic Timber Structures (ICOMOS,1999). Investigating the characterization and deterioration of historic building materials in restorations is crucial for various reasons, one of these being the need to understand the raw material properties of building materials. In archaeological sites, these investigations may be carried out more for provenance research regarding where the materials originated. As a result of the characterization of materials, conclusions about chronological analysis or some valuable interventions may also be facilitated by evaluating the systems of construction. Another aim of research on building materials is to understand the types, depths, and causes of deterioration. Historic buildings are susceptible to decay due to various factors, including environmental conditions, human impact, and natural disasters. Different building materials deteriorate at varying rates based on geography and climate. Appropriate methods and materials for protecting building surfaces can be determined by identifying the causes of deterioration. Continuing material research during the selection phase is important. Depending on the

Corresponding Author: Işıl POLAT PEKMEZCİ **E-mail:** polatisil@itu.edu.tr
Submitted: 29.10.2023 • **Revision Requested:** 04.12.2023 • **Last Revision Received:** 21.12.2023 • **Accepted:** 25.12.2023 • **Published Online:** 16.01.2024
This article is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0)

type of surface deterioration, some stone facades or architectural elements may require a superficial application of consolidants or water repellents. Evaluating the effectiveness of the application and its long-term impact on the structure are essential, providing that no adverse effects occur. Performing specialized laboratory tests is also crucial. Ensuring the ability to retreat repair materials is of utmost importance, even if complete reversibility is impossible. One must essentially consider that the repair materials be compatible with the original materials. This is a scientific fact that must be considered in any project involving repairs. Ensuring similarity in physical, mechanical, and mineralogical properties and thermal expansion coefficients between the original material and repair materials during their selection or production are imperative. Having the original material and repair materials match in color, texture, and finish are also essential. All of these issues require comprehensive analyses and experimentations on the materials. Institutions are conducting an ever-increasing amount of material research to ensure optimal effectiveness worldwide. This research can cover a wide range of subjects related to material preservation, such as identifying the nature of deterioration and degradation processes, characterizing materials, suggesting repair materials and techniques, recommending surface consolidants, and identifying the composition of cosmetic repair mortars. Different test programs should be developed based on the specific properties and preservation state of the materials under investigation (Ersen et al., 2010) In order to assess the structural integrity of historic buildings, experiments need to be conducted on both the buildings and the materials used to construct them (Giordano et al, 2022; Barnaure et al., 2020).

Testing and evaluating historic building materials are important, but problems in the experimental field must also be acknowledged. In recent times, instances have occurred where modifying national or international standards was necessary in the field of conservation regarding construction and building materials (Fassina,2015). Alternatively, new protocols have needed to be established for conducting experiments on historical building materials. While efforts are underway to improve testing standards for historic building materials, further studies are clearly needed to investigate some more materials and properties.

2. Laboratories for Architectural Conservation: First Interdisciplinary Efforts and Leading Institutions

In the second half of the 20th century, conservation science became increasingly important, particularly with regard to conservation issues and studies in archaeometry. As archaeometry has progressed, the integration of physics, chemistry, biology, and geology has yielded new insights into historical materials, such as joint studies frequently involving the dating of materials (D'Agostino, 2022). The physicist Lord Cherwell believed that science could make significant contributions to fields like archaeology. He contributed to the development of an x-ray fluorescence spectrometer used to analyze archaeological materials. After conducting his research, he and a group of colleagues came up with the concept of creating the Research Laboratory for Archaeology and the History of Art (RLAHA). The laboratory was eventually established in 1955, and by 1958, Oxford University had begun publishing the Bulletin of the Research Laboratory for Archaeology and the History of Art (Research Laboratory for Archaeology and the History of Art, n.d.). This publication would later become an international journal: Archaeometry. The laboratory has played an important role in archaeological education and has enabled much interdisciplinary and science-led research to be carried out, and continues to do so today with advanced technological facilities.

After World War II, UNESCO became known for its efforts in establishing two non-governmental organizations: the International Council of Museums (ICOM), which concentrates on the problems of museums and galleries, and, more recently, the International Council on Monuments and Sites (ICOMOS), which specializes in the matter of monuments and sites that are of interest to architects, planners, and engineers.

These developments were followed by the establishment of the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) in Rome in 1959, and an environment was created through ICCROM for training experts from different countries of the world on the conservation of historical building materials (Plenderleith, 1998). Initially, ICCROM was dedicated to gathering and sharing scientific and technical knowledge related to conservation. A 1959 survey showed an urgent need for specialists in restoration work worldwide. In 1962, the Centre began teaching in collaboration with the University of Rome. By 1966, however, it had taken sole responsibility for the courses. The training was architecturally based, with a strong emphasis on material science and the technology of construction and repair (Goddard, 2020).

In 1965, Harold Plenderleith, ICCROM's director, asked Giorgio Torraca to establish a scientific research laboratory at the Rome Centre. However, Torraca's list of advanced equipment for the laboratory was subjected to intense scrutiny at a meeting of the Rome Centre Council. Although the advanced laboratory was not completed, the facility was repurposed to support ICCROM training (Toracca, 2009). The Scientific Principles of Conservation (SPC) course at ICCROM needed that laboratory. This course covered various materials such as wood, stone, and metals after providing a general understanding of materials science. Mornings consisted of theoretical lectures, while afternoons were reserved for hands-on laboratory training. The SPC course aimed to familiarize conservators, architects, historians, and conservation scientists with the nature of materials and durability issues. The objective was to equip them with the knowledge and skills necessary to handle cultural property with care and to avoid causing damage to it in the future. Working collaboratively, professionals could also develop a common language for interdisciplinary

work. The courses in Rome were successful and provided Centre staff with direct contact to leading conservation experts and student colleagues from national institutions (Toracca, 2009). By the 1970s, ICCROM was running many training courses for architectural structures, such as stone conservation in Venice and wood conservation in Norway, as well as programs for museums and interiors (Jokilehto, 2009). In 1982, Jeanne Marie Teutonico joined the Architectural Conservation course as a participant and later returned to ICCROM to work on developing the course's laboratory curriculum. She mentioned having the desire to develop this aspect of the course further so as to provide a more hands-on consideration of building materials and their decay, analysis, and conservation. The course content aimed to increase the practical methods of material deterioration, analysis, and conservation. As a result of these developments, the course duration was extended, and the number of lectures and applications on historical building materials increased. Experts lectured on adobe, mortars, plasters, painted finishes, and their applications. Teutonico's photocopies of laboratory exercises for the participants were then published as A *Laboratory Manual for Architectural Conservators* in 1988 (Teutonico, 2009). ICCROM trainings, which were continuously developed in the late 1980s, can be considered as an important model for its time and one that trained experts in many countries. Getty Conservation Institute (GCI) and ICCROM have collaborated together for various trainings. The first was the three courses at ICCROM devoted to Architectural Records, Inventories, and Information Systems for Conservation (ARIS), which was delivered in 2005, 2007, and 2009. The two institutions collaborated on the International Course on Stone Conservation, which was delivered four times between 2009 and 2015. The 3 month-long courses provided comprehensive learning on the mineralogical and physical characteristics of stone, their decay mechanisms, and the best methods for analysis, maintenance, and preservation. Participants, as well as a global audience, were provided with educational materials and resources (Coddy, 2020). While working in the field of historic monument conservation in France in the 1960s, Jean Taralon alerted his superiors to the need for a scientific body dedicated to the problems of historic monuments. He had long been concerned with the uncontrollable nature of the traditional processes used in the restoration of historic monuments and wanted to see conservation operations better supervised using scientifically validated methods. He pioneered the establishment of the *Laboratoire de Recherche des Monuments Historiques* [Historical Monuments Research Laboratory] (LRMH) in 1970, which is a department of the Ministry of Culture and part of the General Directorate for Heritage. Since its foundation, the laboratory has aimed to preserve historical monuments and objects of cultural heritage classified as *Monuments Historiques* [historical monuments] through its knowledge and expertise in materials and research. Since the laboratory's establishment, it has gained significant experience in intervening with historical buildings, especially during times of disaster. After the Notre Dame fire in 2019, the laboratory team's experts quickly prepared a protocol and documentation, as well as an inventory for reusable materials for starting the restoration (Magnien, 2020; Zimmer, 2020). The *Consiglio Nazionale delle Ricerche* [National Research Council of Italy] (CNR), which started to expand its organization in the late 1960s, has an important background in heritage science research. In 2019, many research laboratories in different cities in Italy merged under The Institute of Heritage Science (ISPC), creating an organization with a large number of researchers and laboratories. Today, the institution has various groups and labs focused on archaeological conservation, heritage materials science, built heritage, and more (L'Istituto di Scienze del Patrimonio Culturale, n.d.). Apart from the aforementioned laboratories, which boast experienced staff and advanced equipment, numerous research facilities are also found affiliated with universities and institutions worldwide. An increasing trend is seen toward utilizing experts from various disciplines and technologies in a collaborative system. (*El Consejo Superior de Investigaciones Científicas* (The Spanish National Research Council), HERKUL,n.d).

3. The Current Situation in Türkiye

State authorities in Türkiye house laboratories that are responsible for conserving heritage building materials. The Istanbul Directorate of Central and Regional Laboratory for Restoration and Conservation was established in 1985 under the Turkish Ministry of Culture and Tourism, Directorate General of Cultural Assets and Museums in Istanbul. Its primary goal is to perform conservation and restoration work on cultural heritage based on scientific principles for movable and immovable items. The history of the laboratory can actually be traced back to the *Kimyahane* in the Istanbul Archaeological Museum (Yarlıgaş, 2021, Ertürk, 2022). In 2012, approval was granted for the establishment of nine regional laboratories across Türkiye in Ankara, Trabzon, Erzurum, Diyarbakır, Gaziantep, Nevşehir, Antalya, İzmir, and Bursa. Over the years, the laboratories have expanded their staff and research facilities. Researchers from different disciplines have gained experience in training programs organized by UNESCO and ICCROM, and some of the trainings have taken place at significant historical sites in Türkiye (Ok, 2019). Following the establishment of the Directorates for the Conservation, Implementation, and Supervision of Cultural Assets (KUDEB) by the Law No. 2863 in 2005, a Restoration and Conservation Laboratory was established within the Istanbul Metropolitan Municipality by KUDEB in 2007. The unit began work under the consultancy of experts, has added staff from different disciplines to its body, and started its active work in and beyond Istanbul. Material characterization and conservation reports have been prepared for many buildings, and the team has also carried out research studies together with their academic advisors. The team created a laboratory handbook to explain test methods for assessing historic building materials and their deterioration mechanisms (KUDEB & Istanbul Metropolitan Municipality [İBB], n.d.). The unit shared the results of their work and other current works on conservation with the

public through the publication of *Restorasyon Konservasyon Dergisi*, a journal on restoration conservation publishing a total of 23 issues between 2009-2020 (KUDEB & İBB, Dergiler, n.d.) Following the establishment of the laboratory in Istanbul, several KUDEB units in other cities have also set up their own laboratories.

Universities offering education in architectural conservation often have conservation labs, as the conservation of historical buildings and laboratory research are closely related. The Architectural Conservation Laboratory of the Department of Historic Preservation at the University of Pennsylvania was founded in 1991 as one of these. (Architectural Conservation Laboratory, n.d.) The Historic Preservation program at the University of Texas Austin offers courses that involve laboratory applications in their Architectural Conservation Lab. (Materials Lab ,n.d.)These laboratories not only support education but also provide research assistance for public and private projects. The Heritage and Technology Laboratory at TU Delft was established for the development and assessment of solutions for the conservation of historic buildings. Conservation materials could be subjected to laboratory testing to assess their effectiveness, compatibility, and application techniques. (Heritage and Technology Lab, n.d.)

Turkish universities operate conservation laboratories specifically designed for educational and research purposes. The laboratories of METU, ITU, MSGSU, and IYTU are some examples that can be mentioned. (Material Conservation Lab, Mimari Koruma Laboratuvarı, Merkez Araştırma Laboratuvarı, Malzeme Araştırmaları Merkezi, n.d.)

Apart from these few examples, a low number of architectural conservation training programs are observed to include laboratory studies. This situation may cause difficulties for conservation architects when communicating with other specialists about material research or managing sampling and developing research methodologies. Importantly, archaeologists, architects, and art historians should learn how science can aid in conservation efforts.

4. The Strong Link Between Conservation Laboratories and Scientific Research and the Challenges Encountered in the Process

When analyzing research laboratories concerned with architectural conservation worldwide, commonalities become apparent. Clearly, these institutions were founded due to a lack of scientific and experimental research in the restoration field. This need, seen intensively since the mid-20th century, continues today without diminishing. In addition to maintaining existing institutions, new laboratories must also be established for historical material characterization, diagnosis and detection of deterioration, and identification of repair materials. In this context, conservation laboratories should expect developments in their relationship with restoration projects and applications. The conservation work on historical materials can begin in the field and continue in the conservation laboratories. After conducting research, continuing efforts toward archiving is imperative, as well as publishing findings (Figure 1).

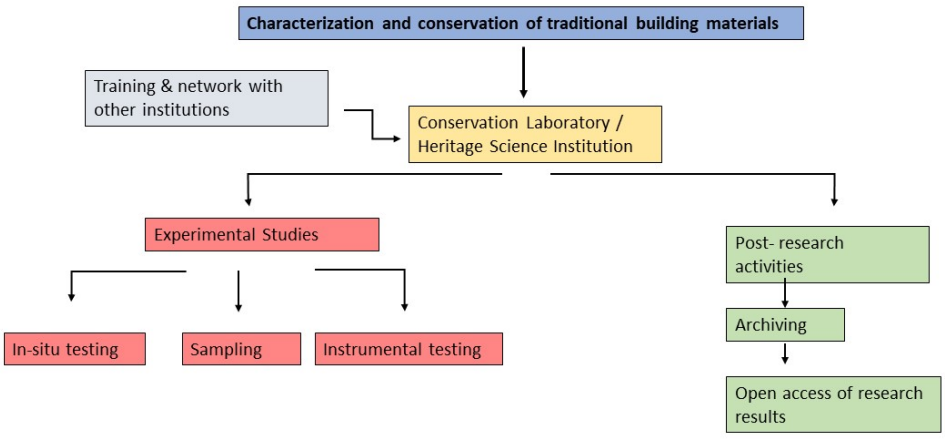

Figure 1. Conservation laboratories and processes refer to the practices involved in preserving and restoring cultural artifacts and historical objects.

At the ICCROM Forum on Conservation Science held in 2013, some key messages were drafted by the participating institutions. These messages conveyed the importance of conservation science and the need for a community of conservation scientists who possess credibility, relevance, influence, and transdisciplinary connections. When engaging in research and development projects, involving all stakeholders (e.g., scientists, conservators, and other heritage experts) who will collaborate to define the issues and objectives is vital. Conservation institutions should conduct research and development to address issues and establish sustainable solutions and guidelines proactively. By collaborating and sharing their resources and expertise, conservation institutions can enhance efficiency, increase access, reduce inequalities, and ultimately achieve better outcomes for a sustainable future. Additionally, conservation institutions should play a leading role in promoting conservation and ensuring access to knowledge at all levels, including knowledge produced by others (Corbeil, 2015).

4.1. Giving Sufficient Time to Material Research

Although material research is essential in architectural conservation, it cannot guarantee successful results in every sense. Describing applicable and tested repair materials and methods based on laboratory analyses is necessary. Simply completing some analyses on materials taken from buildings will not be sufficient for achieving this goal. Having competent people with practical experience in the field of restoration run evaluations will determine what experimental studies contribute to practice. In some cases, having only laboratory research results may not be sufficient; in this regard, some experiments and analyses should be carried out in the field. As these processes tend to consume a lot of time, they must be scheduled meticulously. Viewing materials research as an ongoing process is preferable to seeing it as a task to complete.

4.2. Correct Sampling

The responsibility of architectural conservation laboratories should be valid from the sampling stage to the successful conclusion of the application. The study should start with purposeful, accurate, and non-destructive sampling, followed by an experimental program to understand the problems.

Visual analysis has the potential to accomplish a lot while requiring minimal investment. Having experienced analysts on hand can quickly help clarify problems and identify materials. However, emphasizing that the correct individuals must be employed is important; otherwise, identifications may be incorrect. Visual analysis is a non-destructive technique and should be utilized as much as possible prior to further laboratory or on-site technical investigations. (Hughes et al., 2002) Having architects or archaeologists who have documented the building or site to guide the sampling team during sampling would be more appropriate for ensuring accuracy and relevance.

4.3. Determining the Experimental Methods

The experimental studies should produce high-quality results to guide the restoration project or application. Materials research is a field that evolves with technological advancements (Adriaens, 2004). While some analysis methods and materials have been used for years, keeping up with new materials and research techniques is important. Some excellent research may provide solutions that are inaccessible due to complexity or cost. Currently, powerful technologies such as multispectral imaging and synchrotron radiation studies at national facilities are not widely available. As usage becomes more widespread, sophisticated technologies tend to become more affordable and user-friendly. A good example of this is Raman spectroscopy instrumentation, which used to be confined to research facilities due to its complexity (Corbeil, 2015). Studies can be carried out in the field with some new non-destructive analysis methods. Over the years, a wide range of experimental techniques, including Raman spectroscopy, x-ray fluorescence (XRF) spectroscopy, and Fourier transform infrared (FTIR) spectroscopy, which were initially designed and used for laboratory-based research, have now been modified and made smaller for *in situ* analysis in cultural heritage-related fields. Experimental methods for the characterization of historic materials or structures, environmental effects on materials, and deterioration processes have become familiar, as well as the many studies and publications on the use of these methods (Zhao et al., 2019). Research shows that multiple techniques may complement each other or be more advantageous in certain cases (Carmona-Quiroga et al., 2010). Hence, institutions involved in conservation research evidently require state-of-the-art equipment and skilled personnel. Fulfilling these requirements also apparently necessitates providing sufficient support and budget to this field.

4.4. Training

Laboratories that have been carrying out research on historical materials for many years have considerable experience. This experience encompasses the perspectives of both institutions and specialized staff, including laboratory and field studies. Conducting extensive studies on historical building materials is sometimes necessary for making informed decisions due to their diverse nature and deterioration. When considering that architects are primarily trained in the field of restoration, engineers, researchers, and technical staff from different disciplines working in these institutions can be provided with specific knowledge and awareness on conservation issues through experience and different training in the process. Planning and training new researchers alongside experienced experts is crucial for ensuring a continuity of knowledge and experience.

Past experience shows that continuously training the laboratory team is an issue that needs to be emphasized. Different organizations can come together on a regular basis to follow current developments and exchange information through different trainings on the points where they feel deficient. This is also important for the formation and maintenance of a common language. The fact that the researchers working in the laboratory are familiar with archival research and have an idea about construction techniques or developments in construction technology will enable them to better comprehend the subjects they will evaluate (Toracca, 2009). To have the people who prepare the laboratory reports prepare them in a way that architects, art historians, or conservators can understand will also be important so that the work can be understood correctly.

4.5. Archiving the Samples

The areas where conservation laboratories conduct studies often contain unique materials and construction techniques. Some samples taken from buildings are used for analysis, while others are preserved as valuable documents. The preserved specimens should be displayed and, if possible, properly archived and cataloged and easily accessible for future researchers. The Mora Sample Collection Project serves as an illustration of this. Paolo and Laura Mora, former ICCROM trainers, have preserved samples from their fieldwork that are now stored at ICCROM's Rome headquarters. Today, the Mora sample collection is an extraordinary resource that showcases the complexity and diversity of mural painting as a medium for cultural expression across different civilizations and time periods. The fact that some of the areas where the samples were taken are inaccessible today increases the value of the collection for possible future research (Mora Sample Collection Project, n.d.). ICCROM launched the Heritage Samples Archives Initiative (HSAI) to preserve and promote the use of collections for educational purposes, recognizing similar situations in other institutes worldwide. The aim of the HSAI is to increase awareness about the value and importance of sample archives; establish good practices, policies, procedures, tools, and methodologies for managing sample archives; and create a roadmap for enhancing the accessibility and utility of sample archives by linking them through open digital platforms (Heritage Samples Archives Initiative, n.d.).

The Historic Building Materials Collection (HBMC) of the Architectural Conservation Lab of the University of Pennsylvania has a similar material samples collection from historic buildings and sites around the world. The collection serves as a library of building materials used in construction worldwide, including archaeological sites. The primary function of the collection is to provide direct access to traditional and historic building materials, whether as bulk samples or through advanced sample analysis such as cross-section or thin-section analysis. A searchable online repository for the collection has been created with a digital interface that allows for filtering using date ranges and more. Those who wish to submit a piece to the collection can also apply via the website (Historic Building Materials Collection, n.d.). UPenn's Walker Zanger Reference Stone Collection holds 5,000 natural stones from the 20th and 21st centuries. In 2024, a publicly searchable database will become available.

4.6. Open Access to Results

As mentioned earlier, publications on laboratory techniques and research started in the first years of the establishment of conservation laboratories. Specialized publications on conservation issues have been produced by organizations such as ICCROM and the Getty Research Institute, many of which can be found online. In addition to material samples, the ICCROM archives contain a vast amount of historical correspondence, photographs, and architectural drawings that are available for research purposes. The Digital System Applied to Heritage and its Sciences (SYNAPSE) portal of LRMH can also be used to access resources online or in person. This includes a library of publications related to research and studies on the problems of conservation and restoration of monuments and works of art, an archive of research and reports by laboratory researchers, and a database on research and analyses (Le Laboratoire de Recherche des Monuments Historiques, n.d.).

5. Conclusions

Conservation laboratories evidently play a crucial role in preserving cultural heritage. Given the knowledge that has been gained from the past to the present and the advancements in technology, having administrations demonstrate their support and interest in these institutions is vital. The existence of such institutions, especially in areas with a large number of architectural and cultural heritage such as in Türkiye will facilitate the work of professionals and practitioners working in this field. In addition to equipping institutes with advanced experimental instruments, competent personnel should also be assigned to these institutions. Researchers who have not completed their undergraduate education in cultural heritage may need time to gain competence in this field. Researchers from different disciplines should attend continuing education programs in order to acquire theoretical and ethical knowledge in the field of conservation and to analyze studies on the historical materials they are investigating. In addition to these theoretical studies, they should also master field studies due to some of the material experiments that can be carried out in the field. Joint studies between experienced personnel and new researchers will play a key role in this regard. Having global institutes frequently exchange information will be crucial for honoring cultural heritage without borders. Joint meetings, trainings, and an inter-institutional exchange of researchers can enhance collaboration. The focus on cultural heritage starts from the sampling stage and extends to conservation practices. Sensitivities toward this issue can be explained to public institutions and the public through conservation laboratories, and conservation research clearly should be communicated to a wider audience.

Peer Review: Externally peer-reviewed.
Conflict of Interest: The author have no conflict of interest to declare.
Grant Support: The author declared that this study has received no financial support.

ORCID ID of the author

Işıl POLAT PEKMEZCİ 0000-0002-2367-4353

References

Adriens, A. (2004). European actions to promote and coordinate the use of analytical techniques for cultural heritage studies. *TrAC Trends in Analytical Chemistry*, Volume 23, Issue 8, 2004, 583-586, ISSN 0165-9936.

Architectural Conservation Laboratory, University of Pennsylvania. (n.d.) Retrieved on November 6, 2023 https://www.design.upenn.edu/resources/architectural-conservation-laboratory

Barnaure, M., & Cincu, M. (2020). *IOP Conference Series: Materials Science and Engineering*, 789, 012003. IOP Conference Series: Materials Science and Engineering, Volume 789, International Conference CIBv2019 Civil Engineering and Building Services 1-2 November 2019, Braşov, Romania

Carmona-Quiroga, P. M. , Martínez-Ramírez, S., Sánchez-Cortés, S., Oujja, M., Castillejo, M., & Blanco-Varela, M. T. (2010). Effectiveness of antigraffiti treatments in connection with penetration depth determined by different techniques. *Journal of Cultural Heritage*, 11(3), 297-303. https://doi.org/10.1016/j.culher.2009.09.006.

Coddy, J. BUILDING CAPACITY The GCI's Efforts in Built Heritage Conservation, Conservation Perspectives, GCI Newsletter, 35(2), Fall 2020, 11-14.

Corbeil, M. C. (2015). Conservation institutions as agents of change, *Studies in Conservation*, 60, 33-38.

D'Agostino, S. (2022). Conservation and Restoration of Built Heritage, Taylor and Francis Group, London.

El Consejo Superior de Investigaciones Científicas, (The Spanish National Research Council). (n.d.) Retrieved on November 2, 2023 https://www.csic.es/en

Ersen, A., & Verdön, İ. (2010). Konservasyon biliminin restorasyon proje ve uygulamalarına katkıları. *Türkiye Bilimler Akademisi Kültür Envanteri Dergisi*, 8, 7–20.

Erturk, N. (2022). The conservation-restoration history of museum collections in Turkey. *Museum History Journal*, 15(2), 176-192. https://doi.org/10.1080/19369816.2022.2079810

Fassina, V. (2015). CEN TC 346 Conservation of Cultural Heritage Update of the Activity After a Height Year Period, G. Lollino et al. (eds.), Engineering Geology for Society and Territory – Volume 8, DOI: 10.1007/978-3-319-09408-3_3, Springer International Publishing, Switzerland 2015, 37-41.

Giordano, A., Mele, E., & De Luca, A. (2002). Modelling of historical masonry structures: comparison of different approaches through a case study. *Engineering Structures, 24*(8), 1057-1069. https://doi.org/10.1016/S0141-0296(02)00033-0.

Goddard, J. (2020). Education in Architectural Conservation, Its Origins and Development, Conservation Perspectives. *GCI Newsletter*, 35(2), Fall 2020, 4-10.

HERKUL. KU Leuven. (n.d.) Retrieved on November 2, 2023 https://heritage.kuleuven.be/

Heritage Samples Archives Initiative, ICCROM. (n.d.). Retrieved on November 3, 2023 https://www.iccrom.org/projects/heritage-samples-

archives-initiative

Heritage and Technology Lab. TU Delft. (n.d.) Retrieved on November 4, 2023 https://www.tudelft.nl/bk/onderzoek/onderzoeksfaciliteiten/heritage-technology-laboratory

Historic Building Materials Collection, University of Pennsylvania. (n.d.) Retrieved on November 6, 2023 https://acl.design.upenn.edu/

Hughes, J., & Callebaut, K. (2002) In-situ visual analysis and practical sampling of historic mortars. *Materials and Structures/Mat6riaux et Constructions*, 35, 70-75.

ICOMOS. (1964). International Charter for The Conservation and Restoration of Monuments And Sites (The Venice Charter 1964), Venice. https://www.icomos.org/en/resources/charters-and-texts

ICOMOS. (1990).i Charter for the Protection and Management of Archaeological Heritage, 1990, Laussane. https://www.icomos.org/en/resources/charters-and-texts

ICOMOS. (1996). Charter on the protection and management of underwater cultural heritage,1996, Sofia. https://www.icomos.org/en/resources/charters-and-texts

ICOMOS. (1999). Principles for the Preservation of Historic Timber Structures, 1999, Mexico. https://www.icomos.org/en/resources/charters-and-texts

Jokilehto, J. (2009). ICCROM's First Fifty Years. *Museum International*, 61(3), 26-35, https://doi.org/10.1111/j.1468-0033.2009.01690.x

KUDEB, İBB. (n.d.). Retrieved on November 4, 2023 https://kudeb.ibb.istanbul/restorasyon-ve-konservasyon-laboratuvarlari-kitabi/

KUDEB, İBB, Dergiler. (n.d.). Retrieved on November 4, 2023 https://kudeb.ibb.istanbul/dergiler/

Le Laboratoire de Recherche des Monuments Historiques. (n.d.). Retrieved on November 6, 2023 https://www.lrmh.fr/centre-de-ressources-synapse.aspx

L'Istituto di Scienze del Patrimonio Culturale. (n.d.) Retrieved on November 1, 2023 https://www.ispc.cnr.it/en/

Magnien, A. (2020). Science and the Study of Heritage, 1970-2020 The Historical Monuments Research Laboratory, Half a Century Serving French Heritage, *BeauxArt Editions*, 6-8.

Malzeme Araştırmaları Merkezi, IYTE. (n.d.) Retrieved on November 6, 2023 https://mam.iyte.edu.tr/

Material Conservation Lab, METU. (n.d.) Retrieved on November 3, 2023 https://bs.metu.edu.tr/materials-conservation-laboratory

Materials Lab, The University of Texas at Austin. (n.d.) Retrieved on November 6, 2023 https://soa.utexas.edu/materials-lab

Merkez Araştırma Laboratuvarı (MERLAB). MSGSU. (n.d.) Retrieved on November 6, 2023 https://merlab.msgsu.edu.tr/

Mimari Koruma Laboratuvarı, ITU. (n.d.) Retrieved on November 3, 2023 https://itulabs.itu.edu.tr/Laboratuvar/Detay/1c8c2646-e33b-4d95-9e7f-728df6f0285f

Mora Sample Collection Project. ICCROM. (n.d.) Retrieved on November 3, 2023 https://moracollection.iccrom.org/index.php/About/Index

Ok, İ. (2019). Kuruluşundan Günümüze İstanbul Restorasyon ve Konservasyon Merkez ve Bölge Laboratuvarı Müdürlüğü (1985-2018). *RAD Rölöve Anıtlar Dergisi*, 1(1), 52-73.

Plenderleith, H. J. (1998). A History of Conservation. *Studies in Conservation*, 43(3), 129-143. http://www.jstor.org/stable/1506740

Research Laboratory for Archaeology and the History of Art. (n.d.) School of Archaeology University of Oxford. Retrieved on November 1, 2023. https://www.arch.ox.ac.uk/research-lab-archaeology-and-history-art

Teutonico, J. M. (2009). The Iccrom Architectural Conservation Course 1982–92: history, evolution, impact. *Museum International*, 61(3), 49-54. https://doi.org/10.1111/j.1468-0033.2009.01693.x

Torraca, G. (2009). Science, Technology and ICCROM. *Museum International*, 61(3), 71-82. https://doi.org/10.1111/j.1468-0033.2009.01695.x

Yarlıgaş, V. (2021). "Türkiye'de Kültür Varlıkları Konservasyonunun Öncü Kurum ve Kişileri: Kimyahane ve İki Uzmanı Nurettin Akbulut ve Hadi Tamer". *Osmanlı Bilimi Araştırmaları*, 22, 121-138.

Zhao, C., Zhang, Y., Wang, C. C. , Hou, M., & Li, A. (2019). Recent progress in instrumental techniques for architectural heritage materials. *Heritage Science*, 7(36), 2-50. https://doi.org/10.1186/s40494-019-0280-z

Zimmer, T. (2020). Appraising and Responding to Emergencies. 1970-2020 The Historical Monuments Research Laboratory, Half a Century Serving French Heritage, *BeauxArt Editions*, 22-24.

How cite this article

Polat Pekmezci, I. (2023). Science and Technology in Architectural Conservation: The role of scientific research on traditional building materials and an evaluation of conservation laboratories. *Journal of Technology in Architecture Design and Planning, 1* (2), 111–118. https://doi.org/10.26650/JTADP.23.004