CONSERVING
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HERITAGE

Concrete

Case Studies in Conservation Practice

Edited by
Catherine Croft and
Susan Macdonald

CONSERVING MODERN ARCHITECTURE

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The Getty Conservation Institute

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Case Studies in Conservation Practice

Edited by Catherine Croft and Susan Macdonald
with Gail Ostergren

The Getty Conservation Institute, Los Angeles

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Tullia Iori and Sergio Poretti

Magliana Pavilion

Rome | 1945

ARCHITECT/DESIGNER
Pier Luigi Nervi

PROJECT DATES
2012–13

PROJECT TEAM
SIXXI: Storia dell'ingegneria strutturale in Italia (Twentieth-Century Structural Engineering: The Italian Contribution) | European Research Council Advanced Grant, PI Sergio Poretti

CLIENT/BUILDING OWNER
Private property

INTRODUCTION

The Magliana Pavilion (fig. 6.1) is a spacious hall constructed of ferrocement that was designed and built in Rome by Pier Luigi Nervi (1891–1979). Nervi's ferrocement, a material of his own invention, consists of a unique combination of concrete and reinforcement that completely reverses the proportions of the two components found in ordinary reinforced concrete. He developed the very thin application (never more than 3 cm thick) of cementitious material to fine steel mesh as a solution to the material restrictions (particularly steel) imposed by Italy's Fascist regime during its autarkic propaganda campaign at the end of the 1930s. Nervi's famous structures of the 1930s and 1940s, from Florence's municipal stadium to his hangars in Orvieto and Orbetello, had fully exploited reinforced concrete's structural capabilities. In his ferrocement, he continued these experiments with the material's architectonic, building, and structural potential.

In 2013, conservation of the pavilion was undertaken as part of the applied experimental research activities of SIXXI: Storia dell'ingegneria strutturale in Italia (Twentieth-Century Structural Engineering: The Italian Contribution), funded by a European Research Council Advanced Grant. The conservation adopted an experimental approach, as the typical treatment techniques developed and tested for ordinary reinforced concrete are not applicable for ferrocement.

The pavilion, originally a warehouse, was built at 238 via della Magliana in Rome on property belonging to the firm Nervi and Bartoli. It has a rectangular footprint, 21 meters long and slightly more than half as wide. The entire perimeter of the structure has a characteristic, undulating profile (fig. 6.2). The resistance of the walls and roof, which are made entirely out of ferrocement 3.5 cm thick, results from its form, with the wave-shaped contour creating a great moment of inertia. Construction of the pavilion began in the summer of 1944, a few weeks after the arrival of Anglo-American troops during World War II. When the Nazis invaded Italy following the Armistice of Cassibile, announced on September 8, 1943, Nervi refused to collaborate with the Todt Organization and closed his construction company. For many long months, he worked secretly in his house on the Lungotevere in Rome, perfecting his particular formulation of ferrocement. As soon as the city was liberated, he summoned his trusted workers to commence construction and together they built, completely by hand and with great effort, this small masterpiece of craftsmanship, envisaged as a large sculpture.

Before the pavilion was completed, the project was published in the first and most famous of Nervi's books, *Scienza o arte del costruire?* (Science or Art of Construction?) (Nervi 1945). The book celebrated the end of the war and the beginning of Nervi's new professional life, which would elevate him to the pinnacle of international engineering.

An experimental design, the pavilion was his first building conceived and completed in ferrocement and remains the only building made entirely on-site from this material. In Nervi's later, more complex architectural works, he used ferrocement in combination with another of his building inventions, structural prefabrication, which entailed the creation of separate small pieces of ferrocement assembled on the ground and then put together like puzzle pieces. This combination of innovations became the basis of the "Nervi system" (Iori 2009a; Iori and Poretti 2013, 2015b), which was employed in the construction of all his later masterpieces, including the Salone B in Turin (1947), the Palazzetto dello Sport in Rome (1957), and the Papal Audience Hall in the Vatican (1971) (Poretti 2008, 2010). The pavilion is a unique prototype in its use of ferrocement, and it represents the beginning of Nervi's innovative and creative journey, eventually securing his position as one of the most famous engineers in the world. Thus, the pavilion holds significant historic, scientific, and social value in that it demonstrates the evolution of Nervi's ideas and his contribution to modern architecture. The material, ferrocement, is of importance to the building's

Fig. 6.1. The Magliana Pavilion under construction, 1945. Photo: MAXXI Museo nazionale delle arti del XXI secolo, Rome. MAXXI Architettura Collection, P. L. Nervi Collection

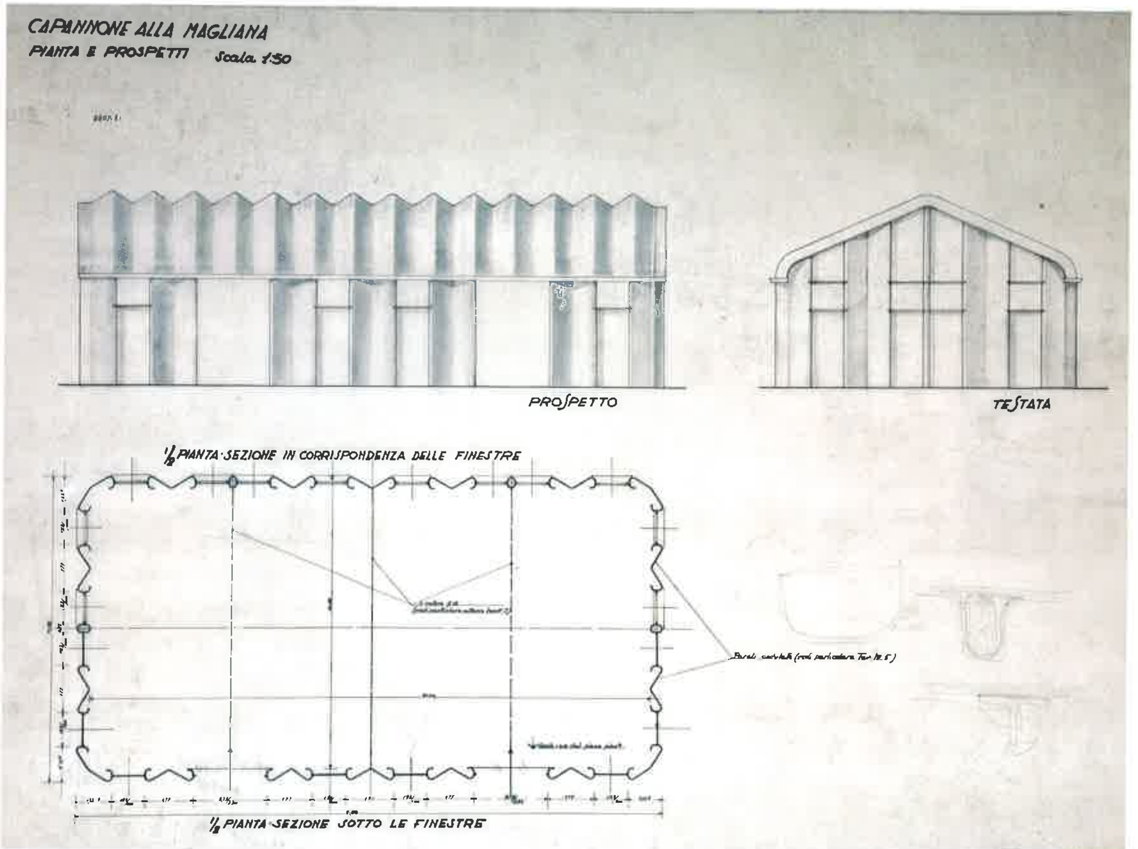

Fig. 6.2. Plan and perspective drawings of the Magliana Pavilion, undated [1944]. Drawing: P. L. Nervi Collection, Study Center and Archive of Communication. Photo: CSAC, University of Parma

authenticity and integrity; the conservation of the building, therefore, aimed to conserve this significant fabric.

THE PROJECT

A long history led to the conservation of the pavilion. Ten years were spent researching the building's history, in particular the history of reinforced concrete and the works of Nervi (Poretti 1983; Iori 2001, 2009a; Iori and Poretti 2010). The project engaged some twenty young researchers over the years (Iori and Poretti 2015a).[1] The genesis of the undertaking can be traced to the 2010 exhibition *Pier Luigi Nervi in Rome: Architecture as Challenge—Genius and Building* at Rome's MAXXI, Museo nazionale delle arti del XXI secolo (National Museum of Twenty-First Century Arts).[2] In the exhibition, the place of honor was occupied by the motorboat *La Giuseppa*, constructed entirely from ferrocement by Pier Luigi and his son, Antonio Nervi, in 1972. *La Giuseppa* was the family boat and was in use for six years during summer vacations, principally along the Amalfi Coast. After the show, the boat's voyage continued from the interior of the headquarters of the Food and Agriculture Organization of the United Nations to the Circus Maximus, where it was displayed in an exhibition dedicated to Nervi's boats made from ferrocement. Before going on view, the motorboat underwent careful and pioneering conservation that informed the subsequent conservation work to the Magliana Pavilion.

The body of the ferrocement vessel is barely 1.5 cm thick. Ordinary repair treatments for reinforced concrete were not considered appropriate, and the intervention offered a unique opportunity to analyze the material directly and experiment with possible conservation methods. The conservation of the motorboat was made possible by sponsorship of the Italcementi Group Bergamo, who developed innovative materials for the treatment and provided technical assistance to the researchers from the University of Rome Tor Vergata involved in the project (Iori and Meda 2012). As a result of this positive and formative experience, Italcementi expressed interest

in sponsoring the conservation of additional ferrocement works by Nervi utilizing the products developed for the motorboat. This catalyzed negotiations with the owner of the Magliana Pavilion.

Following the deaths of Pier Luigi Nervi and Antonio Nervi in 1979, a small private firm purchased the property, including all of its buildings. This owner later helped prevent the demolition of the small building. Around 1990, the Commune of Rome decided to expropriate and raze to the ground all of the area's buildings (including the pavilion) in order to build a public parking lot for the nearby train station. At that time, the architect Irene Nervi, Pier Luigi's granddaughter, alerted to the threat of demolition by the owner, succeeded in obstructing the proceedings and preventing the demolition (Greco 1994). Over the years, the building has lacked suitable maintenance. It currently serves as a covered parking lot.

In 2003, the pavilion was added to the local heritage inventory, preventing demolition and enabling it to be further investigated. In the meantime, many plans to transform the site into a cultural center were considered, but none were financially viable. Over time the pavilion had fallen into a state of advanced disrepair, and given the pioneering nature of the ferrocement employed, this disrepair could have become dangerous and irreversible. At the end of 2012, the owner finally agreed to proceed with partial conservation, sponsored by the Italcementi Group, who covered the material and labor costs of the project, which was planned and led by the SIXXI team (Iori 2015; Iori and Poretti 2016). In 2016, proceedings were initiated to add the pavilion to the Italian state's list of monumental heritage sites.

INVESTIGATIONS: BACKGROUND RESEARCH, ANALYSIS, DIAGNOSTIC WORK, TESTING, AND TRIALS

A detailed historical study of the building and ferrocement preceded the conservation. The research was undertaken using the working drawings of the pavilion found in the Communication Study Centre and Archive at the University of Parma, which holds the main body of Pier Luigi Nervi's design archive, as well as the Architecture Archives Centre at MAXXI, which holds an important group of drawings and the principal collection of photographs of Nervi's building sites (Zhara Buda 2016). The physical investigations and analytical work were undertaken within a short period in advance of the repair work, which is described in the conservation section below.

Nervi's ferrocement originated during the Italian autarkic period, which followed the country's invasion of Ethiopia in 1935. In response, the League of Nations condemned the invasion and imposed economic sanctions. Despite the fact that the sanctions lasted only a few months, the Fascist regime took advantage of them and launched its national policy of economic self-sufficiency (autarky). Fascist propaganda pushed the use of Italian materials and prohibited the use of steel; Italy's modest production, along with the small quantity that the country was able to purchase abroad, was reserved for military purposes in preparation for the imminent world war. Reinforced concrete, which requires steel reinforcement for its structural framework, was classified non-autarkic. Its use was progressively limited until it was finally prohibited entirely in 1939.

Nervi, who had worked with reinforced concrete since he completed his studies, persevered until he devised an alternative solution, ferrocement. This unique invention is a variation on reinforced concrete, beginning with the same materials: concrete and steel. The ratio of concrete to steel in ordinary reinforced concrete is much higher than in ferrocement, in which steel is the prevalent component. Although it seems contradictory, Nervi demonstrated that for any given span, his material, with its reduced thickness, would require much less steel than ordinary reinforced concrete, thus fulfilling the Italian regime's goal of autarky or self-sufficiency. Of course, in order to be useful in construction, ferrocement had to be formed into appropriate shapes (wavy or pleated, for example) to make it "shape-resistant."

Nervi was guided in his experiments by Arturo Danusso, one of the most important Italian scholars of structural theory, and the two collaborated during these years. Nervi's structures were highly complex and hyperstatic, making it too difficult to calculate using traditional analytic tools. For this reason, Danusso constructed and tested celluloid scale models in his lab at the Polytechnic University of Milan as a means of verifying Nervi's designs.

Nervi completed his first ferrocement slabs in 1943. They were produced by spreading high-strength cement mixed with fine aggregates onto panels made up of many layers of thin metal mesh or chicken wire. The concrete was pressed with a sponge float trowel on one side until it emerged from the other. The slabs were generally 2 to 3 cm thick. The new material was very resistant, elastic, ductile, isotropic, practically homogeneous, and light. Extraordinarily malleable, it could be made into any shape or form. It was also exceptionally economical. Above all, the new material did not require the wooden formwork typical of ordinary reinforced concrete. Metal mesh can be bent into any shape and then saturated with directly applied cement

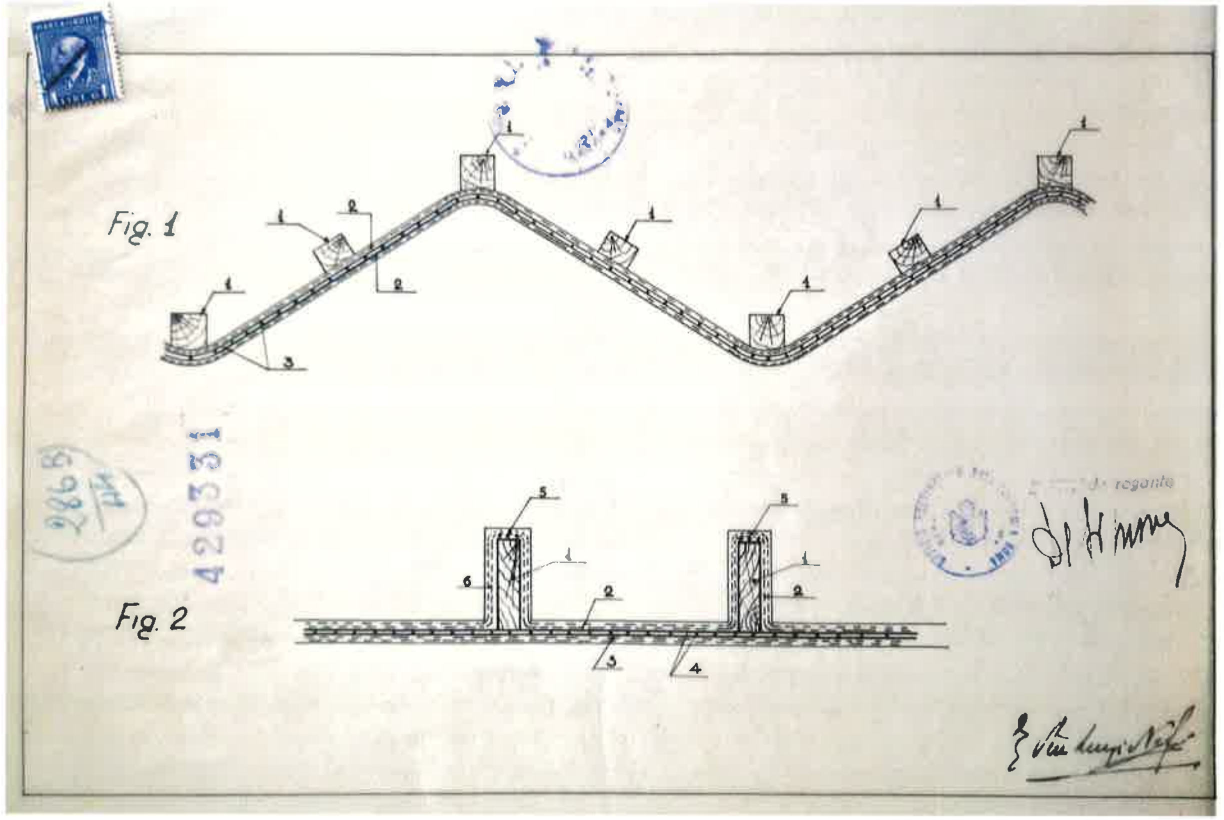

Fig. 6.3. Patent 429331 by Pier Luigi Nervi, protecting the ferrocement used in the Magliana Warehouse, 1944. Photo: SIXXI Collection, Rome Tor Vergata University

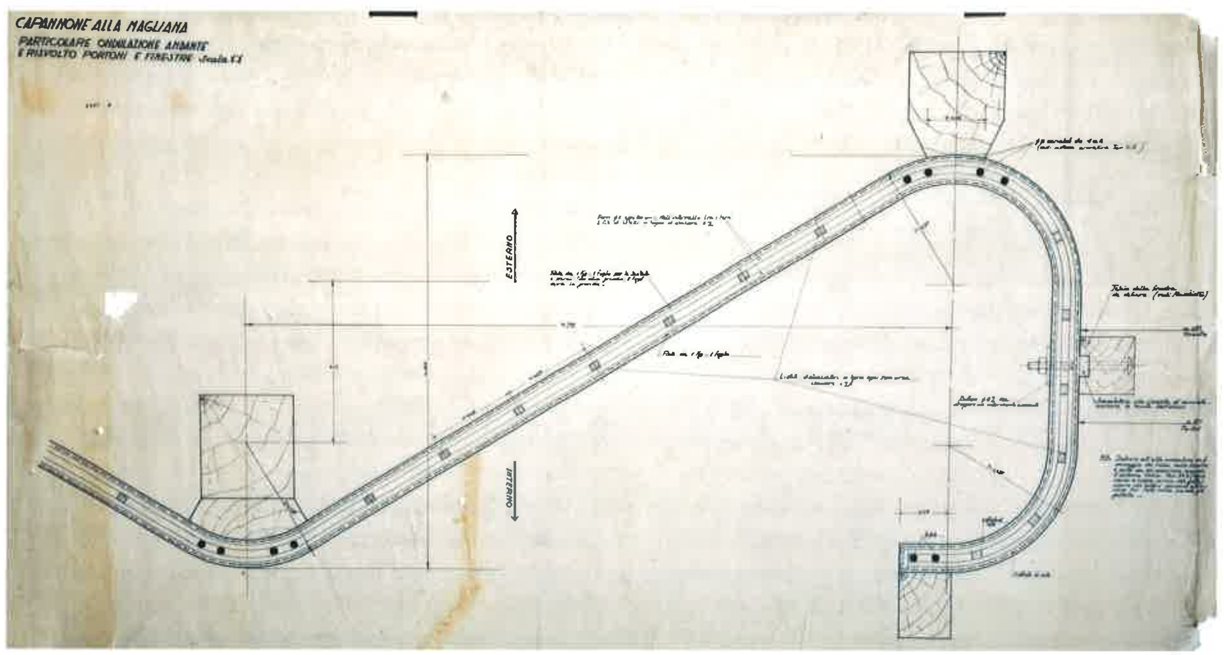

Fig. 6.4. Detail of the perimeter wall of the Magliana Pavilion, undated [1944]. Drawing: P. L. Nervi Collection, Study Center and Archive of Communication. Photo: CSAC, University of Parma

mortar, without the need for a reverse mold. Freeing construction from the constraints of wooden formwork, Nervi was able to explore a world of shapes that until then was unthinkable.

The first patent protecting the invention of ferrocement, titled "Perfection of the Construction of Slabs, Sheets, and Other Reinforced Cement Structures" (patent no. 406296), was registered by Nervi in Italy on April 15, 1943 (Nervi 1943; Greco 2008).

By the winter of 1943, Nervi was considering using ferrocement for the construction of boats. Ferrocement was an easy and economical material with which to construct a doubly curved hull by folding the metal mesh and then applying cement by hand. Using this invention, between 1945 and 1948 he constructed the 400 metric ton motorized sailboat *Irene* (1945), the pontoon *Toscana*, the fishing vessel *Santa Rita*, and the elegant luxury ketch *Nennele* (Nervi 1950). However, he abandoned the nautical projects immediately after these initial experiments, dedicating himself to large structures.[3] Subsequently, he found many other applications for ferrocement, initiated by the small, experimental Magliana Pavilion.

The pavilion's undulating walls (created through the repetition of a standard module, with the shape providing structural inertia/resistance), pitched roof, eaves gutters along the long sides of the building, windowsills, and architraves are all made from ferrocement. Nervi explained: "The construction yields excellent technical results, even if it is slightly more expensive than traditional materials" (Nervi 1951, 75).[4]

The method of execution of the pavilion was patented in Italy in September 1944 (patent no. 429331), an elaboration of the principal patent of 1943 (Nervi 1944) (fig. 6.3). The patent is accompanied by a design that closely resembles the pavilion's walls (fig. 6.4). The procedure for constructing the building can be outlined in a few steps. First, one places temporary wooden uprights in direct proportion to the resistance capacity of the metal mesh (fig. 6.5), then the metal layers are prepared, and the reinforcing steel bars and square wooden battens are inserted inside them. The different layers of mesh and steel bars are secured to one another by means of iron wire in order to reach the right resistance and stability. A premade wooden profile is used to model and bend the mesh and steel into the correct shape (fig. 6.6). Once the metal layers are in place, the concrete is applied to the structure from the side opposite the uprights, while ensuring that it reaches full stability through uniform distribution inside the structure (fig. 6.7).

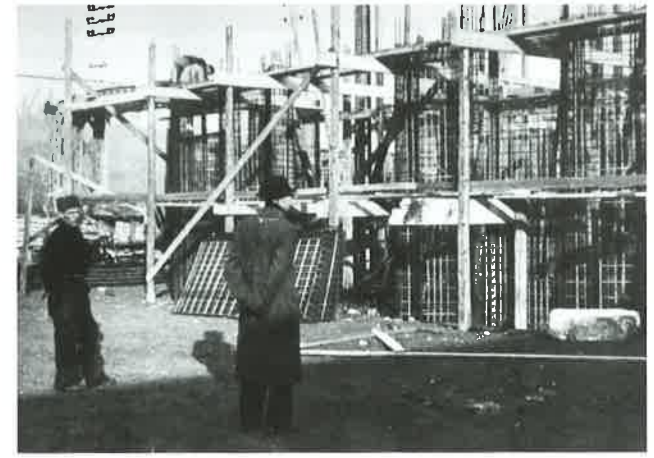

Fig. 6.5. The Magliana Pavilion under construction, undated [1944]. Photo: P. L. Nervi Collection, Architectural Archive Center, MAXXI, Rome

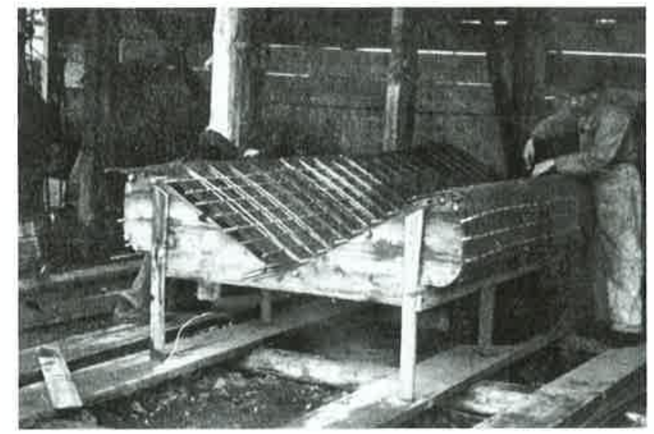

Fig. 6.6. Wooden profile for modeling the ferrocement framework for construction of the Magliana Pavilion, undated [1944]. Photo: P. L. Nervi Collection, Architectural Archive Center, MAXXI, Rome

Fig. 6.7. Workers spreading concrete by hand for the ferrocement walls of the Magliana Pavilion, undated [1944]. Photo: P. L. Nervi Collection, Architectural Archive Center, MAXXI, Rome

Fig. 6.8. Condition of one of the perimeter walls of the Magliana Pavilion before conservation, 2013. Photo: SIXXI Collection, Rome Tor Vergata University

Fig. 6.9. Condition of the roof of the Magliana Pavilion, seen from the inside, before conservation, 2013. Photo: SIXXI Collection, Rome Tor Vergata University

The ferrocement patented in April 1943 was very different from that patented in 1944, and the latter was ultimately used to create the pavilion. Through 1960, ferrocement was continuously perfected and adapted to varying construction requirements. Just as the material characteristics of reinforced concrete differ according to the economic conditions of the country, historical period, designer, and so on, the composition of Nervi's early ferrocement, as described in the first patents and realized in his initial experiments during the war, differs from the materials used in the postwar era and Italy's subsequent economic boom.

For example, the ferrocement that Nervi used to complete the 1,620 rhomboid precast elements for the cupola of the Palazzetto dello Sport (1957) is greatly simplified in comparison with the earlier version. For the latter, there is a broad weave of steel bars and only one layer of mesh in the 2.5 cm thick layer (Iori 2009b). Notwithstanding the simplifications that evolved over time, the material's underlying characteristics are consistent. It is economical, light, and shapeable into any form, even complex ones, without the need for wooden formworks.

Various deterioration effects and mechanisms were present prior to the conservation of the pavilion. Vast portions of the concrete were missing, and the metal mesh reinforcement was corroded in areas. Most of the damage was concentrated in the lowest horizontal area ringing the pavilion, caused by impact damage from cars during parking (fig. 6.8). The upper sections of the walls, which initially appeared to be better preserved, in fact had suffered more severe deterioration, which was revealed after removal of the surface coating. The coating had masked previous, inappropriate interventions that patched over large areas of concrete loss. Many of these were caused by attempts to hang lamps or security devices from the thin ferrocement walls.

The exterior surface of the concrete roof of the pavilion was also badly damaged. In fact, the roof had not originally been coated to waterproof it (fig. 6.9). Rather, in an effort to test the properties of the ferrocement, Nervi said, "It is also foreseeable that the impermeability of the roof will remain intact, without the need for an additional protective layer or moisture barrier, yet in this respect, we cannot draw definite conclusions until it has undergone the seasonal change from summer to winter at least two times" (Nervi 1945, 133).[5] However, a coating of bituminous tar was applied a few years after construction when water infiltration became apparent, disappointing the engineer. When conservation work began, widespread damage to the external impermeable coating and the resulting clumsy attempts at maintenance had created pools of standing rainwater, leading to infiltration and resulting in clearly evident corrosion of the metal reinforcement and subsequent spalling of the concrete. Unfortunately, the extent of damage was more than anticipated, and the available funds were inadequate to cover the costs associated with retreatment of the roof with an impermeable barrier. This work is still urgently needed.

Laboratory analysis was carried out on a portion of the original ferrocement that was selected from an area unaffected by later interventions. This original fragment was of sufficient size to determine the range of grain sizes present in the mortar. Laboratory tests established the maximum (1.2 mm) and minimum (0.07 mm) diameter of the aggregates and an almost linear distribution between the two values. In addition, a petrographic analysis by means of thin-section microscopy was undertaken. This showed the presence of natural aggregates within the closed structure of the cement, in particular sand and crushed stone derived from shattered rock, and enabled a matching of the aggregates and their grading. These tests did not provide information about the water-to-cement ratio used, which required that a series of trials be undertaken.

CONSERVATION

The pavilion's continued use as a car park limited access to the site, so the assessment of the condition of the concrete, the physical investigations, and the repair program were undertaken over a relatively short period, informed by the extensive historical research on Nervi's construction methods employed for ferrocement. From June to September 2012, the general survey and inspection works were conducted directly on the building. The new repair material to be used was produced by Italcementi according to the outcomes of the physical analysis and investigations. In late December 2012, treatment methods were tested on a restricted portion of the wall. Conservation began in January 2013 and was completed by early February 2013. All work was scheduled between late morning, when the pavilion became more or less free of cars, and early evening, when people leasing the parking spaces returned with their cars.

First, the internal surfaces of the pavilion were cleaned with pressurized water in order to remove the existing coatings. Light hammering over the entire internal surface facilitated detachment of already loosened areas of concrete and areas that had previously been poorly patched. At this point, the data detailing the materials and geometry gathered from the pavilion's historical records was

Fig. 6.10. Wooden profile used in the fabrication of the 1:1 scale model of the Magliana Pavilion's perimeter wall, 2013. Photo: SIXXI Collection, Rome Tor Vergata University

Fig. 6.11. Steel and wooden reinforcement used in the fabrication of the 1:1 scale model of the Magliana Pavilion's perimeter wall, 2013. Photo: SIXXI Collection, Rome Tor Vergata University

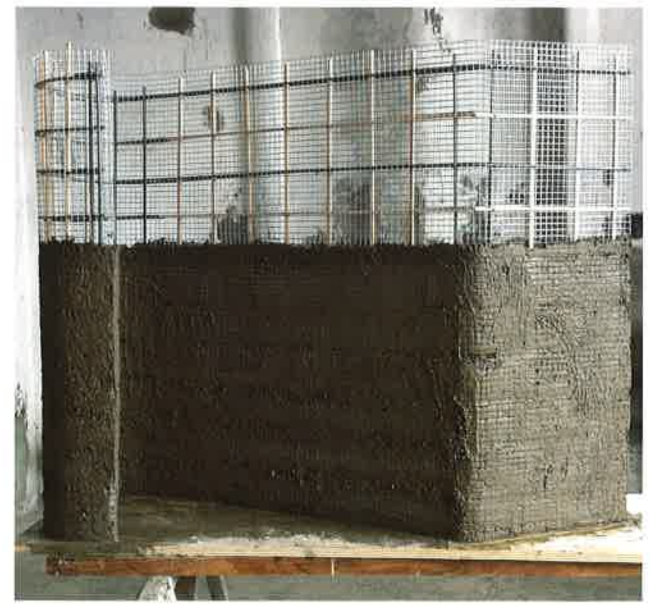

Fig. 6.12. Application of concrete in the fabrication of the 1:1 scale model of the Magliana Pavilion's perimeter wall, 2013. Photo: SIXXI Collection, Rome Tor Vergata University

meticulously verified. A survey of all visible parts was carried out, confirming the exact position of the reinforcing steel bars in the framework, the square wooden battens, and the thin metal mesh. The survey results matched Nervi's working drawings for the pavilion exactly.

Soon after the start of works, a 1:1 model of the waveform wall of the pavilion was created, 135 by 45 cm square by 1 m high (fig. 6.10). This served as a mock-up for the workers to use in trialing the repair in advance of conservation work. The trials re-created the sequence of steps undertaken by Nervi. First, the curvilinear wooden profile was created and placed horizontally for shaping and securing the metal reinforcement components together by hand using iron wire. Then, 6 mm diameter horizontal and vertical reinforcing steel rods were bent and arranged with 5 by 5 mm square battens of wood that stiffened the whole (fig. 6.11). This framework was then placed vertically, fixed to a wooden base, and completed with the attachment of two layers (one external and one internal) of 1 by 1 cm weave welded wire mesh, secured with iron wire. To follow, the mixture of cement and carefully selected aggregates was applied about halfway up the framework, for a maximum final thickness of 2.5 cm (fig. 6.12). This phase of the work allowed testing of the correct ratio of water to cement to provide adequate workability. This 1:1 scale model is currently preserved in the SIXXI laboratory in the civil engineering building at the University of Rome Tor Vergata. Once the ability of the workers to re-create ferrocement had been tested, the conservation of the pavilion began.

Portions of the metal reinforcement that had been exposed after cleaning and hammering were cleaned by hand with metal brushes and treated with a protective realkalizing corrosion-inhibiting protective coating. Sections of the original metal reinforcement that had been lost due to corrosion and breakage were replaced with a new layer of mesh of the same diameter and weave spacing. The new reinforcement was secured to the existing steel rods. In one section of the roof, corrosion of the principal framework of steel reinforcement rods had progressed to the stage where it compromised structural integrity and needed to be replaced. The rest of the structure was well preserved. In no case was it necessary to replace the wooden slats in the walls, which were perfectly anchored in the cement and as a result in an excellent state of preservation.

After repair of the metal reinforcement, a cement-based product developed by the Italcementi Group Bergamo laboratory especially for this specific treatment was applied. The product required the following properties:

- cement-based
- compatible with the original composite
- granularity as similar as possible to the original
- matching the color of the very aged original material
- with thixotropic consistency adequate for application by hand, following the same techniques utilized for manufacture of the original ferrocement
- able to be applied in layers of only a few millimeters, preventing alteration of the geometric peculiarities of the structural materials (thickness less than 30 mm)
- ability to protect the structure over time, guaranteeing an adequate durability for the ferrocement, consistency of color over time, and retention of the smooth texture of the treated surface

For this final reason, TX Active, a proprietary photocatalytic cement, was added to the repair material mix. The material aims to reduce atmospheric pollutants, including exhaust emissions from cars, and consequently provides a self-cleaning surface. This high-performance material was premixed and produced by the Italcementi laboratory with the brand name Effix Design ST. The product, created for the pavilion and patented, is not commercially available. Despite this, the project demonstrated the potential to work with repair product companies to create bespoke repair materials. Here, the company was able to respond to the special needs for this project and create a site-specific mortar. This is an approach that the university repeated recently for another important building.

As the material is workable only for a limited time, it was mixed with water in small quantities and immediately applied with a plastering trowel (fig. 6.13). Its application, carried out by the firm SA.GI. Lavori snr of Rome, required exceptional care, following the curvature of the walls and roof (fig. 6.14). The repair mortar was extensively applied, in some places for only a few millimeters in depth; in others the full depth of the wall was reconstructed. The resulting somewhat patchy surface appearance is similar to its original state. This reflects the building's utilitarian function as a warehouse and the experimental use of the material. The surface was not repainted, enabling monitoring of the repair over time.

The work was filmed in its entirety, and the footage was edited into a documentary film titled *Conservare il ferrocemento di Pier Luigi Nervi* (SIXXI 2012), which also includes video documentation of the restoration of the motorboat *La Giuseppa* and original archival materials such as construction photographs, patents, and working drawings.

Fig. 6.13. Repair of the perimeter walls, 2013. Photo: SIXXI Collection, Rome Tor Vergata University

Fig. 6.14. Repair of the roof, 2013. Photo: SIXXI Collection, Rome Tor Vergata University

CONCLUSIONS

Conservation of the Magliana Pavilion provided an exceptional opportunity to study Nervi's works and his ferrocement (fig. 6.15). The intense manual labor involved contributed greatly to our understanding of the material's history and construction methods. Indeed, it was possible to reconstruct the original sequence of steps involved in the manufacture of ferrocement, rediscovering the construction process, which had been difficult to deduce from the available archival documentation.

The workers who completed the project described the manual labor as extremely strenuous. Even if the kind of movement required to carry out the intervention was similar to that used when spreading out plaster, the cement composite is much less workable and therefore requires considerable power and strength in the arms. This feedback led to the conclusion that the original workers in 1944–45 encountered similar difficulties and probably shared this information with Nervi. This may explain why few additional buildings were constructed by Nervi using ferrocement produced on-site; the work is too strenuous. Of the other works completed by Nervi using ferrocement produced on-site, none have survived. These included the undulating roof of the hemicycle building at the 1948 Fiera di Milano (demolished in 2008), the diving tower at the Kursaal beach resort at Ostia (the landmark that still characterizes the beachfront at Ostia, demolished in the 1970s and recently reconstructed in wood), and a spherical sculpture exhibited at the 1953 International Agricultural Exposition of Rome, designed by Adalberto Libera, Amedeo Luccichenti, and Vincenzo Monaco, and completed by Nervi and Bartoli, which was demolished shortly after the exposition.

In his later, most famous masterpieces, Nervi adopted a new strategy utilizing a combination of in situ traditional reinforced concrete and ferrocement. Generally, the elevated portions such as columns and walls were constructed of reinforced concrete and the roof was constructed of small prefabricated components of ferrocement. This facilitated great structural innovations coupled with construction efficiencies.

The conservation of the Magliana Pavilion facilitated substantial advancements in the theoretical and practical understanding of the techniques invented by Nervi for accomplishing his designs. Historical research into his patents enabled a deeper understanding of his material selection and construction techniques. This allowed the team to reverse engineer the building, which was necessary in order to determine how to conserve it. It also provided

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Fig. 6.15. Inside of the Magliana Pavilion after conservation, 2013. Photo: SIXXI Collection, Rome Tor Vergata University

information on how closely Nervi's patents matched his buildings. This know-how could be useful when, in the future, it is necessary to treat more complex structures, such as the large dome of the Palazzetto dello Sport.

Further work is needed to secure the Magliana Pavilion, including waterproofing the roof. As it is in private use, its ongoing conservation is dependent on the owner's goodwill to continue to preserve such a utilitarian but nevertheless important building, as well as the ability to sustain a use that has some economic utility.

Translated from the Italian by Aimée Ducey-Gessner

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NOTES

1. The European Research Council Advanced Grant, received in 2011 by Sergio Poretti, the principal investigator, made possible the creation of a research group within the University of Rome Tor Vergata, led by Poretti and Tullia Iori (www.sixxi.eu).
2. The exhibition was on view December 15, 2010, to March 20, 2011, and was co-curated by Iori and Poretti (Iori and Poretti 2010).
3. In 1970, however, the United Nations Food and Agriculture Organization asked Nervi to design two motorboats to be taken to Egypt and used to teach the local population how to economically construct a fishing boat. Nervi completed the project pro bono. Shortly thereafter he built the aforementioned motorboat, *La Giuseppa*, for his family, still full of enthusiasm for this application of ferrocement, which he felt had been cast aside too early.
4. Translation by Aimée Ducey-Gessner.
5. Ibid.

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Front cover: National Theatre, London. Photo: © Philip Vile / Haworth Tompkins
Page 6: Unité d'Habitation, Marseille. Le Corbusier's Modulor Man cast into concrete beside the main entrance. Photo: Geoffrey Taunton / Alamy Stock Photo
Page 15 (top to bottom): View of the reinforced concrete dish of the iconic 30-foot diameter Listening Mirror in 2005 (detail, fig. 1.1). Photo: Tony Watson / Alamy Stock Photo; the Magliana Pavilion under construction, 1945 (detail, fig. 6.1). Photo: MAXXII Museo nazionale delle arti del XXI secolo, Rome. MAXXI Architettura Collection, P. L. Nervi Collection
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Page 17 (clockwise from top left): The repaired bear ravine at the Dudley Zoological Gardens, 2015 (fig. 4.1); the terrace to the café-restaurant at the Gänsehäufel Swimming Facility, following conservation (detail, fig. 7.5). Photo: Bettina Neubauer-Pregl. Courtesy of Federal Monuments Authority Austria, Vienna; view of the National Theatre following conservation, 2016 (detail, fig. 12.11). Photo: Ana Paula Arato Gonçalves; Morse and Ezra Stiles Colleges, Yale University, 2013 (detail, fig. 10.1). Photo: Michael Doolittle / Alamy Stock Photo
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Page 190: Morse and Ezra Stiles Colleges, Yale University, New Haven, Connecticut. Photo: Richard Barnes
Page 201: Covered walkway at Strandbad Gänsehäufel, 2010. Photo: Daniel-tbs, Wikimedia Commons, CC BY-SA 4.0
Back cover (left to right): View of the Listening Mirror in 2005 (detail, fig. 1.1). Photo: Tony Watson / Alamy Stock Photo; the repaired bear ravine at the Dudley Zoological Gardens, 2015 (detail, fig. 4.1); the north end of the First Christian Lower Technical School Patrimonium after conservation works (detail, fig. 9.12). Photo: Raoul Suermondt Architectural Photography

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