“OVIDIUS” UNIVERSITY OF CONSTANȚA
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FIELD: CIVIL ENGINEERING AND INSTALLATIONS

CONTRIBUTIONS REGARDING TECHNIQUES AND METHODS FOR STRENGTHENING HISTORIC MONUMENT STRUCTURES

PhD THESIS ABSTRACT

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Research motivation

Cultural heritage is an essential component of national identity and reflects diversity, history, and shared values, both at national level and in close connection with other European states. In the current era, strongly marked by globalization, migration, and social transformation, Europe is moving toward integrated cultural-policy approaches designed to protect, valorize, and promote heritage in a sustainable way. Such strategies can foster social cohesion, drive economic development, and strengthen local identity.

At both the national and European levels, a new integrated approach has emerged, grounded in an interdisciplinary attitude toward heritage values and seeking to address heritage from cultural, educational, tourism, environmental, and other perspectives. This entails integrating heritage into the economic and social life of communities and, consequently, the active involvement of local communities in managing heritage assets, leveraging new technologies, digitization, and artificial intelligence.

In this context, heritage management can no longer be addressed in isolation or reduced to the simple preservation of historic monuments.

The current stage calls for an integrated approach and a holistic vision able to connect culture with the social sphere, the economy, education, and, especially, technology. Within this new perspective, endorsed by European states, heritage can become a engine of sustainable development and social cohesion.

Interdisciplinarity and institutional collaboration play a key role. Interdisciplinarity entails the involvement of all relevant fields, history, engineering, architecture, IT, and others. As for institutional collaboration, local public authorities are increasingly required to work with higher-education institutions, NGOs, and the private sector, strengthening public-private partnerships. As seen in other European countries, such an approach not only consolidates the past but also becomes an active instrument for the future, an intelligent valorization that can lead to democratic access.

The conservation and restoration of historic monuments are complex activities aimed at safeguarding the historic substance of valuable components and bringing them to the fore. Restoration is inherently interdisciplinary: architects, urban planners, structural engineers, conservators of artistic components, physicists, chemists, and historians contribute in equal

measure to the restoration and valorization of historic sites, protected areas, and monuments as a whole. Heritage is an expression of values, beliefs, and traditions that result from the interplay between human factors and the natural environment.

The topic “Contributions regarding techniques and methods for strengthening historic monument structures” through its research program and objectives, makes an essential contribution to affirming local and regional identity; to advancing knowledge for the protection and valorization of historic monuments; and to increasing community understanding of the past.

The research conducted within the program is grounded in the study of highly valuable historic site whose cultural evolution spans more than 600 years, with multicultural influences in both history and architecture.

Given that the doctoral research program was made in urban areas with a particularly rich historical background, outstanding cultural heritage, and cultural evolutions recognized over centuries, the results obtained represent a significant value asset, an exceptional database capable of contributing to the integrated development of cultural values and to sustainable development. This involves community members, enables the implementation of digitization in the mission of managing the existing built heritage, and supports the economic, educational, tourism, and social development of local communities.

I. CURRENT STATE OF KNOWLEDGE

Romania’s built heritage, as an essential resource of national identity, is currently confronted with a new attitude and vision generated by the need to include it in urban policy, a step that will, in turn, attract funding to save these values and to promote the principles of conservation and restoration.

In this context, the Ministry of Culture, through the 2024–2028 Government Program, has proposed a series of strategic priorities aimed at revitalizing and digitizing the heritage sector, simplifying and debureaucratizing administrative processes, and strengthening institutional capacity in the field of heritage protection. The 2024–2028 Government Program aligns with the current needs of the built cultural heritage, as well as with the requirements and standards of the European Union, with the Ministry of Culture acting in the direction of:

- funding emergency interventions on historic monuments;
- establishing integrated inventory systems to identify and provide access to heritage;
- adopting administrative instruments to protect heritage buildings.

The Romanian Government's current vision regarding the conservation and restoration of cultural heritage treats the field both as a distinct domain and as a generator of value for citizens and society at large.

In this context, where culture must be supported to operate in relation to other sectors, local and national policies need to create the prerequisites for integrating these principles, i.e., to bring together responsible stakeholders in both conservation and urban policy.

Therefore, conservation activity relies heavily on strengthening conection between the cultural sector and business, and the broader economic and social spheres; in this context, the doctoral research project included studies and investigations whose results are applicable to supporting this policy.

European policy practice has highlighted the importance of restoring urban archaeological sites and bringing these categories of cultural edifices to the fore. For this reason, I considered it necessary for the research project to include a chapter on the conservation and restoration of urban historic sites, emphasizing the enhancement of archaeological sites, a particularly important mission in the areas studied in Constanța.

In this context, by applying these approaches, the South-East region of Romania proves to possess an exceptional built cultural heritage. The research project therefore aims to identify it and to analyze the classification criteria for monuments specific to the South-East, across all types of civil buildings, residential, administrative, religious, and others.

I.1. Purpose and relevance of the research

The research was made to identify a valuable built heritage in South-Eastern Romania across different historical stages, both before and after 1878, together with traditional elements and technologies and the characteristics of constituent materials, in order to establish restoration solutions and to enhance these assets by applying methods and techniques best suited to their structural systems.

The study implemented a set of investigation methods for historic monuments grounded in qualitative analyses, with the aim of identifying behavioural parameters, the

actual mechanical strengths of constituent materials, and ways to interpret seismic risk in relation to the load-bearing capacity of each monument. The methods and techniques focus primarily on structural elements of loadbearing masonry, wood, and metal, materials commonly used in the 18th, 19th, and early 20th centuries.

Analytical evaluation involves calculation programs to quantify, within their modelling assumptions, the results of the qualitative evaluations.

Within this doctoral thesis, research techniques and methods were applied to selected case studies selected from the list of historical monuments representative of South-Eastern Romania, a region with an extensive built heritage but a high degree of vulnerability.

In this context, the research identified degradations stemming from multiple causes which, when prioritised, show that the main deficiencies arose from improper use, lack of timely and good-quality maintenance, human negligence, seismic activity, aggressive factors linked to climate change, leakage from water-carrying pipes, and others.

The research program also highlighted the need to establish measures related to improving property administration, long-term monitoring, and allocating adequate funds for quality works. An important outcome was the emphasis on community valorisation of heritage, helping members of the community understand that preserving authenticity, uniqueness, and integrity is essential to proper education in the conservation and protection of monuments.

Another aim was to synthesise valuable elements that can be correlated across different communities in South-Eastern Romania. Accordingly, the program identified buildings made in the same periods with authentic architectural values, some sited on older, significant ruins that were reused at certain points in the area's historical evolution. One such example is the investigation of the building at 19 Mihai Eminescu Street in Brăila.

The value analysis of buildings within the historic site, covering Brăila, Constanța, and Medgidia, followed a set of procedures characteristic of listing and inventorying historic monuments, thus a systematic analysis designed to reveal the scientific and technical information for each building.

In this context, the research addressed:

- Identification parameters: property names, addresses, construction periods, ownership, and the evolution of constructions on the same site, since for many studied buildings the

substructure belongs to an earlier built phase than the superstructure. In numerous cases within Brăila's historic area, substructures (foundations, basements) date to the late 18th and early 19th centuries, while the superstructure corresponds to the second half of the 19th century and into the 20th.

- The history of urban planning regulations across different construction periods;
- The history of restoration and refunctionalisation works, often followed by structural interventions, as well as bibliographic information.

For each analysed building, I made an evaluation concerning:

- Criterion concerning the building's age;
- Criterion concerning architectural components and urban-design elements;
- Criterion concerning similar buildings in the historic centre;
- Criterion concerning the memorial value of the construction.

As is known, regarding to the age criterion, buildings are classified into five categories, delimited historically by periods significant to the socio-historical evolution of communities.

Within the buildings studied in South-Eastern Romania, I identified an exceptional building, built around 1780 (the "Turkish House" in Brăila), as well as buildings of very high value dating roughly between 1770 and 1830, most often preserved as basement or semi-basement structures and only rarely as complete constructions.

In the South-East, such sites often correspond to former locations that suffered earthquake damage; foundations, basements, and semi-basements were retained while the above-ground portions were rebuilt.

A frequently encountered category in Danube-side towns and in Dobrogea comprises buildings of high importance built between 1831 and 1870, followed by those of medium value from 1871 to 1945, which represent the majority listed as historic monuments or situated within urban historic sites.

Very interseting results in the research were obtained from analysing elements that attest to authenticity. Fort the most part, these elements concern structural components, brick type, mortar quality, construction technique, metal components, but authenticity also concerns the architectural composition of façades, balconies, balustrades, anchors, joinery, and more.

Authenticity was examined both in terms of functional concept and technological concept/materials. A relevant indicator was the siting of buildings relative to the street line.

After 1800, urban areas reveal a systematisation concept expressed through a series of regulations that were observed.

The analysis highlighted a set of measures that should be included in conservation and restoration programs.

Chapter 3 presents the criteria of listing of buildings as historic monuments. The structure of these criteria must be understood, as they represent the historical substance of a monument and any proposed intervention must not prejudice its valuable elements.

II. PERSONAL CONTRIBUTION

II.1. Research Objectives. Applied Research Methodology

The objectives of the research project were set to identify the main methods and techniques for the structural analysis of heritage buildings within an integrated approach, in line with European policies for the socio-economic inclusion of heritage.

Another component of the project's objectives was capacity-building in conservation and restoration through the application of new, digitisation-based technologies, together with the involvement of local communities, the stimulation of residents' interest, and strong interdisciplinarity.

The first element was initiated from the need to manage cultural heritage efficiently, through a holistic vision able to combine the cultural and engineering dimensions with the economic and educational components.

Preparing the digitisation component of all heritage-related activities began with setting up the primary data administration: identification elements, characteristics, technical condition vs. analysis of behaviour over time.

Accordingly, the research project proposed the following objectives:

a. Identifying the characteristics of listing the historical monuments in South-Eastern Romania by analysing structural systems, construction periods, building materials, and characteristic technologies;

b. Analysing their behaviour over time and identifying the destructive factors that have led to the cultural and historical depreciation of historic monuments;

c. Methods and techniques for the conservation and restoration of heritage buildings specific to South-Eastern Romania;

d. Socio-economic analysis to identify parameters for enhancing these heritage assets;

e. Identifying strengthening techniques specific to such constructions, intended to restore their load-bearing capacity without affecting their historic substance and values;

f. Contributions to advancing knowledge;

g. Identifying the elements needed to issue, in the future, a guide of conservation and restoration measures, potentially contributing to improvements in current technical provisions and regulations;

h. Developing new research directions to be pursued in the future, aligned with contemporary techniques, given the era of digitisation and the use of artificial intelligence in the qualitative assessment of buildings.

Applied Research Methodology

The research methodology aimed to identify the construction characteristics of heritage buildings in order to improve, as realistically as possible, the parameters for structural modelling and, at the same time, to quantify characteristic strengths for analytical calculations. This procedure was applied to multiple buildings, focusing on:

- Architectural composition;
- Knowledge of the historical evolution of both the area and the buildings analysed;
- Identification of constituent materials through façade stratigraphic survey studies and stratigraphic studies;
- Laboratory investigations made in accredited labs, including tests on mortars and bricks;
- Investigation of the behaviour over time of wood elements, identifying the degree of structural degradation;
- Study and analysis of site conditions;
- Study of interventions performed over time, whether or not they affected load-bearing elements.

The methodology also sought to identify the historical period of construction wherever concrete data on the building's age were available. At the same time, it considered the identification of the valuable elements that led to the listing of the entire area as a historic site.

In parallel with this procedure, I performed a comparative analysis of the behaviour over time of each element studied, based on the knowledge gained in the first stage of the research and on the locality's economic profile for given periods, factors that corroborated the scientific interpretation (for example, whether materials were sourced domestically or from abroad).

The methodology further relied on a socio-economic investigation of the periods through which the historic area has been used an absolutely necessary and economically justified approach.

Naturally, the aim of this research was to identify the most suitable methods and techniques for conserving and restoring historic monuments, so they can be meaningfully valorised within the current framework of cultural policies.

An in-depth study of techniques and materials was carried out using a methodology for the microstructural and mineralogical analysis of mortars composition that formed part of the load-bearing masonry. The case study focused on the "I. N. Roman" House of Culture in the city of Medgidia, built by the Governor of Bulgaria in 1856 and extended/restored in 1937.

The mortar analysis was performed using the university laboratory's specialized technologies, namely a diffractometer, microscope, and spectroscopic methods presented in detail in the thesis.

Samples were taken from the original structure (single-storey at the time) and from the early 20th-century extension.

The mortar research showed the presence of very fine aggregates and, due to the passage of time and weathering, significant mass losses and relevant endothermic effects findings that led to the conclusion that these can be attributed to the loss of physically and chemically bound water, as well as calcium (and dolomite) deposits.

All results were verified through complex thermal analysis, which proved comparable to the X-ray diffraction results.

The methodology also included a chemical analysis based on the ratio between the percentage of carbon dioxide and chemically bound water, in order to assess the extent to which the mortar was affected by decarbonation.

All these results presented in detail in thesis were aimed at identifying compatibility aspects between the existing mortars and the mortars to be used in the restoration process.

The research methodology drew on a number of buildings, generally listed as historic monuments hence of great importance to the community and on information provided by historical studies and the specialist literature.

In addition, the methodology relied on in-situ investigations using a sclerometer for brick compressive strength, a penetrometer for mortar strength to identify the degree of degradation, and structural radar for detecting reinforcement or other strengthening interventions within wall structures. Together, these methods helped identify the structural calculation parameters needed to evaluate seismic risk and define intervention measures.

Within the thesis I showed how these methodologies were applied to the case studies: the "Ion Bănescu" House in Constanța, the "I. N. Roman" House of Culture in Medgidia, and the "Water Castle" in Brăila.

Multiple structural typologies were analysed, residences/administrative headquarters/places of worship, belonging to both value group "A" and value group "B", in line with the classifications set out in Law no. 422/2001 on the protection of historic monuments and the List of Historic Monuments.

II.2. Results and Discussion

The research project set objectives whose fulfilment would enable the creation of a database, an intervention concept, and an in-depth analysis, both of these buildings and of the principles of conservation, their evolution, and the principles and evolution of intervention methods.

All proposed objectives were achieved. The research results were disseminated through articles, conference papers, scientific events, and a series of personal contributions that led to:

- creating a database to improve knowledge used in the methodology for assessing structural safety;
- identifying, as realistically as possible, behavioural parameters, characteristic strengths of materials, degradation factors, and response coefficients;

- advancing knowledge on the structural composition of constituent materials, an aspect that supports the development of typical intervention details for specific categories of heritage buildings;
- producing highly useful material for preparing historical studies, façade stratigraphic survey, and stratigraphic investigations;
- compiling a database of specialist studies on changes in material properties under climate-change effects (temperature variations, critical moisture levels, excessive wind speeds, and combined effects).

In this context, the doctoral thesis stands as a highly valuable work which, in my view, not only advances knowledge but also opens new research directions based on novel management concepts using artificial intelligence. It enables the computerisation of systems and subsystems for tracking and recording the technical condition of elements, which will help establish a robust maintenance methodology and ensure quality parameters at performance level.

Another outcome highlighted by the research is the feasibility of developing special mortars and finishing systems that embrace the concept of carbon-neutrality while also providing the necessary resilience and sustainability.

The study presents calculation procedures and laboratory investigations, with results reported coherently and progressively, in line with the project's development.

The doctoral research shows that South-Eastern Romania has a very rich historical fabric and distinctive characteristics, site conditions (foundation soils), materials used, and applied technologies, these last being closely tied to historical phases and contemporary policies. The region's multicultural character has left a strong imprint on historic buildings; consequently, central areas are generally designated urban historic sites, marked by powerful historic substance and by architectural influences from different peoples, transmitted across roughly two centuries. Notably, the oldest constructions that predate this timeframe are underground structures and archaeological sites.

Analysis of the conducted studies indicates that all objectives were achieved, each of the ten chapters applying its objective to a case study. The work offers elements of originality and synthesis, as well as statistical analyses, crucial for shaping a view of urban evolution and of changing attitudes toward the conservation and protection of historic monuments.

The study brings to light the authentic features of the existing building stock, so that any restoration or conservation effort should begin from the monument's authenticity, and any intervention should be grounded in the behavioural parameters of the constituent materials. The thesis examines aspects of urban history, identifying construction periods and architectural influences. These investigations supported the definition of an intervention concept and structural design principles, with the aim of setting restoration works that can be revisited over time as knowledge advances.

Almost every chapter functions as a case study and is characterised by a renewed research methodology and comparative analysis. Understanding structural parameters enables the identification of the degree of vulnerability and seismic risk, which, in turn, guides the selection of interventions that do not harm the historic substance.

Subchapter 8.1 presents interventions for strengthening the foundation soil and the infrastructure; subchapter 8.2 addresses the infrastructure of historic buildings; and subchapter 8.3 provides solutions for interventions on the superstructure. Some interventions are invasive solutions that still allow for further works over time, while others depending on the constituent material and importance class, motivated approaches that both increase structural safety and enhance the monument within the framework of an integrated policy concept.

III. GENERAL CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

The thesis addresses a particularly important and timely field, the conservation and protection of historical monuments, within the context of European cultural policies that call for an integrated approach designed to ensure sustainability and interdisciplinarity in identifying national values.

South-Eastern Romania has an highly valuable heritage, which makes it imperative to adopt urgent conservation and rehabilitation measures that can be efficiently managed by those administering these assets at the community level.

The doctoral thesis highlights that heritage management is no longer merely about preserving objects; it is a holistic vision that interweaves cultural, educational, economic, and social dimensions.

The research project also showed that now more than ever interdisciplinarity is the only viable path to both administer and adopt effective measures. Any intervention on a monument begins with an understanding of its historical importance or architectural value and with identifying the value-based requirements and criteria that warranted its listing as a monument.

If community members, administrators, or owners aim to promote artistic components and showcase architectural styles or other visually identifiable elements, it must be noted that this research uncovered new value-identification elements for historic monuments, factors related to functionality, strength and stability, resilience, and sustainability, that, in a forward-looking view, can become selective criteria conditioning intervention measures.

In this context, I refer to authentic construction features of masonry, cornices, balconies, parapets, and bay windows, all of which possess strength and stability dependent on the building's structural system as a whole.

Another finding of the research project is the need to protect urban archaeological sites through intervention solutions that inform the forms and dimensions of infrastructure, solutions that both shield archaeological components and often help to enhance them.

The research required studies tracing how buildings evolved in historic urban areas, producing comparable insights both across structural elements of the same type within a given perimeter and across solutions applied in a wider area. This shows that, at given historical stages, the inhabitants' building activity was grounded in a shared culture, an architectural conception, and a construction system.

Archival investigations led to the conclusion that many of the projects for the buildings studied, both in Brăila and in Constanța, were designed by renowned architects and engineers. This correlates with each community's economic development and is explained by increased investment capacity.

Both architectural and structural aspects display multicultural influences, crucial for understanding the area's history and, even more, the vision and customs of the people who lived there.

The project examined not only constituent materials and execution technologies, but also accessory elements that improve structural behaviour or shape the architectural character of façades. An interesting aspect concerns the design of structural ties, implemented via tie

rods and anchors, and the arrangement of bricks within the masonry. The shapes of anchor plates can provide important clues about the construction period; likewise, window forms, architectural mouldings, and cornice types help date buildings and reveal the evolution of urban regulations governing construction in different periods.

A core concept developed in this research is durability as a primary factor in meeting strength-and-stability requirements. While any structural solution may be considered for new buildings, interventions on heritage structures must allow future works to proceed in step with scientific advances.

The work presents a coherent set of interventions for both substructure and superstructure, prioritising measures that do not harm historic monuments. The findings underscore that historic monuments should meet performance requirements comparable to those for new buildings; however, for such structures the performance levels and specific quantification methods are not defined in current technical regulations. In international practice, for interventions on existing buildings, strict congruence with the performance levels required of new buildings is not demanded; accordingly, building codes serve as guidance. The vast variety of conditions in the existing stock age, wear, site conditions, cannot be subsumed under design rules for new construction.

In rehabilitation, the primary objective must remain the conservation and enhancement of the characteristics of uniqueness, rarity, and originality. Even in seismic-risk assessment for historic buildings, international practice shows a nuanced attitude.

Through the studies undertaken, the thesis highlights cultural value as perceived by contemporary observers, expressing the degree of societal interest. In another view, this is an "associated heritage value," inherently subjective because it depends on political, economic, and social factors.

Community involvement in conserving and protecting historic monuments is an emerging direction in cultural policy, enabling each asset to be valorised economically.

The research showed that intervention measures for restoring historic monuments must be correlated with the degree of structural impairment and with how the asset will be valorised. Recently, the degree of structural impairment has become a primary element in analysing long-term behaviour. The findings indicate that, in addition to earlier causes, poor maintenance, repurposing, exceptional actions, climate change is increasingly present in the

degradation trajectory through excessive temperatures, high humidity, strong winds, or pressure differences. Consequently, both calculation methods and exposure assessments must be adapted to current challenges.

The case studies demonstrated that materials used in conservation and restoration must be compatible with the original materials, and structural interventions must not damage architectural components, which often extend to interior elements.

Restoration is a highly complex activity engaging large teams of specialists. The overall project lead should invariably be an architect; in parallel, the structural engineer determines the feasible scope within the building's available parameters.

The investigations aligned with principles from the specialised literature show that, in the field of historic monuments, restoration principles must follow the criteria underlying monument listing, and interventions must not harm the asset. Proposed works should constitute an invasive solution (so they remain a "reserve" for future research responsive to conservation and restoration principles); where this is not permissible and the asset is exceptionally valuable, restoration should focus on conservation and on enhancing the monument's message in economic and social terms. That message is its historical substance, defined by authenticity and originality, and modern means and techniques must not alter traditional traits. From this point of view, concrete is not always the optimal material for interventions.

The case studies addressed either the strengthening of masonry piers (vertical wall elements) or the transformation of load-bearing masonry into self-supporting masonry by introducing resistant elements capable of taking over stresses and deformations.

Across the European Union there is a wide range of restoration and conservation measures in use, including modern concepts such as carbon-fibre and glass-fibre composites and various durable fabrics compatible with mortar or concrete. Another widely used principle is the incorporation of metal elements anchored into the structural system to take over part of the stress state (e.g., metal decking/plates over vaults and arches) and, in many cases, timber components.

In structural terms, restoration is complex and challenging, both in mathematical modelling (so the analytical model approximates real behaviour) and in execution. For this reason, the existing built heritage must be regarded as a viable component not only culturally,

but also economically and socially, integrated as compatibly as possible into communities' evolving urban concepts.

Looking ahead, the historic monument will form an exceptionally important pillar for the development of knowledge, culture, and traditions and will soon become a driver of progress in both construction materials and high-performance technologies.

At present, restoration faces new challenges brought by the increasingly tangible effects of climate change. Case histories are no longer a prospect for the future; we are confronted with a fait accompli, with effects unfolding in real time. Consequently, progress in restoration must urgently adapt to these new challenges.

Future Research Directions

The doctoral research project brought to light a wealth of highly valuable findings from historical research, façade stratigraphic survey, stratigraphic investigation, and the study of construction materials. The results were synthesized into a database that will be especially useful to future researchers, enabling them, beyond the historical context, to examine numerous aspects related to the technologies and materials used, as well as interventions on the load-bearing structure that do not compromise elements of authenticity, artistic components, and more.

In this context, the civil engineering research drew on a wide range of studies and analyses, historical and architectural studies, geotechnical investigations, façade stratigraphic survey, stratigraphic studies, laboratory testing, physical and chemical analyses, and scientific interpretations, integrated into a coherent whole capable of identifying a valuable built heritage whose presence must be conserved, preserved, and restored.

The research project revealed numerous highly valuable aspects that, until now, had not been highlighted. The results in civil engineering capitalised on a wealth of historical and architectural studies, geotechnical investigations, façade stratigraphic survey and stratigraphic surveys, laboratory tests, physical and chemical analyses, and scientific interpretations, together forming an integrated framework capable of identifying a valuable built stock whose presence must be conserved, safeguarded, and restored.

The research has identified a highly relevant path forward: by leveraging the results as a database within the digitization process, they can be used further to determine the composition of materials to be employed in restoration.

The results also show that the service life of heritage buildings is reduced by the decarbonation process affecting nineteenth-century mortars. Consequently, future research can be directed toward identifying materials and technologies to neutralize or mitigate this process, products that can be applied to affected surfaces to attenuate the phenomenon.

Likewise, the rehabilitation technique used at the "Ion Bănescu House" can serve in future as an applicable solution for the structural system of historic buildings, benefiting from its invasive character.

The research results highlighted the need to extend the study to structures built in the early 19th century, in order to collect as much characteristic data as possible for the digital valorization of these assets within a new framework for the conservation and restoration of buildings in the Dobrogea region.

Future research outcomes could also lead to new ways of valorising subterranean structures and "hrube" (vaulted underground galleries), integrating them into tourist and economic circuits.

IV. ORIGINALITY OF THE DOCTORAL THESIS

The research project, through its results, provides restorers working in the urban historic site with an original approach grounded in integrated restoration principles, both by enhancing archaeological sites and by valorizing the authentic elements of the architectural and structural components.

Starting from the criteria that define a historic monument, authenticity, rarity, uniqueness, I carried out value analyses for each component, recommending intervention techniques and methods for the various elements, namely substructures and superstructures.

I conducted the research in an urban context, primarily within the historic sites of several municipalities and towns in South-Eastern Romania, chosen according to the historical weight of their central areas. Building on the identification of heritage in this region, I extended the study over a long period, predominantly the 19th–20th centuries.

The doctoral research programme was aligned with current needs in cultural heritage and with European cultural policies. Its objectives sought to identify structural analysis and restoration methods and techniques; the studies and investigations undertaken responded to the requirements of new, digitisation-based technologies, with originality in the approaches adopted and with an emphasis on stimulating public interest. The objectives also arose from the need to manage cultural heritage by creating databases capable of establishing the main factors that influence structural calculation and behaviour.

In this context, the research methodology, through original studies, identified construction characteristics of materials and technologies, volumetric structure, functional configurations, and, not least, long-term behaviour. The research drew on unique elements and began from a historical reading of building periods, the evolution of construction regulations, and the development of the restoration concept.

Within the project, I implemented research methods based on qualitative analyses and on analytical assessment for a memorial house; intervention solutions, methods and technologies were applied to several case studies of listed buildings. In terms of results, these provide a rich information base that stands as hypotheses for structural interventions on categories of heritage buildings located in South-Eastern Romania.

The thesis comprises 10 coherently structured chapters with substantial, relevant content, 210 figures, and 15 tables.

An important component of the research concerns the protection of urban archaeological sites. Their analysis is presented in an original way in the context of valorisation on the sites of new constructions, detailed in Chapter 3, which exemplifies multiple archaeological sites identified adjacent to major buildings as well as sites uncovered during new building works, exposed in the course of excavations.

Another major component is the valorisation of buildings executed on pre-existing infrastructural components, prior to the erection of the superstructure and in different stages. Such situations are found especially in Brăila, where as shown the substructure belongs to one stage and the superstructure to another, leading to the conclusion that the early-20th-century urban expansion was built upon the infrastructures of much older buildings. The historic site of Brăila abounds in such cases, encountered in residential buildings and sometimes in

administrative ones. In heritage restoration practice, basements and accesses to underground galleries (hrube) are rehabilitated and brought back into functional use.

These results, structured by historical periods, were included in a statistical analysis, presented graphically in an original manner with the conclusions drawn over roughly 100 years. As shown in Section 3.5, the interval 1904–1955 was a period of stagnation; 1955–1980 saw moderate growth in the number of architectural monuments; 1980–1992 shows a progressive increase in architectural monuments and a moderate maintenance of the others (archaeology, memorials).

Within these synthetic analyses, I establish several periods for Brăila corresponding to key waves of interventions or phases of monument identification. Similarly, the research extends to other urban centres such as Medgidia. As noted earlier, the thesis also traces the evolution of the restoration concept, presenting the main stages that shaped rehabilitation through the Venice, Amsterdam, and Granada conventions. The evolution of principles is also examined for Romanian monuments, with a chronological phasing of measures concerning the restoration of major historic monuments over time.

Starting from the criteria defining monument status, I researched the evolution of Brăila's historic centre, identifying rehabilitation works. The study focuses on Traian Street, between Traian Square and the Harbour of Brăila, a route that, according to the research, is over 200 years old, whose buildings are mostly post-1860. It is emblematic for Brăila, linking the Danube to the central urban square and opening onto the theatre, the former "French hotel", and the headquarters of former banks.

Another study presented in the thesis covers part of the listed buildings in Medgidia and part of those in Ovidiu Square, Constanța.

A deep investigation into materials is the microstructural analysis methodology applied to mortars from load-bearing masonry. For this, I also used authorised chemical-engineering laboratories of the University. The results highlighted very fine aggregates and, importantly, evidenced the onset and propagation of decarbonation; the method applied is original in establishing a compatible intervention material. Another element of originality is the chemico-mineralogical analysis using the non-destructive technique of X-ray diffraction.

Recognising that any intervention must consider both the state of deterioration and its causes, I developed a major chapter on the long-term behaviour of heritage buildings whose

findings determine the degree of vulnerability, seismic risk level, and the urgency of maintenance or making-safe works.

The project also develops principles and methods for structural analysis aimed at qualitative and analytical evaluation of heritage buildings. Based on current regulations, these analyses were carried out on listed buildings such as the “Ion Bănescu House,” a memorial house that the Constanța City Hall is fitting out as a Cultural Centre. The case-study results show the need for interventions that avoid destructive impacts on valuable elements and do not compromise authenticity, valorising glass-fibre meshes applied with thermosetting resins, a composite material known for high tensile and shear strength.

A chapter that presents important, original results on intervention measures for heritage buildings is Chapter 8, which sets out measures targeting increased durability of constructions. The case studies in this chapter, all from South-Eastern Romania, document projects in which I actively collaborated, both substructure strengthening and superstructure consolidation.

Chapter 9 is another key section, developing the analysis of constituent materials with original results concerning the requirements and performance criteria of materials used in restoration. The research results stand out for their originality, as they provide concrete details on how buildings were constructed in Dobrogea at the end of the 19th century and the beginning of the 20th century, offering unique material that documents both the characteristic strengths of the materials and the technologies employed.

Through the database created, the project makes a substantial contribution by supplying a resource for the management of these buildings and for the application of BIM technologies, even in conservation and restoration, as well as for planning intervention works. Thus, the results establish the conditions to leverage this material with artificial intelligence in the very next phase.

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