MECHANICAL ENGINEERING | PHYSICS |
PRESERVATION OF THE ARCHITECTURAL HERITAGE | STRUCTURAL, SEISMIC AND GEOTECHNICAL ENGINEERING |
URBAN PLANNING, DESIGN AND POLICY | AEROSPACE ENGINEERING |
ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING |
ARCHITECTURAL, URBAN AND INTERIOR DESIGN | BIOENGINEERING | DATA ANALYTICS AND DECISION SCIENCES |
DESIGN | ELECTRICAL ENGINEERING | ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY |
ENVIRONMENTAL AND INFRASTRUCTURE ENGINEERING | INDUSTRIAL CHEMISTRY AND CHEMICAL ENGINEERING |
INFORMATION TECHNOLOGY | MANAGEMENT ENGINEERING |
MATERIALS ENGINEERING | MATHEMATICAL MODELS AND METHODS IN ENGINEERING
The Doctorate Course in ‘Preservation of the Architectural Heritage’ was first held at Milan-based Politecnico back in 1983.

The PhD program focuses its attention to some currently crucial themes for the preservation, conservation, management and valorization of Architectural Heritage. Starting from the fundamental topics of knowledge, preservation, design and intervention, the PhD program takes care of the most important and urgent problems affecting the built Heritage and Cultural Landscapes: the fragility and the abandonment of historic marginal areas; the climate change and its effects on the built environment; the improper pressure of mass tourism on our historic settlements and sites of cultural interest, the needs for a wider social involvement in the field also through appropriate ICT mediums, the management and the use of architectural Heritage.

The conservation of Architectural Heritage is, in fact, a strategic field as well as one of the main important resources for worldwide economy and for a sustainable future in different areas of the world. The team of professors, promoting and participating in the debate about these matters on a national and international scale, will thus deal with a broad range of issues requiring strong and real multi-disciplinary approach.

In addition to the professors of architectural restoration, history of architecture and structural strengthening of the Politecnico di Milano, the Faculty Board includes representatives from other well-known universities and research institutes (Università IUAV, Venezia; Università di Genova; Università degli Studi di Bergamo; ICVBC - CNR); they collaborate actively in the teaching and research activities.

The ultimate purpose of the Faculty Board not only resides in broadening the experiences that the PhD candidates acquire over the first three years of the course, where they have the opportunity to interact with scholars from different backgrounds; it chiefly aims at providing the PhD candidates with a unique training experience in the Italian panorama, so far unparalleled also in domains other than the preservation and restoration of the cultural heritage. Such context investigates the synergies and responses to the modern themes of cultural heritage protection.
In this connection, the PhD programme deems to carry on the long-standing collaboration with the ICVBC-CNR (the Institute for the Preservation and Enhancement of Cultural Heritage).

As for the thesis research, candidates thus have the opportunity to address and investigate in-depth the wide-ranging themes connected to heritage knowledge and preservation broadly meant, such as advanced methods of investigation.

The multi-disciplinary nature of the doctoral courses, encouraged in the framework of the PhD programme since its establishment, equally values the fundamental contribution of historical research and its methods; at the same time it features innovative, pioneering themes: impacts of climate change on architectural heritage and cultural landscapes; Inner Areas: census, conservation and re-use of Architectural Heritage; strategic approaches for the preservation; social involvement and Communities engagement in the protection and management of their Heritage; Impact of mass tourism on architectural heritage and cultural landscapes; cultural and sustainable tourism policies and practices; Architectural Heritage at risk in seismic or in conflict areas; Architectural Heritage and Cultural Landscapes in Countries in transition; Cultural Heritage and Economic Evaluation.

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THE ROCK-CUT MONUMENTS OF NAQSH-E RUSTAM: A CONTRIBUTION TO UNDERSTANDING THE SITE EVOLUTION AND THE DECAY PHENOMENA THROUGH HISTORICAL AND PRESENT SURVEYS

Sahar Ahmadinezhad - Supervisor: Prof. Andrea Pane
Co-Supervisors: Dr. Antonio Sansonetti, Prof. Rasool Vatandoust

The PhD thesis aimed to investigate the evolutions of decay mechanisms of stone material in architectural heritage. Such evolutions resulting from human-induced changes in climatic and environmental conditions have manifested themselves in the visible forms of increased and intensified decay patterns which imposed a new challenge in architectural conservation. While the historical resources have considerable potential to assist the research about this challenge, there is still a gap between the scientific experimental studies and historical investigations on the records related to stone monuments and sites to frame the evolution of the decay patterns in a more comprehensive way. Therefore, the objective of this research is to develop a timelining method for the evaluation of the changes in decay patterns in the rock-relief monuments with a focus on the historical site of Naqsh-e Rustam (Marvdasht county, Iran) and to highlight the relationship between the timeline of the changes in decay patterns with the historical sequence of events in the greater area surrounding the site. The site was selected as a focal point as it has been visited frequently by travelers and pioneer archaeologists who described the site’s characteristics and its surrounding context using drawings, photos, and even experimental methods. Therefore, the study is structured in 3 phases. The first phase comprises the analyses of the potential influence of the surrounding territory on the site (macro-scale) with a focus on potential risk factors such as air pollution caused by agricultural activities and urbanization processes. The second phase includes the analysis of the historical documentation with particular attention to the analysis of photographic documents and historical drawings of the rock reliefs and the changes on their surfaces (mesoscale). The third phase, accomplished using instrumental analyses, includes an evaluation of the samples taken from the rock material and the surface decay products (microscale). Based on the results of investigations at the mesoscale, the tomb of Xerxes was selected for instrumental analyses since the timeline of decay evolutions for the rocks of this tomb was less disrupted in comparison to other elements of the site of Naqsh-e Rustam. The timelines of changes in each of the three scales of the study were developed for evaluation of the increased decay and identification of the potential impact of the human-induced environmental changes. Regarding the macroscale, the research highlighted increasing air pollution in the broader area surrounding the site. In four historical phases including the land reforms after the 1910s, the industrialization in the 1930s, the second period of land reform in the 1980s, and finally after the new rural planning started since the 1980s. On the other hand, the historical investigations at the mesoscale showed observable changes in decay phenomena, i.e., the emergence of the black crusts and highly intensified surface erosion, on rock reliefs of the tomb of Xerxes in the period between the 1930s and the recent period. The increased decay was quantified by the indexes of decay (Dišin and Dipro2) using a method of image processing developed for this study. Only a few indications of decay problems in the tomb of Xerxes were identified in the surveyed historical documents about the earlier periods. The estimations based on modeling the air pollution levels show that the concentrations of pollutants, including CO2, CH4, VOCs, PM2.5, NOx, SO2, and NH3 have been highly increased during the 1970s as a result of intensified agricultural land use, by the establishment of the sugar factory and later with other agri-food industrial units. However, the intersection of the historical data on the macroscale with the data collected on the micro-scale demonstrated that the decay phenomena such as black crusts have been formed later. The comparison of early scanning electron microscope (SEM) images from the mid-1970s with those taken from new rock samples showed that the types of weathering effects on the stone surface in the 1970s were mainly erosion caused by mild acidic solutions, which could be similar to the carbonate rocks’ decay in unpolluted areas. The generation of black crust and highly intensified surface erosion in the new samples are linked to the pollution from the petrochemical industry and the urban population increase in Marvdasht county started in the 1980s. Moreover, regarding the historical records of climate changes, a significant reduction of the annual precipitations since 2006 along with changes in the Standardized Precipitation Index (SPI) and wind speed were highlighted. Although the impacts of these climatic factors in stone decay have been almost negligible in comparison to the highly increased effect of the local air pollution, climate changes with fluctuations of precipitation in long term will intensify the deterioration processes. The problems in the integration of the results from the three different scales of the investigation were discussed in the final part of the thesis. The potentials of the timelining method, as the output of this research, to assist in the prediction of future decay changes and its strengths and limitations compared to other approaches was assessed as a tool for studying similar rock-cut architecture sites, especially in long-term conservation planning for the rock-cut sites in Marvdasht county and in the scope of the extension of the boundaries of the world heritage site of Persepolis to cover the site of Naqsh-e Rustam.

Fig. 1 - Rock reliefs on the tomb of Xerxes, Naqsh-e Rustam, Iran
The research explores the decommissioned military sites and artefacts built during the Cold War in Italy, such as nuclear weapon stores, communication and radar systems, military airfields, aviation and naval sites, and missile defence structures. The objectives are the identification and knowledge of military complexes built between 1947 and 1989 that the armed forces decommissioned, listing and mapping them and describing the selected systems’ architectural, technological and functional features. The sites under study, especially those connected with the missiles and communications, are part of peculiar systems for the Cold War, become obsolete after a few years of use and have been decommissioned, in some cases, before the end of the period of contention between the two blocks. These include missile sites (Jupiter, Nike, Hawk, Cruise) telecommunications sites (ACE High Tropo Scatter), research and communications sites (test sites, NATO headquarters).

The analysis of the sites related to the Cold War highlights the strict connection between military strategy, architecture and technology they had to host. This systemic architecture, tailored as the infrastructure around specific bellisic aims and operations, was used for a concise cycle of use, after which it became obsolete. The site systems described were chosen primarily for this impermanence because of to the close link between the instrument of war as a site and the technology adopted, and the site’s lack of adaptability to rapid changes in war technology. In addition to the problematic adaptability to rapidly and irrevocably changing military technologies, the short history of use of most of these sites also offers evidence of how difficult it would be to put them back into the current defence strategy of the armed forces today due to the effect that decades of neglect have had on the structures. This situation opens an engaging reflection on how to preserve, reuse, or notify these material testimonies, which used to contain the most dangerous weapons in circulation.

Studying Italian Cold War military within the field of history of architecture and architectural preservation in a systematic way could help overcome the peculiarity of the segmented military forces organisation, which does not facilitate the integration into systematic knowledge. Studies on the military matter must be approached by taking into account the fragmented nature of the organisation of the armed forces. Starting from the analysis, the problematisation of the lack of reuse and protection strategies for the material traces of this part of history is a possible outcome. With the recognition of these areas as specific territorial and economic resources, the research presents the need for strategies in their reuse and questions whether some of these artefacts can be considered heritage and should therefore be preserved in the future. At the moment, it is not possible to protect any of these buildings in the context of the Italian legislative framework since they were built less than 70 years ago.

The risk is to lose the sites and related knowledge before it could be possible to preserve them, which resides both in the material remains and in the memory of the people who have worked and served in these places. A reflection on the protection of the sites would have more success when the generation who has lived during the Cold War has not disappeared yet. It is vital to record these intangible features, part of the memory of one site, with its material traces, quality and characters, and open a discussion on the criteria for the recognition for protection in the framework of Italian law. The archival records regarding the mentioned complexes are still only partly accessible due to the temporal proximity of the events related to the sites and the dispersion of the sources and the memory of its participants.

The awareness of the meanings and historical, technical and use interests around these sites will be raised following several methodological steps:

- the state-of-art analysis of Cold War architecture studies and the recognition for protection and reuse project initiated in other international contexts. The analysis of two specific cases has been carried out, opening the exploration of contemporary but very different approaches to the identification of Sweden and the United Kingdom:

- the Italian historical and strategical context analysis during the period and the resulting deployment of sites on the Italian territory;

- the study of the classification localisation of the military sites, the types of building use, and their decommissioning process is recorded using comparative categories and systems inventory sheets;

- the description of five site systems exemplary of the systemic architecture peculiar to missile and communication sites. The sites have been chosen because of their connection to international and national historical events, their presence in published bibliography, and, above all because they represent a whole group of sites with specific use interests around these sites will be raised following several methodological steps:

- the state-of-art analysis of Cold War architecture studies and the identification, preservation and reuse project initiated in other international contexts. The analysis of two specific cases has been carried out, opening the exploration of contemporary but very different approaches to the identification of Sweden and the United Kingdom:

- the Italian historical and strategical context analysis during the period and the resulting deployment of sites on the Italian territory;

- the study of the classification
THE SEISMIC PROTECTION OF THE BUILT ARCHITECTURAL HERITAGE – THE ORGANISATION OF KNOWLEDGE AS A PREPARATION TO RISK

Enrica Brusa - Supervisor: Prof. Claudio Chesi
Co-Supervisor: Prof. Stefano Della Torre

This work is the result of an interdisciplinary research, developed jointly between the PhD course “Preservation of the Architectural Heritage” (DABStU) and “Architecture, Built Environment and Construction Engineering” (DABIC) of Politecnico di Milano. The research, supported by a specific interdisciplinary grant entitled: “Heritage assets at risk. Prevention modalities and benefits”, treats the matter of the protection of the Built Heritage from the seismic risk, focusing in particularly on the emergency phase that follows an earthquake.

One of the principal aims of the research was to highlight some criteria that would be able to improve the promptness of the reaction carried out by the public Agencies in order to protect the built heritage from a worsening of the damage – i.e. the one provoked by the aftershocks. For this reason, the research deals in particular with the topic of the technical countermeasures that are taken during a seismic emergency on the damaged built heritage. The general question that guided the development of the research has been: “After an earthquake, is it possible and how to improve the promptness of the securing interventions on the built heritage, aiming to limit additional damage produced by the aftershocks?”. The ability to promptly install technical countermeasures on historical buildings damaged by an earthquake represents an important issue in relation to the protection of the built heritage from the progress of damage, reducing the risk of further material losses due to the occurrence of aftershocks. This kind of intervention, also known in the Risk analysis as the coping capacity of a society, can be a valid resource in order to stop the progress of damage on the built heritage, if well managed and promptly executed. Moreover, it can also provide for the lack of previous works aiming at vulnerability reduction in historical buildings. Indeed, despite these latter constitute the more appropriate solution to improve the seismic resistance of buildings, it is often difficult to realize them, mainly due to their high costs or to the presence of specific constraints related to the building cultural value. Regarding the protection of the cultural heritage, different public Agencies are involved in the emergency operations – such as the National Fire Brigade (NFB), the Civil Protection Department (CPD) and the Ministry of Culture (MiC). For this reason, also the cooperation capability of the specialised operators, together with knowledge availability and specific technical solutions developed to protect the cultural heritage, constitutes an important issue for assuring a satisfactory level of the securing emergency activities. The analysis of the operations that during an emergency are performed by the public Agencies for the protection of the built heritage represents an innovative topic, which has permitted to highlight the main features of a complex scenario, characterized by different regional laws and rules, by various exigencies of the involved specialists and by dishomogenous local experiences with respect to the emergency interventions. Furthermore, it has revealed the possibility to interpret emergency interventions as a particular phase of the more ample procedure of damage prevention, since they can be seen as a specific activity to prevent the occurrence of further damage. The thesis has analyzed the topic of the seismic emergency that followed the earthquake occurred in Central Italy in 2016, since that experience has well demonstrated the damage increase that can be provoked by the aftershocks, especially in those buildings that hadn’t been secured following the first ground shock. Another interesting element was due to the involvement of different Regions, each one characterized by specific forms of emergency procedures and expertise. Additionally, the areas had been affected by previous seismic emergencies, like the one that followed the earthquake of Umbria and Marche in 1997, and the one that followed the earthquake of L’Aquila in 2009. The research has analyzed the technical countermeasures that were realized by the NFB onto the built heritage during the first two months of the emergency phase. This time corresponds to the interval between the earthquake of 24th August 2016 and the main aftershocks, which happened at the end of October 2016. Meaningful case studies have been identified in the Regions of Umbria, Marche and Lazio, thanks to the help of the NFB and of the local offices of the Ministry of Culture. The research has proved the importance of promptly realizing technical countermeasures for securing the built heritage damaged by an earthquake in order to minimize further material losses produced by the aftershocks. It has also highlighted that the good interoperability level among technicians and public officials positively influenced the realization of the emergency activities, assuring a prompt reaction and successful coordination during the field operations, in addition to fulfilling the needs of both the conservation of the historic buildings and the safety of the operators. One of the main aims of the PhD thesis has consisted in the attempt to focus the elements that still need to be improved during the execution of technical countermeasures, as for instance the effective sharing of the available knowledge among all the involved operators. Indeed, the possibility to access available data on historic buildings is a main issue in the process of understanding the structural behaviour and to properly designing countermeasures. Nevertheless, these data are usually fragmented, as they are kept in different archives and not digitalized. Information, therefore, is hardly accessible during an emergency, with no possibility to be rapidly consulted. Thus, a relevant improvement could be achieved through a wide communication action and a deep exchange of existing data among the Agencies that are involved in the emergency phase, through a widespread organisation of knowledge, anytime respecting their peculiar requirements. Moreover, achieving such a kind of exchange will allow for the realization of a better inter-operability among the public Agencies that participate to the implementation of technical countermeasures on the damaged built heritage, also allowing for a better preparation to promptly face the seismic risk and to reduce the occurrence of further damage eventually produced by aftershocks. One of the innovative aspects highlighted in the thesis comes from considering the improvement in the organization of the available knowledge of single historic buildings as a valid instrument of prevention. This instrument is also necessary in order to reach a more effective preparation to risk.
Between the first and second postwar periods, the Istituto Autonome Case Popolari (IACP) of Milan (IACPM) built more than 40 social housing districts: the Treccia (1925-27), the Stadera (ex-XXVIII Ottobre, 1927-28), the Treccio (1933-38), and the Lorenteggio (ex-Renzo and Mario Mina, 1938-44). The selection of case studies comes from the choice of paying particular attention to those accommodations - originally defined as ultrapopolari or popolaresime - built and forcibly placed on the market - through direct or indirect action - by the public authorities to meet an unmet demand of very low-cost accommodations triggered by the great housing crisis that exploded in Europe at the end of the First World War and by urban renewal policies conducted by the regime in Italy. These architectures have indeed represented an unprecedented policy of differentiation of users inaugurated in the twenty years of fascism, but whose discriminatory results have survived in part within the most recent housing policies.

The whole discourse was therefore made to rotate around the life of four of these districts: the Solari (1925-27), the Stadera (ex-XXVIII Ottobre, 1927-28), the Treccio (1933-38), and the Lorenteggio (ex-Renzo and Mario Mina, 1938-44). The selection of case studies comes from the choice of paying particular attention to those accommodations - originally defined as ultrapopolari or popolaresime - built and forcibly placed on the market - through direct or indirect action - by the public authorities to meet an unmet demand of very low-cost accommodations triggered by the great housing crisis that exploded in Europe at the end of the First World War and by urban renewal policies conducted by the regime in Italy. These architectures have indeed represented an unprecedented policy of differentiation of users inaugurated in the twenty years of fascism, but whose discriminatory results have survived in part within the most recent housing policies.

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