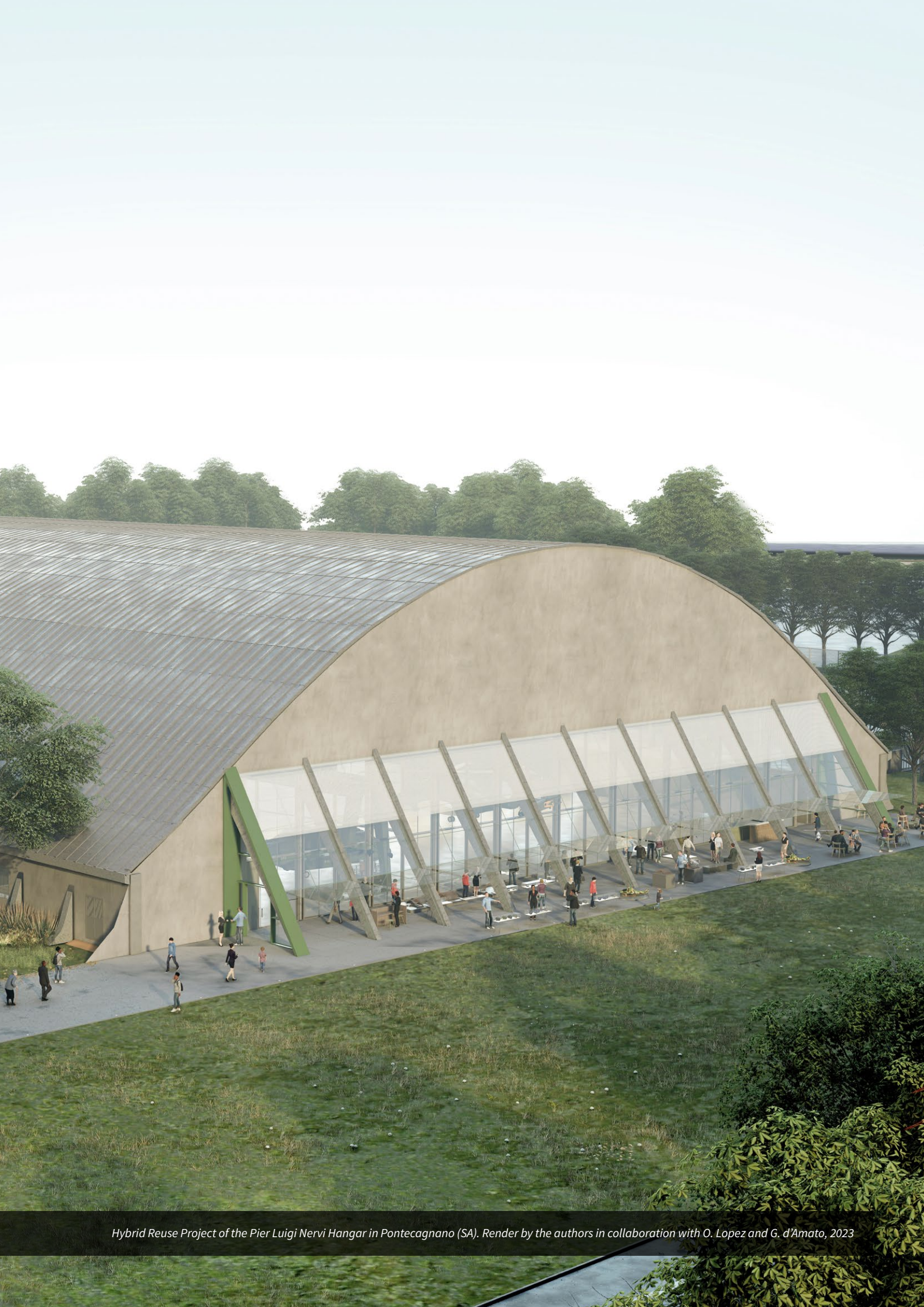


Hybrid Reuse Project of the Pier Luigi Nervi Hangar in Pontecagnano (SA). Render by the authors in collaboration with O. Lopez and G. d'Amato, 2023

Adaptive reuse of modern heritage for cultural purpose: Hybridization strategies in Pier Luigi Nervi Hangar, Italy

Pasquale Cucco*, Giulia Neri, Federica Ribera

Department of Civil Engineering, University of Salerno, Italy.
**Email: pcucco@unisa.it*

Abstract: The evolution of cities and urban landscapes has witnessed the rise of architectural complexes and urban areas adapting to new functions while leaving behind others deemed obsolete. This phenomenon has sparked a surge in research endeavours aimed at hybridizing land use, not only for urban planning but also for the revitalization of historical edifices. This resurgence often entails the requalification and adaptive reuse of architectural artifacts, harmonizing their historical significance with contemporary demands. This paper delves into a case study focusing on the hybridization project of a pivotal piece of Italian engineering history: the 1938 hangar designed by Pier Luigi Nervi in Salerno, Italy, a groundbreaking prefabricated reinforced concrete structure. The study faces the dual challenge of preserving the hangar's cultural and technological heritage while seamlessly integrating contemporary cultural functions alongside its military roots. Through an interdisciplinary approach, this research navigates through the complexities of architectural hybridization, offering insights into the preservation and adaptation of historical landmarks for future generations.

Keywords: Heritage; Conservation; Contemporary cultural functions.

Cite as: Cucco, P., Neri, G., & Ribera, F. (2024). 'Adaptive reuse of modern heritage for cultural purpose: Hybridization strategies in Pier Luigi Nervi Hangar, Italy'. *VITRUVIO - International Journal of Architectural Technology and Sustainability*, *9*(1), 56-77. https://doi.org/10.4995/vitruvio-ijats.2024.21482

1. Introduction

The growth of cities and urban areas has been significantly influenced by technological advancements and evolving societal needs, particularly throughout the 20th century. This trend has resulted in the abandonment of numerous architectural complexes and urban areas that no longer serve contemporary demands, while also fostering opportunities for new programs and renewal initiatives.

In the current international scenario, the theme of adaptive reuse is particularly compelling as it interprets tradition not merely as a straightforward and automatic transfer of assimilated habits, but as a stimulus for innovation within the continuity, aimed at expressing the identity of places and human cultures (Cucco et al., 2023; Ribera et al., 2020). Adaptive reuse, which involves repurposing historical buildings for new functions (Bullen, 2007), entails a "change of use" within the original structure to prolong the property's lifespan (Wilkinson et al., 2014).

It embodies an approach to historical architecture that goes beyond mere, albeit necessary, preservation, envisioning actions and strategies to perpetually maintain the rich and delicate cultural heritage and what it conveys. It is evident that the theme, emancipated from a reductive and even utilitarian connotation, is closely linked to that of conservation and must be approached in conjunction with assessments of past functional history, the quality of the built environment, and the achievable outcomes through the allocation of new purposes. It is a process that, starting from the study of the existing, returns a disused or underused asset to the city, ensuring both its contemporary utilization and the preservation of its historical, architectural, and cultural properties (Petzet, 2009).

In this broad context, there are some emblematic and valuable buildings that, while maintaining their private function, possess intrinsic characteristics of becoming true attractors for the development of an area, for knowledge of its heritage, for activating virtuous productive circuits.

In such cases, it is useful to suggest hybridizations of use, maintaining the function in place and attempting to compatibly incorporate public functions, especially of a cultural nature and suited to the development of a community. Various research encourages to propose hybridized usage models, to integrate civil functions with cultural uses useful to all. The application of hybridization actions to harmonize with the inherent characteristics of each component, aiming to provide optimal solutions for diverse models, land use development, and rapid urban expansion. The complexity escalates when addressing historically significant architectural assets, where the hybridization of use must preserve and enhance the cultural and material values, safeguarding them for future generations. The cultural function is the one that best lends itself to being compatible with both the nature of historic buildings and the possibilities of hybridization without damaging the existing building. Clark (2013) outlines common reuses of existing heritage, including arts and creative industries, tertiary education, residential purposes, and recreational facilities.

Grodach and Loukaitou-Sideris (2007) identify three cultural development strategies: "progressive strategies", "creative class strategies" and "entrepreneurial strategies". Cultural sectors vary based on goals, activities, and target audiences. Public cultural precincts, for instance, serve as spaces for local cultural development, such as public parks, museums, and exhibition venues. Creative class cluster entails cultural activities driven by the creative class, such as independent artists' studios and design-focused companies (Chen et al., 2016). Cultural activities, within a broad development program, encourage the pursuit of sustainability goals, framing them in its three dimensions (Table 1).

This research focuses on the hybridization program concerning an emblematic work in Italian engineering history: the 1938 Hangar designed by Pier Luigi Nervi in Salerno, Italy, a pioneering prefabricated reinforced concrete structure. The challenges lie in both intervening in a structure of historical, architectural, and technological importance and integrating contemporary cultural functions alongside its original military use.

The research is structured into three main segments. The first delves into the discourse surrounding architectural hybridization, elucidating the factors conducive to its emergence with reference to pertinent literature and evaluation criteria. The second segment centres on understanding the historical context and architectural significance of the thirties-era hangar. The third segment focuses on the project for hybridizing the cultural and military functions, aiming to establish a new cultural hub within the region and disseminate knowledge about this unique artifact.

2. Hybrid use

The integration of diverse activities within a physical architectural structure to blend urban life is known as "hybrid" or "mixed-use" (Komossa, 2011). This trend is evident in the evolution of urban settlements, as noted, among others, by Crawford (1995) and Heath et al. (2013).

Table 1 | Three dimensions of sustainability and potentiality of cultural uses.

Dimensions of Sustainability	Goals	Types of cultural projects	Target
Cultural Sustainability	• Public access to art and culture • New form of cultural sharing • Promotion of cultural heritage	• Cultural landmarks • Cultural festivals • Promotional activities • Public arts centres • Arts education programmes	• Residential population • Workers • Tourists • Associations, Foundation, Cultural Centre
Social Sustainability	• Community development • New social links • Amenities	• Arts and entertainment districts	• Residential population • Prospective residents
Economic Sustainability	• Economic growth through tourism and city image • Economic growth through quality of life • Economic trade between space for culture and space for other uses • Promotion of "creative economy"	• Collaboration between arts and private sector	• Workers and employees • Residential population • Prospective residents • Business companies

Bhargava (2018) discusses the evolution of mixed-use from traditional to innovatory, emphasizing its importance for sustainable urban growth. Luna (2010) explains that mixed- use buildings can take various forms, including vertical, horizontal, or shared premises, facilitating multiple functions within a single structure.

The concept of mixed-use development has emerged as a global strategy for urban development and renewal with the aim of achieving sustainability (Ezema and Oluwatayo, 2014). Factors such as urban density and rising land values have contributed to the widespread adoption of mixed-use approaches in building development (Fenton, 1985). The impact of mixed-use development on urban planning and real estate development aligns with principles of smart growth, urbanism, and compact cities, enhancing the built environment universally (Herndon, 2011).

Within architecture, the concept of "Hybridization" has notably emerged in postmodern architecture, characterized by the "Hybrid style" which employed double coding through the principle of binaries and the principle of insertion, involving the juxtaposition of contradictions (Almousawi et al., 2007). Additionally, it was distinguished by the concept of pluralism, which involves combining different elements (Qubad et al., 2023). It is important to highlight that the term "Hybridization", in this context, implies achieving originality within traditional cities by harmonizing heritage with contemporaneity. In this sense, Hybridization serves as a positive mechanism for engaging with traditional city morphology. Hybrid Morphology embodies originality as it presents a new perspective on traditional themes (Sabeeh et al., 2022).

The integration of diverse functions to accommodate living, working, and cultural recreation, is essential for creating new cultural- friendly areas (Niemira (2007).

Many research works focus on the factors that led to the urgence of hybridization: diversity in lifestyle due by globalization, environmental impacts, political reforms, need for multi- functional activity for economic growth, increasing density, strategies for adaptive reuse of key buildings. The development of the buildings, cities and suburbs needs good infrastructure, exclusive zones, special activity for cultural progression (Manoj et al., 2014).

In the field of adaptive reuse, hybridisation works to form and diversify artefacts, as the concept of hybridisation works with the connection of different types of elements or models to produce new architectural forms and new cultural proposals to be used to establish a new communication between buildings and the city, between tradition and innovation, between community and heritage. Such a project involves open spaces, connections, the urban fabric, traffic, etc.

Functional hybridisation is effective when it meets the requirements of the modern age regarding the use of buildings by perpetuating their memory and making their use contemporary. The process of hybridisation on a formal level includes integration of forms, connections, links, without affecting the original form or appearance. Hybridisation at the scale of squares and open areas encourages the removal of some of the less valuable additions and worn-out parts within an urban fabric to transform them into public areas open to the community.

This research focuses on the hybrid use possibilities of the Hangar that Pier Luigi Nervi designed and realised in Salerno in 1939, applying for the first time the use of precast reinforced concrete. Its first military function is still active, with obvious restrictions on visiting and enjoying the building and its appurtenant green spaces. However, considering the significant role within the landscape of 20th- century Italian engineering and its potential to serve as a focal point for the advancement of a peripheral urban area (including the introduction of new green spaces, cycle paths, cultural amenities, and its proximity to the new national airport), an experimental project is underway to merge its military function with new cultural roles. This endeavour aims to devise proposals that align with the unique character of the structure, its military use, territorial development, and the social requirements of local inhabitants. The program has allowed for an in-depth study of the Nervi Hangar, focusing on its formal, structural, and compositive features to understand its conservation challenges, as shown in the following paragraphs.

3. Pier Luigi Nervi's Hangars

During the autarchy and wartime era, Pier Luigi Nervi and his Company, "Nervi & Bartoli", engaged in a series of trials and projects that sparked a complete overhaul of the construction techniques for reinforced concrete structures. The exigencies of the times demanded innovative solutions, prompting Nervi and his team to push the boundaries of conventional methods and explore new avenues of design and engineering.

During the period spanning from 1935 to 1942, Pier Luigi Nervi found himself presented with a unique opportunity to further refine and expand upon his methodologies. This pivotal period arose as the Italian Royal Air Force and the Italian Royal Navy commissioned him to undertake the construction of a series of works for the necessary wartime infrastructure. Part of this significant heritage comprises what would be known as "Aviorimesse", or more commonly, Hangars.

Commencing in 1935, Nervi undertook the construction of a series of reinforced concrete hangars for the Italian air force, known as the "Regia Aeronautica Militare Italiana". Initially, Nervi devised a well-defined typology corresponding to a single pavilion, from which he subsequently designed two distinct versions of hangar structures. The first series, comprised of two hangars, was erected in Orvieto between 1935 and 1938, employing poured-in-place concrete structures using conventional construction methods of the time.

Although not Nervi's initial encounter with such typology (Nervi, 1957), the construction process of this first series of hangars proved to be quite complex. Nervi openly the flaws and mistakes inherent in this initial design strategy, particularly with respect to the challenges associated with casting long-span structures in timber forms, which transcended mere financial considerations (Nervi, 1945). Consequently, he revised the entire construction process which led him to the development of the second series of hangars (1938-1942), divided into two types: larger hangars measuring over 100×36 meters built in Orvieto, close to those of the first series, Orbetello, and Torre del Lago, and smaller hangars measuring 45×55 meters built in Pontecagnano and Marsala (Nervi, 1957). Regrettably, the hangars conceived and erected by Nervi succumbed to the disruptions wrought by wartime circumstances, leaving only the two smaller aircraft hangars in southern Italy as surviving exemplars.

It is within these two hangars that we can still witness Nervi's efforts during his initial experiments with structural prefabrication. Here, he meticulously divided the ribs into elements, preparing them on the ground in series within reusable formworks, significantly reducing construction costs associated with complex carpentry. Another significant element to highlight regarding these hangars is the roofing, where we see the first use of ferrocement panels, an autarchic material that involved the overlaying of various layers of metal mesh followed by the compression of cement and sand mortar. Nervi was experimenting with the initial applications of this material in his warehouse at Magliana, although it would only be patented in 1943 (Iori and Poretti, 2015).

The Hangar at Pontecagnano, close to Salerno, takes on a position of extraordinary significance because it is the last surviving example of Nervi's architectural mastery that has been kept in good condition and is still being used for a function that is consistent with its original purpose (Neri et al., 2024). The load-bearing structure consists of a total of 14 transverse arches, evenly distributed with a spacing of 4.25 meters. Except for those located at the twofronts, each arch is composed of 26 modules, totaling 312 lattice girders (Figure 1). Complementing this frame there are an additional 390 longitudinal girders, characterized by a smaller cross-sectional area but maintaining a height of 100 cm.

The overall span of the arches extends over a length of 61 meters, covering a usable area of approximately 2600 square meters, sufficient to accommodate 46 aircraft. The lateral sections of the structure house areas designated for auxiliary services and offices,

whereas towards the rear, maintenance facilities have been set up to facilitate aircraft servicing operations (Ribera et al., 2014).

Before embarking on any restoration project, it is essential to conduct a preliminary in-depth knowledge and conservation phase of the work or building in question. The conservation of architectural heritage represents a multifaceted endeavor that requires meticulous planning and implementation, especially regarding modern heritage.

In particular, the Conservation Plan can initially be developed by following the guidelines provided by the Getty Conservation Institute and incorporating those outlined in the Burra Charter (2013). This approach facilitates the integration of best practices in repair and conservation processes, exemplified by the implementation of the Conservation Plan for the Flaminio Stadium in Florence (Getty Foundation, 2020) by the same Nervi.

The planning and implementation process of the Conservation Plan involves several fundamental phases, which must be integrated with the guidelines and doctrinal documents of the relevant authorities. These guidelines must be appropriately adapted, considering the type of structure, the context in which it is situated, the current function it serves, and the desired objectives to ensure the effectiveness of the intervention. Beginning with an understanding of the site, territory, and the assessment of its historical and cultural value, the identification of the risks to which the work is exposed is undertaken. This allows for the development and implementation of necessary interventions to restore the masterpiece, followed by a final monitoring phase that allows for timely intervention while maintaining the asset's historical value. From an operational standpoint, we can apply a specific methodology to the Aviorimessa in Salerno, which entails identifying six fundamental phases for the development of the Conservation Plan (Figure 2). These phases can be grouped into two main macrophases: the first phase involves acquiring in-depth knowledge about the current state of the structure, studying its historical and structural characteristics, and proposing targeted interventions; the second phase not only focuses on the concrete implementation of the suggested interventions but also on the supervision and monitoring of the phases following their completion. This approach divides the process into clear and distinct phases, enabling detailed planning and effective implementation of conservation actions.

Initially, a comparative analysis was conducted with other works designed by the author during the same period, allowing for the assessment of their mutual relationship and the contribution of the work in question

Figure 1 | Interiors of Pontecagnano Hangar.

to the artist's overall body of work. This in-depth examination has enriched the understanding of the artistic context and the influences shaping the author's work during that specific period, thus substantiating the evaluation of its value attributes. Subsequently, based on archival documentation, a detailed examination was conducted on the urban context in which the work is situated, as well as the construction phases and the architectural, structural, and plant engineering elements of the original project (Figure 3). Subsequently, the knowledge phase continues with the analysis of the urban context in which the Hangar is located, with its routes and landmarks (Figure 4). Then, an architectural, technological, and geometric survey campaign was conducted with the graphic rendering of plans, elevations, and construction details (Figure 5). Following this, an investigation into the transformations

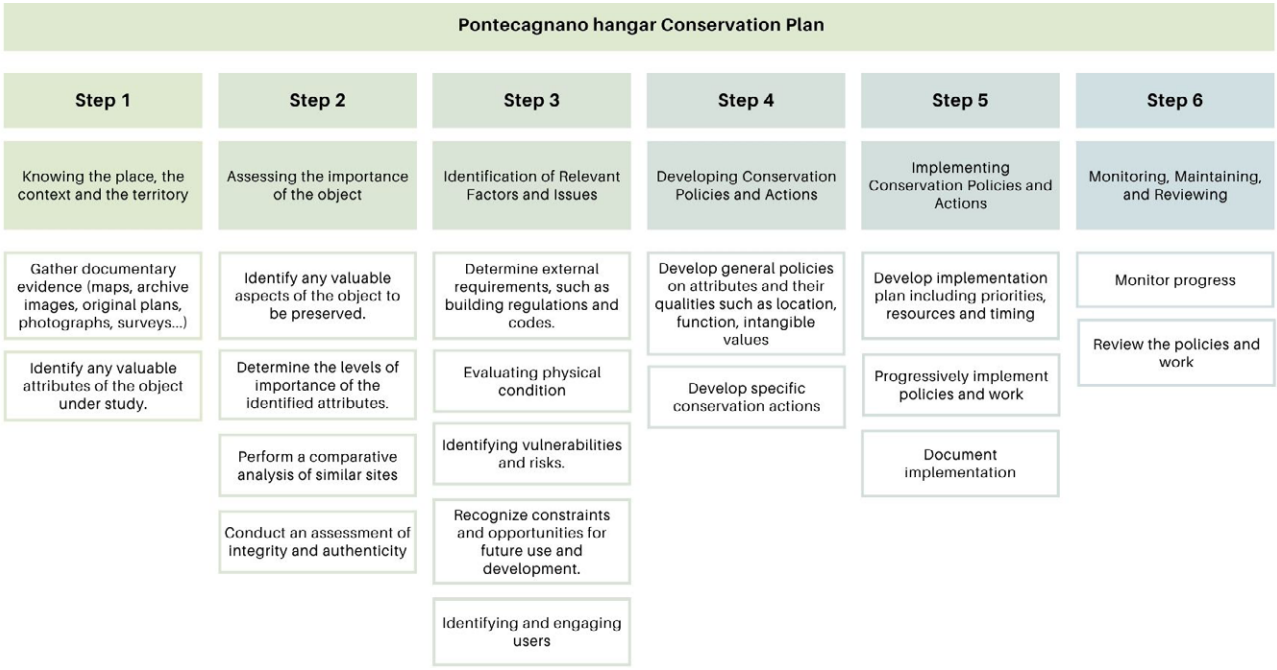


Figure 2 | Identification of the six fundamental phases for the development of the Conservation Plan. Source: By the authors.

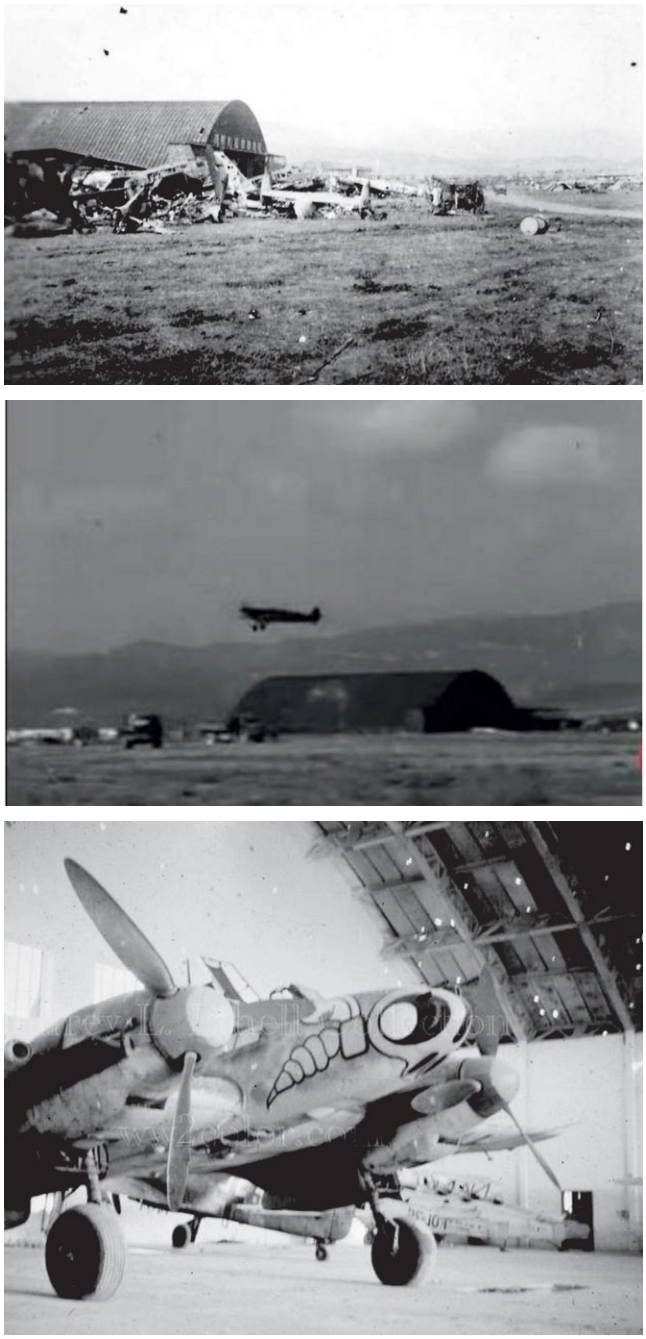
occurring over time was undertaken, starting from 1973, when the structure was acquired by the Carabinieri Helicopter Group, up to the present day (Figure 6). This analysis was made possible through a spatial data acquisition campaign aimed at evaluating the current condition of the structure and facilitating a detailed comparison with the original project.

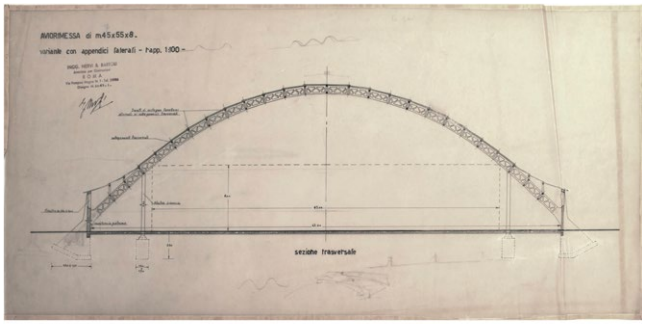
Furthermore, a comprehensive analysis of the degradation phenomena affecting the structure (Figure 7), was subsequently conducted, with the aim of identifying underlying causes and associated risk factors. This phase involved a thorough examination of existing signs of deterioration, pinpointing processes or actions contributing to the degradation of the work, including environmental factors, inadequate the long term. The preservation of modern architectural heritage is a complex undertaking that requires meticulous planning and implementation, necessitating a comprehensive understanding of the challenges associated with its conservation. This entails situating the project within the broader framework of conservation principles and practices outlined here. Only after this preliminary phase of assessment, a program of interventions can be drafted and the project for recovery and repurposing be planned.

4. The project for hybrid use

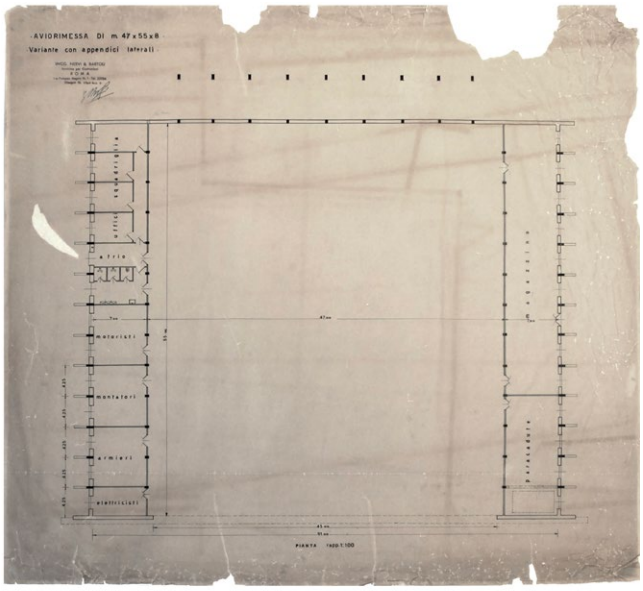
The overall project involves the realization of a form of hybridization of use of the Hangar designed by Pier Luigi Nervi which, on one hand, continues to fulfil its military function by hosting the helicopter unit, while on the other hand, it is converted into a cultural site where a multitude of cultural and exhibition activities converge, capable of promoting the knowledge of the work and its creator, and triggering a fruitful circuit of urban and landscape renewal. Holding together the two dimensions of safeguarding and conservation, and of protection and transformation, requires a complex design attitude and a multidisciplinary approach that is based on the ability to balance respect for the existing and the design of the new.

This is an extremely cautious position in the project and in defining the new within the existing, preferring solutions and actions that can enhance what exists, preserving it and passing it on to future generations, maintaining its integrity and authenticity. Upstream of the design process, there is a need for caution in reading the tangible and intangible identity signs and the transformations that have occurred over time - at both the architectural and urban scales - to better guide the project towards synergistic solutions. In this way, the intervention of reuse, recovery, or redevelopment is inserted into the broader framework of regeneration interventions, where what is

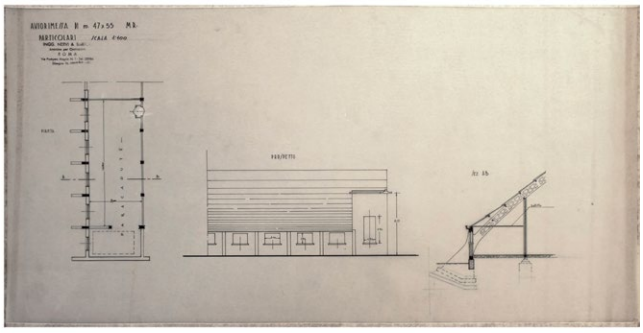




1 //Elaborati di progetto, sezione trasversale



2 // Elaborati di progetto, pianta



3 // Elaborati di progetto, prospetto e dettagli

Figure 3 | Historical photos of the hangar in 1943. Source: 7th Carabinieri Helicopter Group Archive; Original drawings by Nervi. Source: CSAC Parma, Fondo Pier Luigi Nervi, Aviorimessa di metri 47x55 di Montecorvino (Salerno), PRA 119, N.id 13252, coll. 140/2, B002741P.

being recovered is not only a single architectural artifact but a real system that concerns the scale of the city intercepting environmental, urban, social, and cultural issues.

Given this premise, it is clear how the project manifests itself as a complex and delicate field of work that requires a multidisciplinary and cultured approach to the theme of transformation and protection of the built environment.

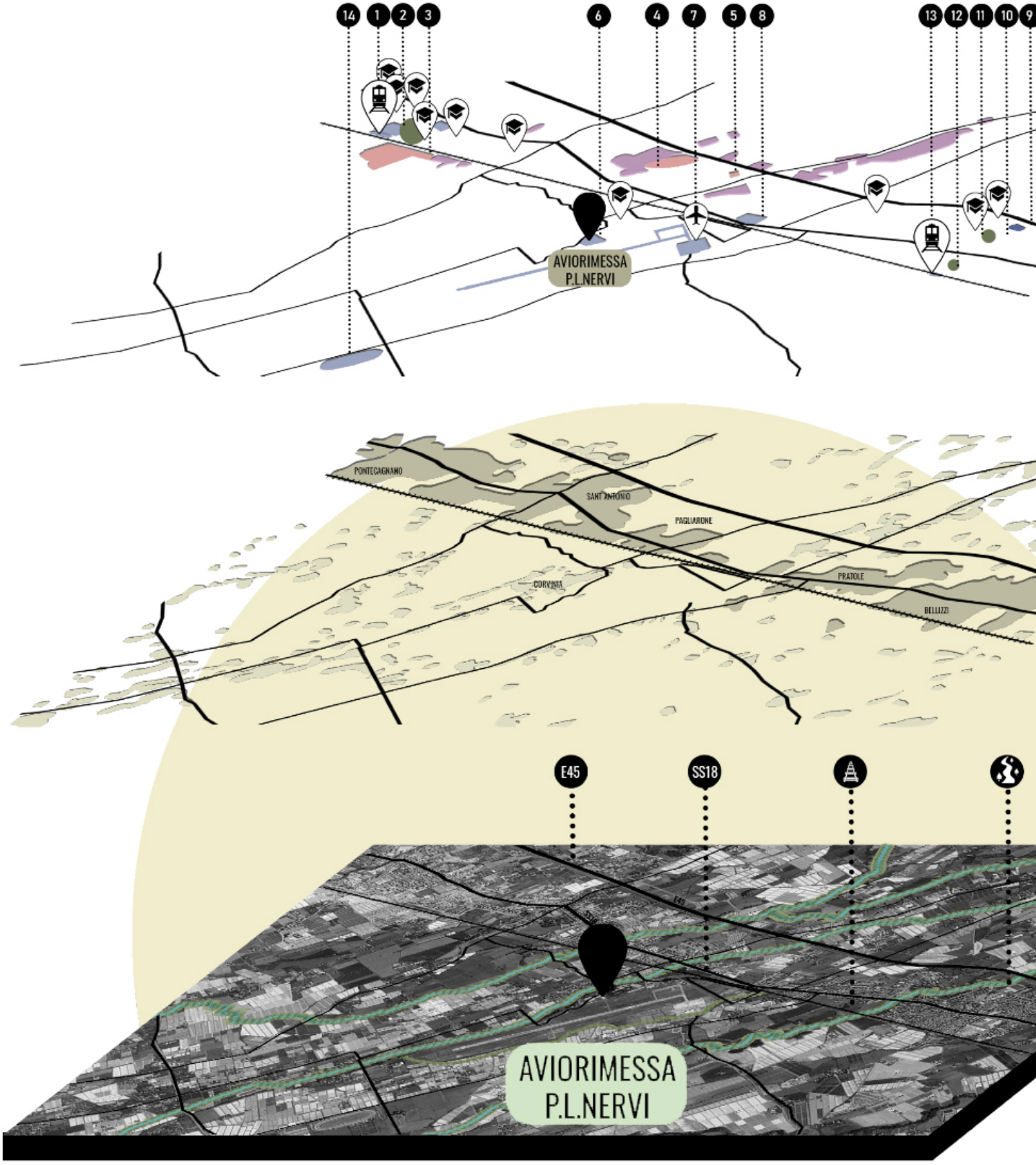
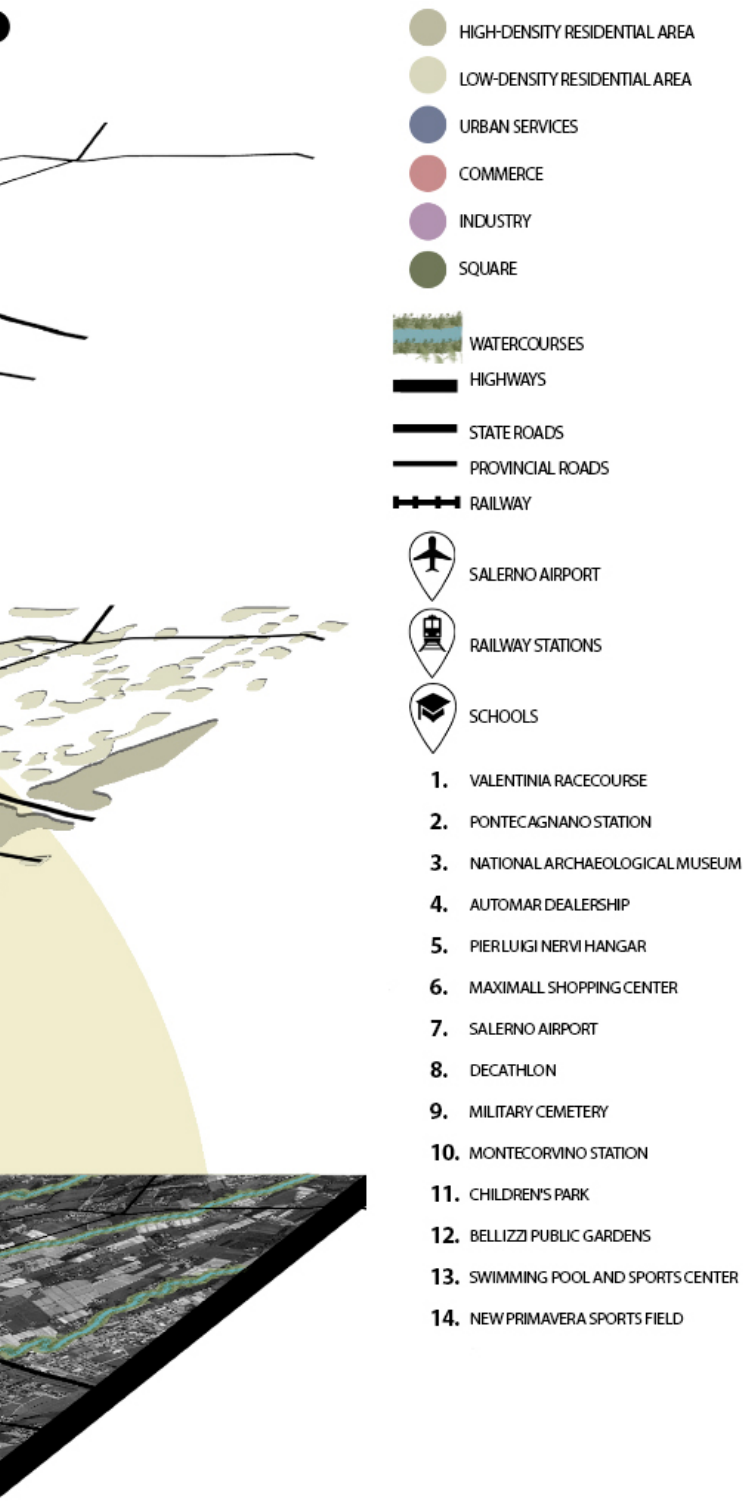


Figure 4 | Urban Landscape in which the Hangar is located. Source: By the authors.



Nervi's Hangar, once a place of experimentation for the most advanced construction technologies of the 1930s, thus becomes the subject of an experiment in hybridization of use, respecting the regulations regarding safety and the use of military and public places.

The Aircraft Hangar, workplace of the Air Force, due to its importance in the history of Italian engineering and its creator, will host the new aviation museum, a place that tells the story and evolution of aviation through interactive exhibitions, permanent and temporary exhibitions, as well as cultural and educational events. Within this space, visitors will have the opportunity to explore and understand the role of aviation in society, from its inception to the latest technological innovations. Furthermore, through guided tours and immersive experiences, visitors will be able to appreciate up close the majesty and grandeur of the hangar itself, understanding its role not only as a physical structure but also as a symbol of human ingenuity and technological progress of the 1930s. The intention is to preserve the technological, historical, and cultural essence of the hangar while projecting it towards the future with innovative architectural and functional solutions, while still maintaining its original function as a military workplace. This approach reflects the desire to valorise the existing heritage while responding to the needs and challenges of modern times. It is an experimental hybridization solution between two apparently incompatible uses, but the uniqueness of the artifact lends itself to becoming a significant landmark for the complete recovery of a peripheral territorial area and an opportunity to experiment with ad hoc strategies for the conservation and restoration of the works of art of the first half of the 20th century. Therefore, the project pays particular attention to seeking synergistic integration among various functions, acting on different scales and in different areas. "Synergy", by definition, refers to a combined and simultaneous action of multiple elements within the same activity, to achieve a common goal, resulting in a performance superior to that obtained by individual elements operating separately. It necessarily requires a holistic approach.

Synergy on a macroscale: Synergy on a macroscale aims to create meaningful connection and fluid communication with the surrounding environment, which is observed and interpreted as a living organism, rich in potential and intrinsic connections. At this scale, actions are taken on the accessibility to the site, on the paths of use, on the characteristics of the landscape, and on the relationships between the built and natural environment. In this context, the proposed new road network is not only a means to reach the Aircraft Hangar, but it becomes a sign of connection and integration itself.

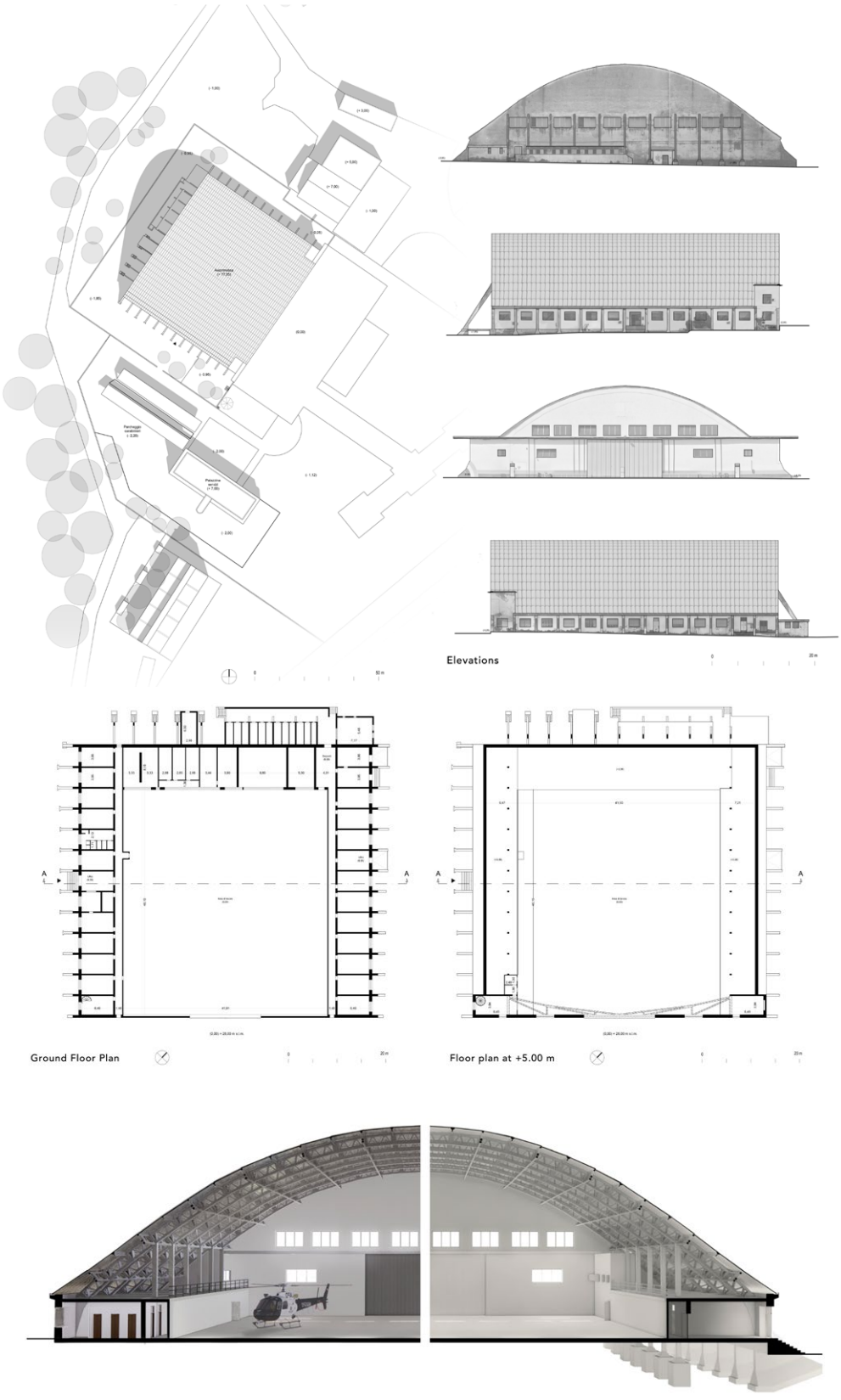


Figure 5 | Architectural survey campaign and graphic representation of plans, elevations, and urban layout. Source: By the authors.

It is conceived to harmonize with the pre- existing landscape, taking into consideration natural elements such as watercourses and green areas, and existing structures such as the disused industrial area. Its conception does not limit itself to the mere creation of a physical connection between the elements but aims rather to establish a dynamic and functional relationship, capable of deep and subtle dialogue with the surrounding environment (Figure 8). The pedestrian path, immersed in green parklands and open-air museum spaces, embodies the concept of total integration between art, nature, and culture. This pathway, through a multisensory experience, guides visitors towards the Aircraft Hangar, where the landscape transforms into a living narrative of history and innovation.

The project involves a double-lane road, a cycle path that follows the course of the waterway, and finally a pedestrian path. Between the cycle path and the pedestrian route, large green spaces are created, serving as a park and an open-air museum. This green pathway leads to the Aircraft Hangar, where the road splits, leading either to visitor parking or to areas reserved for military work. The outdoor space intended for military use has been designed based on the regular spacing of the reinforced concrete buttress modules of the rear facade of the Hangar (Figure 9).

Synergy in the microscale: Synergy in the microscale has 3 dimensions: material, formal, and functional. In terms of the material dimension, the focus is on the restoration work and of the Hangar's facades, according to the principles of preservation of reinforced concrete works of art. As for the front and rear facades, it is planned to restore them to their original appearance, in accordance with the design made in 1938. At the formal level, the added constructions in the back facade are eliminated and the space below the trestles is used. A light body of glass and steel with clearly defined profiles is added to the reinforced concrete forms (Figure 10).

The buttresses at the back create a succession of voids from which the project arises and constitute the tangible element of physical, visual, and temporal synergy. Finally, for functional synergy, the rear walls are removed and replaced by large windows that incorporate the original openings. This solution ensures greater and better entry of natural light into the aircraft hangar (Figure 11). Furthermore, the opening of these windows allows for unrestricted observation of the structure of the aircraft hangar and the daily activities taking place within. Thus, the relationship between content and container is reversed, with the container becoming an integral part of the project and the exhibition path.

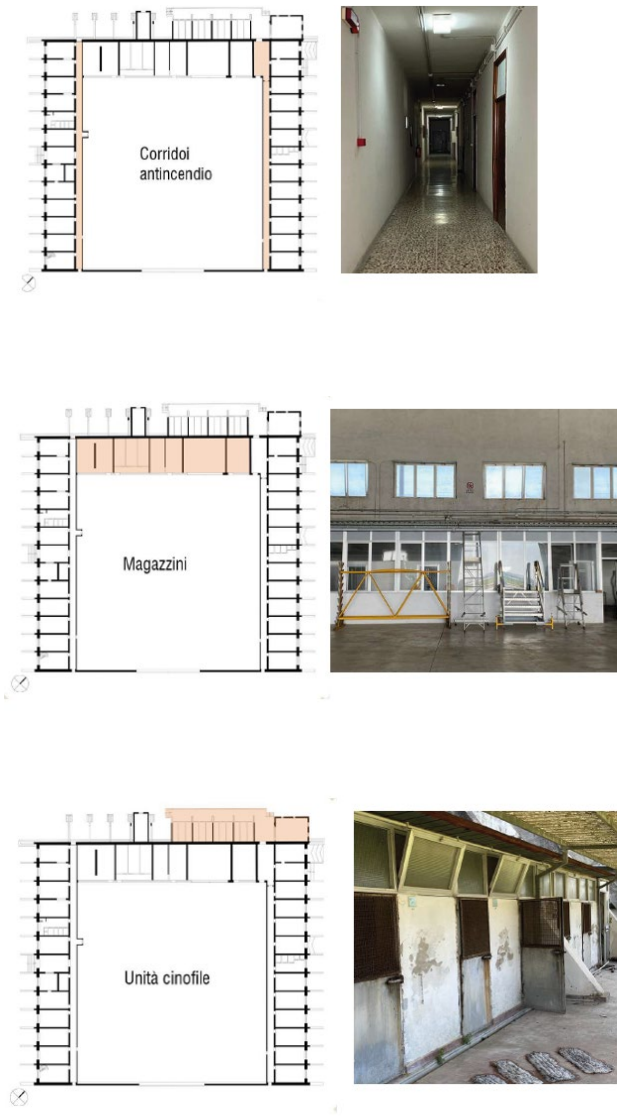
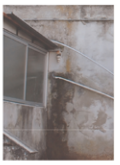


Figure 6 | Some of the alterations of the original layout. Source: By the authors.

Synergy in the exhibition path: Regarding synergy in the exhibition path, beneath the buttresses, the MAVEC (Museo AViorimessa Elicotteristi Carabinieri) is developed: a true exhibition corridor. The journey begins with a permanent exhibition: inside, there are display panels with documents, photographs, and descriptions, also in braille, about the history of the Hangar by Pier Luigi Nervi and the activities of the Carabinieri Helicopter Unit. The permanent exhibition path continues with three- dimensional models of the structure illustrating the technological and constructional specificity of the work. Finally, the exhibition concludes with an area dedicated to temporary exhibitions, with exhibits varying over the

LEGEND OF DEGRADATION PHENOMENA

TYPE OF DEGRADATION	SEEPAGE	BIOLOGICAL COLONIZATION	CRUST	RISING FRONT	LACK	PATINA	HUMAN-CAUSED DEGRADATION
	DA NORMA UNI 11182:2006	*DA NORMA UNI 11182:2006*	*DA NORMA UNI 11182:2006*	*DA NORMA UNI 11182:2006*	*DA NORMA UNI 11182:2006*	*DA NORMA UNI 11182:2006*	
DESCRIPTION	VERTICAL STREAK: OFTEN, NUMEROUS PARALLEL STREAKS CAN BE OBSERVED.	PRESENCE OF MICRO AND/OR MACRO ORGANISMS (ALGAE, FUNGI, LICHENS, MOSSES, HIGHER PLANTS) DETECTABLE MACROSCOPICALLY.	MODIFICATION OF THE SURFACE LAYER OF THE STONE MATERIAL, VARYING IN THICKNESS AND GENERALLY HARD, THE CRUST IS DISTINGUISHABLE FROM THE UNDERLYING LAYERS BY ITS MORPHOLOGICAL CHARACTERISTICS. IT CAN ALSO SPONTANEOUSLY DETACH FROM THE SUBSTRATE.	THE MIGRATION LIMIT OF WATER, MANIFESTED BY THE FORMATION OF EFFLORESCENCE AND/OR MATERIAL LOSS. IT IS GENERALLY ACCOMPANIED BY VARIATIONS IN COLOR SATURATION IN THE UNDERLYING AREA.	LOSS OF THREE-DIMENSIONAL ELEMENTS (SUCH AS THE ARM OF A STATUE, THE HANDLE OF AN AMPHORA, A PIECE OF RELIEF DECORATION, ETC.).	NATURAL MODIFICATION OF THE SURFACE NOT RELATED TO DEGRADATION PHENOMENA, PERCEIVED AS A VARIATION IN THE ORIGINAL COLOR OF THE MATERIAL.	PRESENCE OF ALTERATIONS THAT DAMAGE AND/OR COMPROMISE THE STRUCTURAL INTEGRITY AND AESTHETICS OF THE BUILDING.
CAUSES	MOISTURE: SMOOTH AND NON-ABSORBENT SURFACES.	MOISTURE ACCUMULATION, AUTOTROPHIC ORGANISM INFESTATION.	ACTION OF MICROORGANISMS AND POLLUTANTS; OXIDATION; POOR OR ABSENT AIR CIRCULATION; RESIDUES FROM THE COMBUSTION OF PETROLEUM-BASED OILS.	MOISTURE: SMOOTH AND NON-ABSORBENT SURFACES.	PRESENCE OF CRACKS AND/OR STRUCTURAL DAMAGE; THERMAL STRESS NEAR THE INSERTION OF METAL ELEMENTS; INSTALLATION ERRORS AND USE OF UNSUITABLE MORTARS; ANTHROPOGENIC ACTIONS.	NATURAL AGING.	LACK OF HISTORICAL KNOWLEDGE OF THE BUILDING AND THE NEED TO ADAPT TO MODERN TECHNOLOGIES AND REGULATIONS.
INTERVENTION	As2 Pr1 Pr4	As1 Pl2 Pr4	As1 Pl1 Pl2 Pr1	As2 Pr1 Pr4	Pl1 Co1 Co2 Co3 Pr3 Pr4	Pl1	Rimozione
PHOTO EXAMPLE							
HATCH PATTERN							

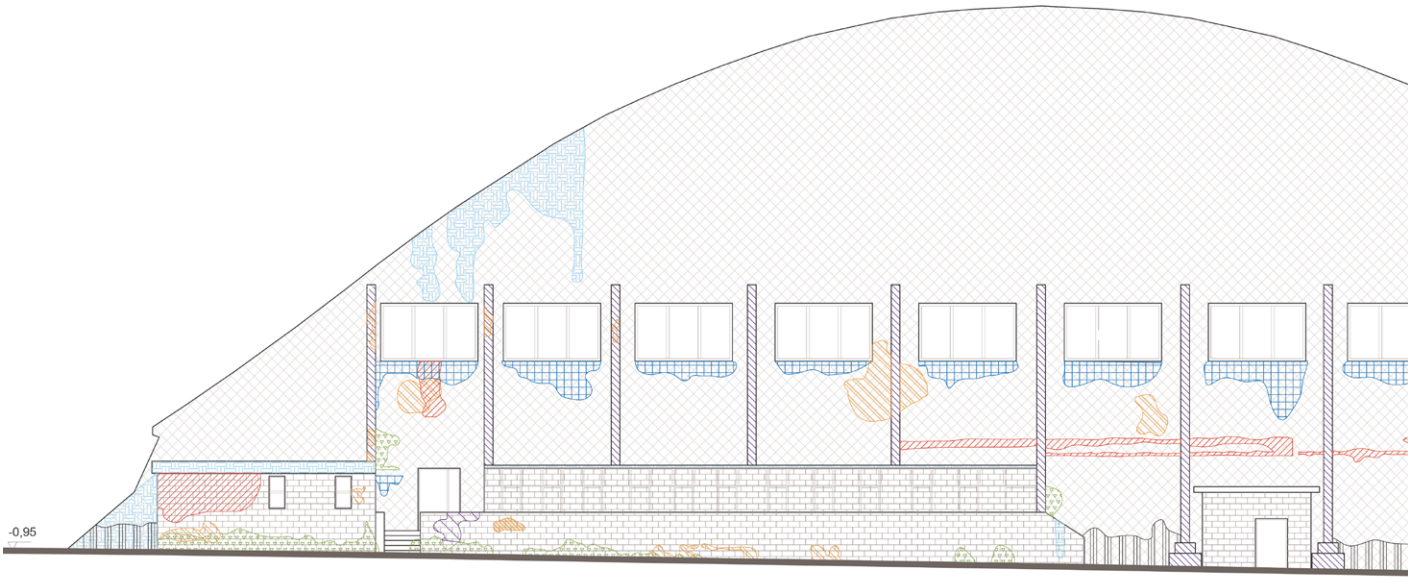
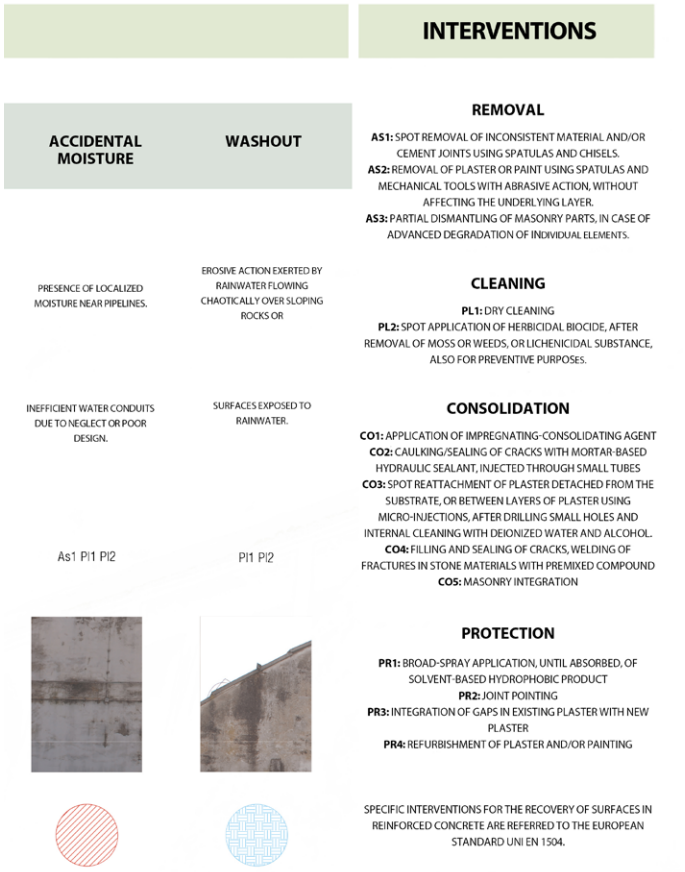
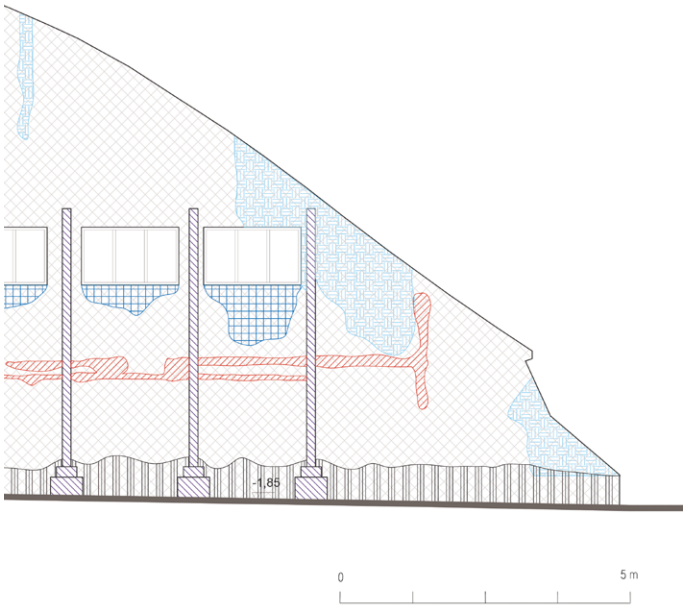


Figure 7 | Identification of risks and determination of main degradation phenomena affectioning the structure. Source: By the authors.





long term and providing an opportunity for visitors to return to the MAVEC. The exhibition corridor ends with leisure and refreshment services (Figure 12).

The exhibition promenade allows visitors to learn about the evolutionary history of the structure while also observing the present. The large windows, in fact, provide a privileged, safe, and protected view inside the hangar and the activities hosted there. The laminated glass ensures the safety and comfort of visitors. Furthermore, light is filtered through the presence of automatic sunshades, whose position varies according to the needs of the users: when fully lowered, they can become a support for the projection of materials, images, or audio-visual works of the museum. Finally, the external windows are operable, allowing the museum space to extend outdoors and create a physical connection with the surrounding greenery (Figure 13).

Synergy in sustainability and technological choices: The recovery project aims to be sustainable by respecting the criterion of minimal intervention and adapting it to emerging needs. On a macro scale, the project offers new mobility options by promoting sustainable transportation systems and universal access to green spaces. In the architectural design, the intervention maintains aesthetic and technological quality by employing compatible materials that are clearly distinguishable from Nervi's structure. Energy efficiency is ensured through natural ventilation of the structure, shading systems, and the installation of photovoltaic panels on parking canopies. Additionally, the exhibition corridor ensures accessibility and enhanced visitability for all user types, as the ground has been levelled to eliminate level differences or barriers.

These choices aim to emphasize the identity of the aircraft hangar on the valorisation of natural resources and improve the well-being and quality of life of residents in the vicinity (Figure 14). Construction details of the technological system have been made (Figure 15). The interior glazing consists of double-glazing: the interior glass is a laminated and reinforced by an impact-resistant PVB silence foil with high acoustic protection. This system ensures the safety and comfort of visitors. Although the façade is predominantly shaded, it provides for the integration of shading systems. In fact, the light that illuminates the room is filtered by the presence of a system of sunshades made of 1.5 mm microperforated steel sheet. The sunshades can be overlapped according to the visitors' needs, sliding on a rail system from the aluminium profile.

Figure 8 | Urban redesign project in the land area where the Hangar falls. Source: Design by the authors.

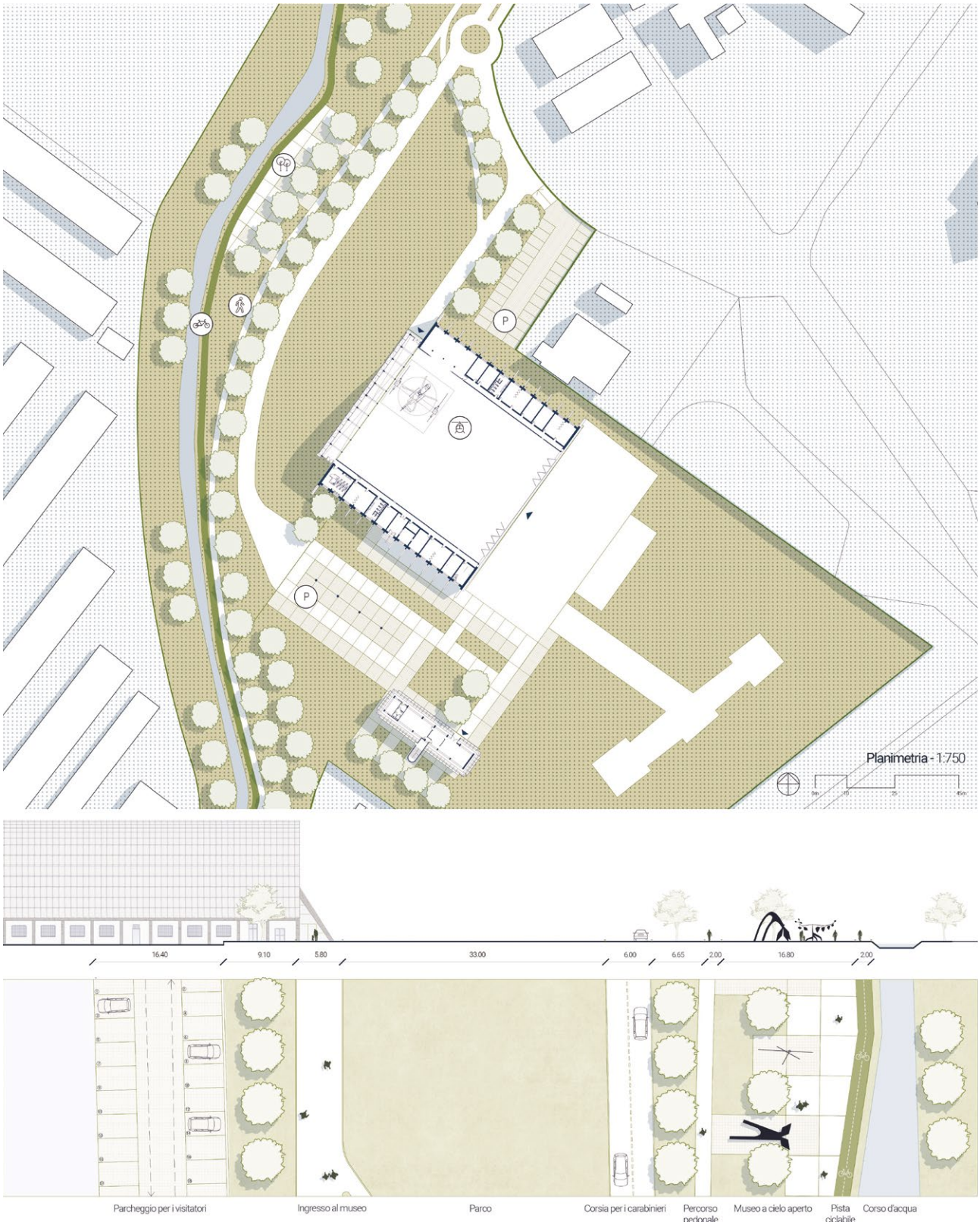

Planimetria - 1:750
16.40
9.10
5.80
33.00
6.00
6.65
2.00
16.80
2.00
Parcheggio per i visitatori
Ingresso al museo
Parco
Corsia per i carabinieri
Percorso pedonale
Museo a cielo aperto
Pista ciclabile
Corso d'acqua

Figure 9 | New driveway, pedestrian and bicycle path and new pedestrian access path to the Hangar. Source: Design by O. Lopez and G. d'Amato on indication of the authors.

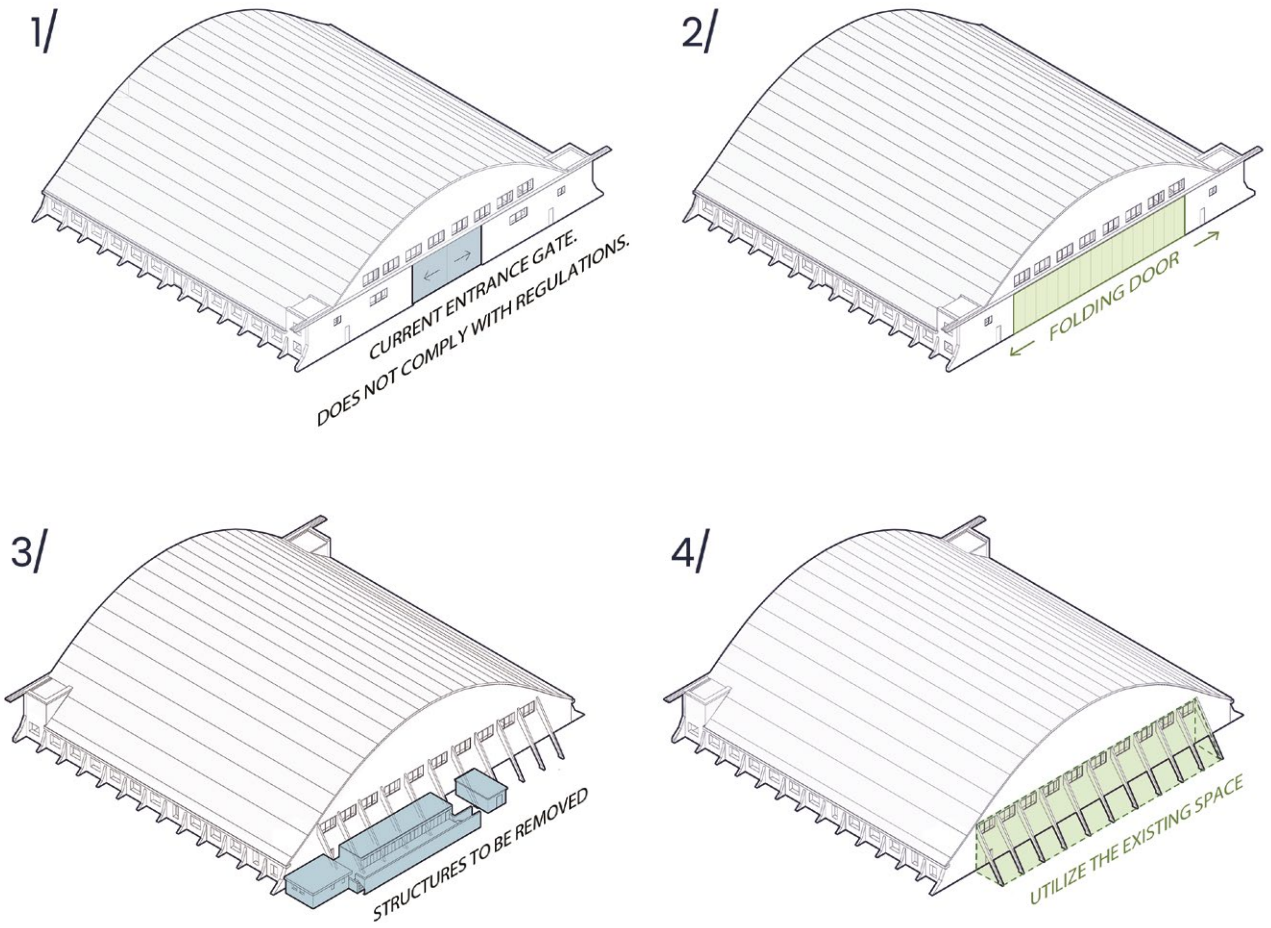


Figure 10 | New additions and demolitions on the main facades. Source: Design by the authors.

Figure 11 | Intervention on the rear facade of the Hangar in which oblique reinforced concrete elements are preserved and exhibition space created. Source: Design by O. Lopez and G. d'Amato on indication of the authors.

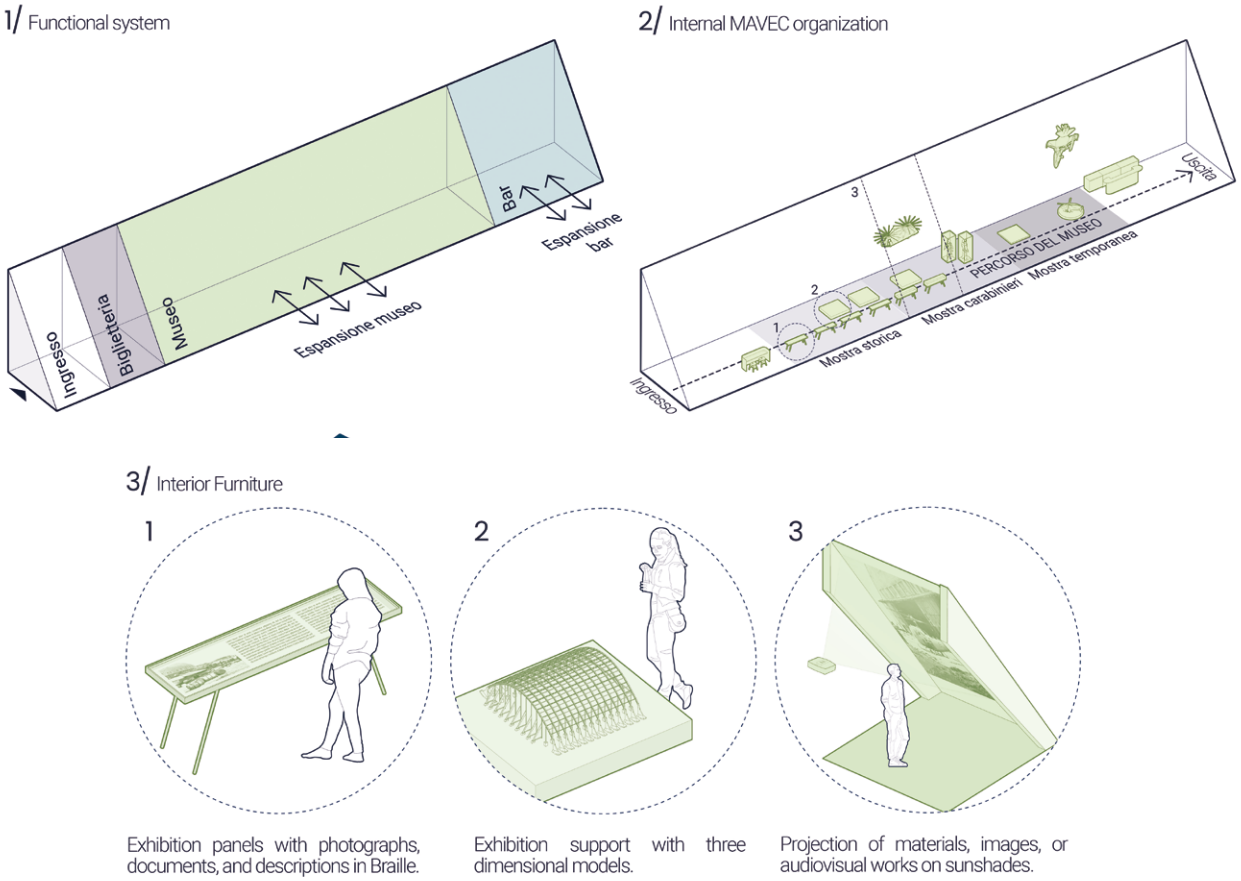


Figure 12 | Interior exhibition space. Source: by the authors.

Figure 13 | Interior exhibition space; structural glazing dividing the museum from the military's workspace; exhibition route opening to the outside; sunshade lowered as a protective support for materials, images, or audiovisual works. Source: Design by O. Lopez and G. d'Amato on indication of the authors.

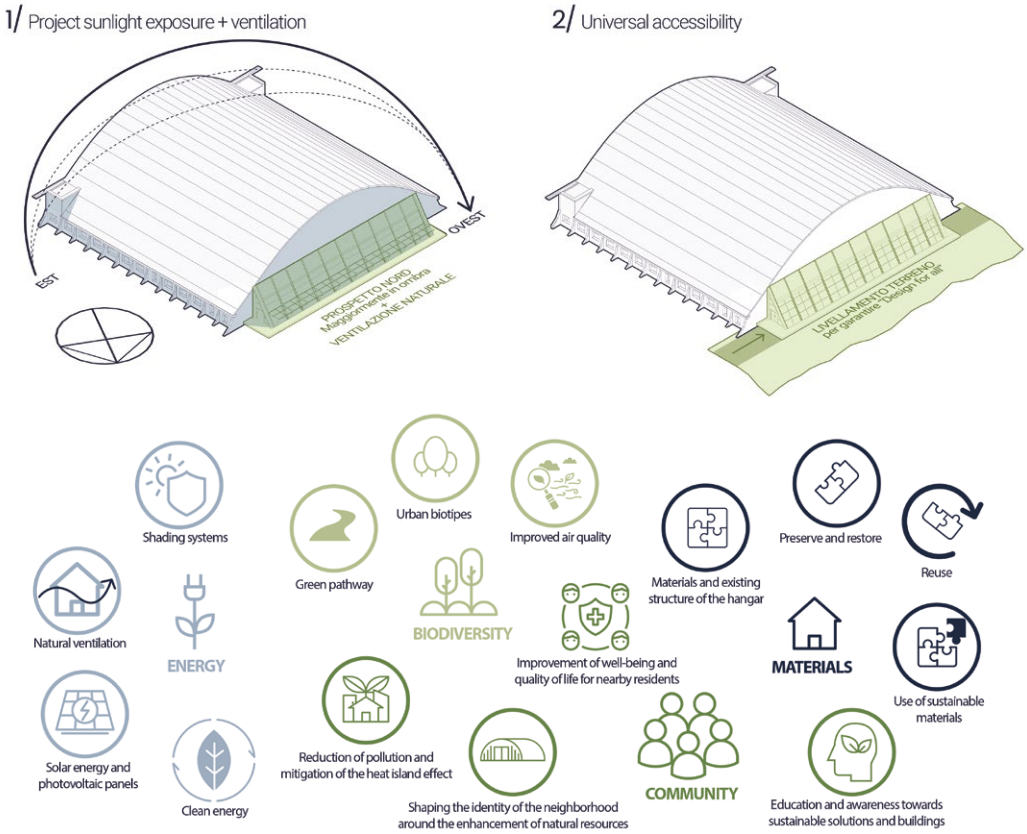


Figure 14 | Sustainable Design choices. Source: Design by the authors.

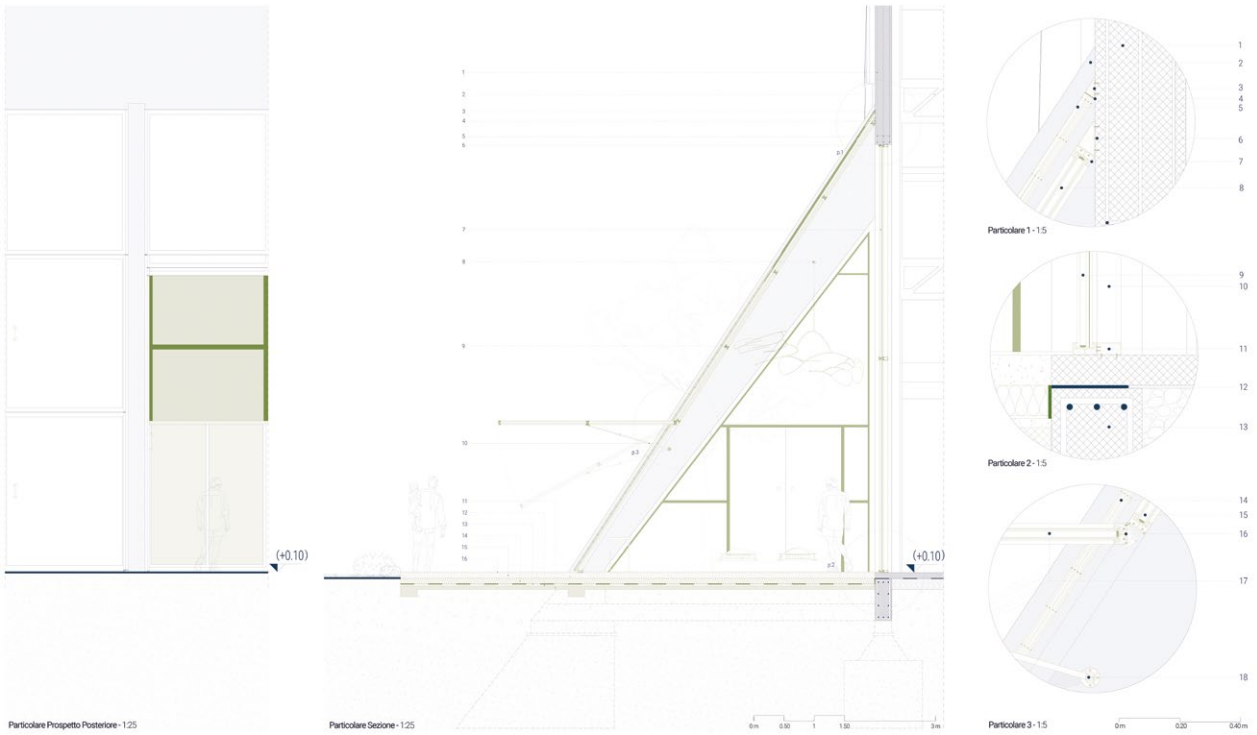


Figure 15 | Technological system Details. Source: Design by the authors.

References

AA. VV. (2020). *The Stadio Flaminio in Rome by Pier Luigi and Antonio Nervi: An Interdisciplinary Conservation Plan*, Università Degli Studi di Roma "La Sapienza".

Almousawi, N., & Alobaydi, A. (2007). *Hybridization as A Mechanism to Develop the Morphology of Traditional City*, PhD Thesis submit to The Department of Architecture University of Technology, Baghdad.

Bhargava, A. (2018). Sustainable urban environment-conceptualization and policy parameters. *J. Environmental Studies, 1*.

Bullen, P.A. (2007). "Adaptive reuse and sustainability of commercial buildings", *Facilities*, *25*(1/2), 20-23. https://doi.org/10.1108/02632770710716911

Chen, J., Judd, B., & Hawken, S. (2016). Adaptive reuse of industrial heritage for cultural purposes in Beijing. *Shanghai and Chongqing, Structural Survey, 34*(4/5), 331-350. https://doi.org/10.1108/SS-11-2015-0052

Clark, J. (2013). Adaptive reuse of industrial heritage: opportunities & challenges, available at: http://architectureinsights.com.au/media/upload s/resources/Adaptive_Reuse_of_ Industrial_Heritage.pdf

Crawford, M. (1995). *Building the Workingman's Paradise: the Design of American Company Towns*, Verso, London.

Cucco, P., Maselli G., Nesticò A., & Ribera F. (2023). An evaluation model for adaptive reuse of cultural heritage in accordance with 2030 SDGs and European Quality Principles, *Journal of Cultural Heritage, 59*, 202-216. https://doi.org/10.1016/j.culher.2022.12.002

Ezema, I.C., & Oluwatayo, A.A. (2014). Densification as sustainable urban policy: the case of ikoyi, Lagos, Nigeria. In: *CIB W107 International Conference: Construction in Developing Countries and its Contribution to Sustainable Development*, January 28-30, 2014, Lagos, Nigeria.

Fenton, J. (1985). *Pamphlet Architecture II: Hybrid Buildings*. Princeton architectural press, New York.

Grodach, C., & Loukaitou-Sideris, A. (2007). Cultural development strategies and urban revitalization. *International Journal of Cultural Policy, 13*(4), 349-370. https://doi.org/10.1080/10286630701683235

Heath, T., Oc, T., & Tiesdell, S. (2013). *Revitalising Historic Urban Quarters*. Routledge, London. https://doi.org/10.4324/9780080516271

Herndon, J.D. (2011). *Mixed-Use Development in Theory and Practice: Learning from Atlanta's Mixed Experiences*. Georgia Institute of Technology.

ICOMOS, (2013). The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance. ISBN 0 9578528 4 3

Iori, T., & Poretti, S. (2015). Conserving Pier Luigi Neri's ferroconcrete. In: *Proceedings of the Institution of Civil Engineers -Engineering History and Heritage* $1 1757-9430 | E-$1 1757-9449 Volume 169 Issue 1, $1 2016, pp. 22-35. https://doi.org/10.1680/jenhh.15.00016

Komossa, S. (2011). Researching and designing GREAT; the extremely condensed Hybrid urban block. *Architectural and Education Journal*.

Luna, R.R.A. (2010). *A Flexible Infra- Architectural System for a Hybrid Shanghai*. Doctoral Dissertation. Massachusetts Institute of Technology (MIT).

Manoj, R.P., & Keskar, Y.M. (2014). Hybridization as a New Paradigm of Urban Development in metropolitan city, a case of Pune City, India. *International Journal of Innovative Research in Science, Engineering and Technology, 3*(1).

Neri, G., Gallo, A., & Ribera, F. (2024). Large Vaulted Structures and Prefabrication. The Case of Pier Luigi Nervi's Hangar in Pontecagnano, Italy. In: Gabriele, S., Manuello Bertetto, A., Marmo, F., Micheletti, A. (eds) *Shell and Spatial Structures. IWSS 2023. Lecture Notes in Civil Engineering*, vol 437. Springer, Cham. https://doi.org/10.1007/978-3-031-44328-2_84

Nervi, P.L. (1945). *Scienza o Arte del Costruire? Caratteristiche e Possibilità del Cemento Armato*. Milan: Edizioni della Bussola.

Nervi, P.L. (1957). *The works of Pier Luigi Nervi*. New York: F.A. Praeger.

Niemira, M.P. (2007). The concept and drivers of mixed-use development: insights from a cross-organizational membership survey. *Res. Rev. 4*(1), 53–56.

Petzet, M. (2004). Principles of preservation: An introduction to the International Charters for Conservation and Restoration 40 years after the Venice Charter. In: *International Charters for Conservation and Restoration. Monuments & Sites*, ICOMOS, München, pp. 7-29.

Qubad Sabah H., Sumbul M.Y., & Adil I.A. (2023). Sustainability-based hybridization interventions, the urban fabric of Erbil Citadel - Iraq – As a case study, *Alexandria Engineering Journal, 75*, 615-625. https://doi.org/10.1016/j.aej.2023.04.064

Ribera, F., Miccio, G., & Apicella, P. (2014). Pier Luigi Nervi a Salerno: l'Hangar ritrovato. In: *History of Engineering. International Conference on History of Engineering.* V Convegno di Storia dell'Ingegneria Napoli CUZZOLIN Vol.2, Pag.1363-1374, ISBN:9788887479805

Ribera F., & Cucco P. (2020). A methodology in choosing a new compatible function in the recovery project of disused religious buildings. Research study in Italy, *VITRUVIO, 5*(1). https://doi.org/10.4995/vitruvio-ijats.2020.13452

Sabeeh Lafta, F., & Almawla, F. (2022). Morphological Change of Traditional City Centres: The Historical Centre of Mosul – Iraq - as a Case Study", *Issues and Smart Solutions in Science and Engineering, 1*(1).

Wilkinson, S.J., Remøy, H., & Langston, C. (2014). *Sustainable Building Adaptation: Innovations in Decision-Making*, John Wiley & Sons, Chichester. https://doi.org/10.1002/9781118477151