Steel and Architecture: Analysis of Some Singular Italian Experiments of the Sixties of the Last Century

Marcello Zordan

Abstract The experiment with steel is one of the most fascinating and challenging chapters in the history of Italian architecture and construction of the last century. Starting from the debate on the modernization up to postwar period and the economic boom years, the innovative aspects related to the continuous and singular Italian tendency to steel structures, have highlighted an important fact: to the contained quantitative distribution of steel structures, compared to the traditional ones, have corresponded to constant and significant experiments in qualitative terms. In the exceptional view of Italian engineering, especially from the postwar period on, they fitted a large number of exemplary works in which the steel was used as a linguistic tool and not just in purely structural and functional terms of building purposes. The theme of the great light has become not only a pretext for the use of large metal roofing, but it so fascinated Italian designers to encourage them the search for solutions from both the experimental point of view of engineering and architecture. The memory will deepen the innovative aspects related to the testing of Italian steel architecture of the sixties of the twentieth century through the analysis of some works considered most representative for which you can highlight specific design is interesting in terms of construction and architecture.

Keywords Construction history · Italian modernist experimentations · Great steel construction · The curtain wall · Cable-stayed bridges

1 Introduction

Why did metal construction not have the same space in Italy as it did in other European countries in the 1960s? Why did the architects of Italian modernity prefer reinforced concrete to steel structures? Why, in the post-war period, did the engineers who built the Autostrada del Sole, for the most part, prefer pre-stressed reinforced concrete rather than metal trusses?

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The reasons, which are complex, are not limited to the scarce availability of raw materials but involve political, economic, industrial as well as social choices. Although confined to this secondary role in building and infrastructural activities, metal construction has, however, been the subject of constant and interesting experimentation. These are the themes around which this research is developed, whose main objective is to provide the elements for the reconstruction of the complex story of the use of steel in Italian architecture in the years of the economic boom, through the critical reading of the typological, constructive and figurative characters of a series of representative works.

Three, in particular, are the areas in which the role that the use of this material assumes in the sixties is outlined and for which experiences of a different nature are analyzed, chosen as representative of these areas: large structures, curtain wall construction and the bridge sector.

Conducted on a bibliographic and archival basis, with direct investigations and with the intention of implementing the levels of knowledge with the use of digital technologies, the research retraces, where possible, in addition to the ideation-design process, the executive events and the construction process. In particular, with regard to the works analyzed, virtual models of the project status and of the actual status are being elaborated, which will also serve for a critical comparison, an essential basis of knowledge to be made usable for future interventions of recovery and conservation.

2 Great Steel Structures

As well known, experimentation with steel had a quite slow and difficult start in Italian architecture and construction history, especially in the building sector. Until the fifties of the last century, in fact, steel frame appears only in some almost prototypical works, which are significant for their experimental contribution, but clearly unable to boost competition to the traditional construction methodology, based on reinforced concrete and masonry.

Particularly in the post-war reconstruction years, the industrial development in all other sectors is matched by the persistence of reinforced concrete in building, thus continuing the process of diffusion started at the beginning of the century. In this field the works of such contributors as Nervi, Morandi, Musmeci, and others emerge, with their achievements of large concrete structures, in which technique is implemented by innovative architectural solutions. Reinforced concrete is, therefore, the main character in most of the Italian great works, and in residential construction as well, within national programs that take place in this period throughout the whole national territory. At this stage, the artisan-like construction techniques of Italian modern tradition still prevail: the bearing structure realized by a reinforced concrete skeleton, seen as the evolution of masonry, and the construction site run by small business, with simple equipment and extensive use of manpower, both qualified and unqualified [1].

The use of steel, which characterized some important buildings of the pre-war period, certainly keeps its episodic character, although experimentation on the subject, started in the years of modernization and interrupted only during the most pressing days of war, continues in this period. In 1951 ECSC (European Coal and Steel Community) is founded. It promotes a series of studies and research by encouraging experimental development, and sums up to the dissemination work of technical magazines, which publish numerous articles featuring the most important steel works made before World War II, thus inspiring designers who are looking for innovative solutions both from a technical and an aesthetic standpoint.

Even during this period, the most highlighted benefits of steel are the possibility of prefabrication, in the first place, the high resistance of the material to bending (allowing the use of thinner pillars and beams, with obvious functional and especially architectural advantages), the speed of execution, the easiness in the plans setup, etc. In this dynamic and purposeful context, between the late fifties and the beginning of the next decade, when a notable expansion of the iron and steel industry takes place, there is a significant revival of steel construction and a greater awareness is achieved of the technical qualities of this material, also in respect of its relationship with the architectural language.

In this context, the theme of grand roofs provides important experiments with steel as the protagonist, allowing renowned designers, architects and engineers to create constructions where this material is used as a linguistic tool rather than merely in purely structural and functional terms.

In order to better understand some of the characteristics and the importance of this issue, it is useful to take a technical, technological and morphological look at four pivotal works (the Burgo Paper Mill in Mantua, Palazzo del Lavoro, and Palazzo dello Sport in Turin and the Palasport in Genoa) considered the most representative. A detailed analysis was made in order to retrace not only the conceptualization and design process, but also the finalization and construction of the buildings.

2.1 The Burgo Paper Mill

The Burgo Paper Mill (Fig. 1), whose steel sections were designed by Pier Luigi Nervi and Gino Covre, is not only one of Mantua's most important building works of the second half of the twentieth century, but was also most certainly a unique construction for Italian and inter-national architecture of the 1960s, especially when examined alongside Pier Luigi Nervi's other works, where, without question, it stands out as being exceptional. Nervi looked for inspiration in the statics of suspension bridges (Fig. 2) to find a solution to the complex functional problem of creating a single large working space with no intermediate or perimeter supports.

The building consists of two independent elements: the two-storey reinforced concrete base which houses the continuous paper making machine and the steel roof suspended. The roof is built from a continuous truss frame and is suspended via four cables to two 47 m tall reinforced concrete piers. The long fronts designed with a

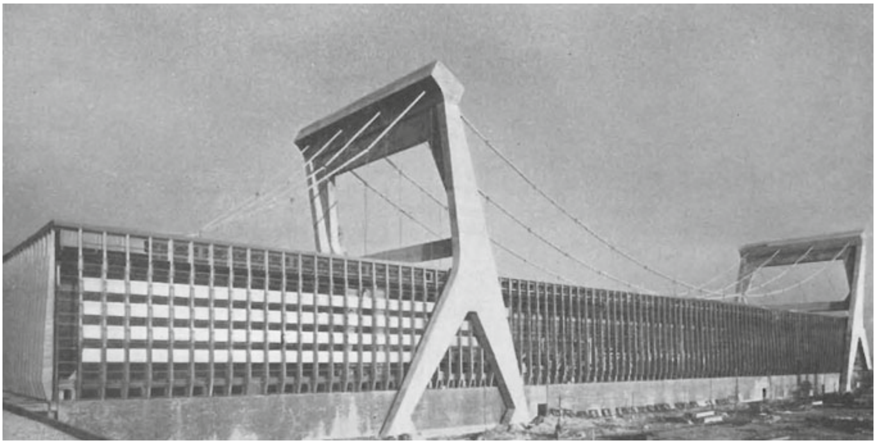

Fig. 1 The Burgo Paper Mill in Mantua. P.L. Nervi. 1960–64. Historical photo (Covre/1963)

Fig. 2 The Burgo Paper Mill in Mantua. P.L. Nervi. 1960–64. Historical photo (Covre/1963)

dense grid of metal elements feature a continuous shell of steel and glass between the base and the roof [2].

The four reinforced concrete piers are connected transversally two by two by pairs of beams of which the upper ones act as anchors to the suspension cables.

This beam has a hollow core and incorporates four steel caissons whose function is to divide the heavy concentrated loads transmitted by the chains to coupled plates. 45 mm round tie rods placed at 10 m intervals support the four longitudinal roof trusses each consisting of two bridles mutually connected via elements arranged transversely and along the two diagonals. Another distinct feature is the long perimeter glass of the outer structure. Apart from the design itself, the singularity of this system lies in an unusual technical feature aspect. In fact, the curtain-wall is not hung from above but is built into the reinforced concrete base and the glass wall, free at the top, opposes the action of the wind as if it were a large vertical console.

The experimental techniques used, combined with a formal result of unique interest—a cable-stayed bridge from which a large box of glass and steel is suspended—means that this building fully addresses the functional requirements of the remit resulting in great strength and visual lightness.

2.2 The Palazzo del Lavoro in Turin

The Palazzo del Lavoro in Turin is one of Nervi's most singular design projects, his first to present a composite resistance system (steel-reinforced concrete).

The design won the tender launched by the committee for the celebration of the Italia'61 Exhibition and is characterized by a large quadrangular space, highly flexible in terms of use, thanks to independent usable areas within the structural system, which is arranged into sixteen "mushroom" elements (40 × 40 m) each consisting of a central pillar in reinforced concrete crowned by secured steel cantilever beams [3]. These elements combine to cover the main hall on the ground floor and the exhibition spaces integrated by the raised gallery which continues right around the perimeter of the building. The second main level ends in a perimeter gallery overhanging the lower one [4].

The building frame features 19 m high glass walls from the roof to the gallery, held up by a series of "spindle" supports consisting of an outer shell stiffened internally with metal elements (Fig. 3).

Twenty consoles, which form the connecting capital and the overlying element connecting the cantilevers of each part of the roof, are welded to the reinforcement rods in the reinforced concrete pillars. The steel beams have a solid core with visible stiffening ribs and are connected by a perimeter beam that acts as a stiffening element for the whole system. The roof frame consists of insulated and waterproofed steel sheet panels. Finally, the sixteen roof squares are connected via a network of 2 m wide skylights, consisting of reverse V-shaped metal frames.

Fig. 3 The Palazzo del Lavoro in Turin. P.L. Nervi. 1959–61. External view (photo by the autor)

2.3 The Palazzo dello Sport in Turin

The Palazzo dello Sport in Turin (Fig. 4), more commonly known as the “Palaruffini”, is situated in the Pozza district in Turin, immersed in the park of the same name. Designed by Annibale Vitellozzi as part of the celebrations of the Italia ‘61 Exhibition’, the building proposes a series of figurative themes already experimented in the Palazzetto dello Sport in Rome, another work by architect Pier Luigi Nervi.

The construction consists functionally and structurally of two distinct parts: the first is the area that is partially underground where the track is located 3.40 m

Fig. 4 The Palazzo dello sport in Turin. A. Vitellozzi. 1960–61. External view (photo by the autor)

below street level, cylindrical in form, punctuated at regular intervals by the various entrances into the building and encircled at the top by a line of windows that illuminates the many rooms it contains (Fig. 5). The other element of far greater importance is the roof which, with its extraordinary and unique steel structure (Fig. 6) with imposing proportions and form, gives the whole building a peculiar characteristic [5].

The base of the complex, where the staircases are arranged, has a reinforced concrete support structure and occupies a circular. The roof's characteristic supporting structure is built wholly from steel, with 100 m span arches which intersect at the central and vertical axes of the building.

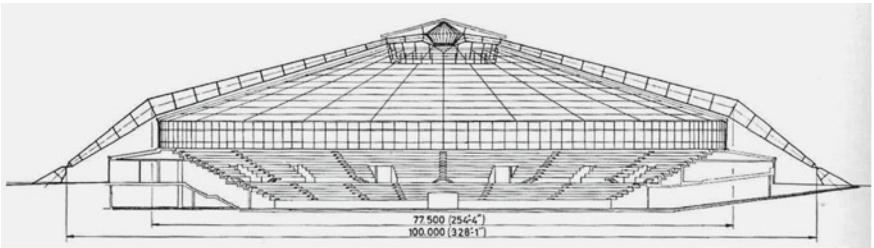

Fig. 5 The Palazzo dello sport in Turin. A. Vitellozzi. 1960–61. Section (Paolillo/1961)

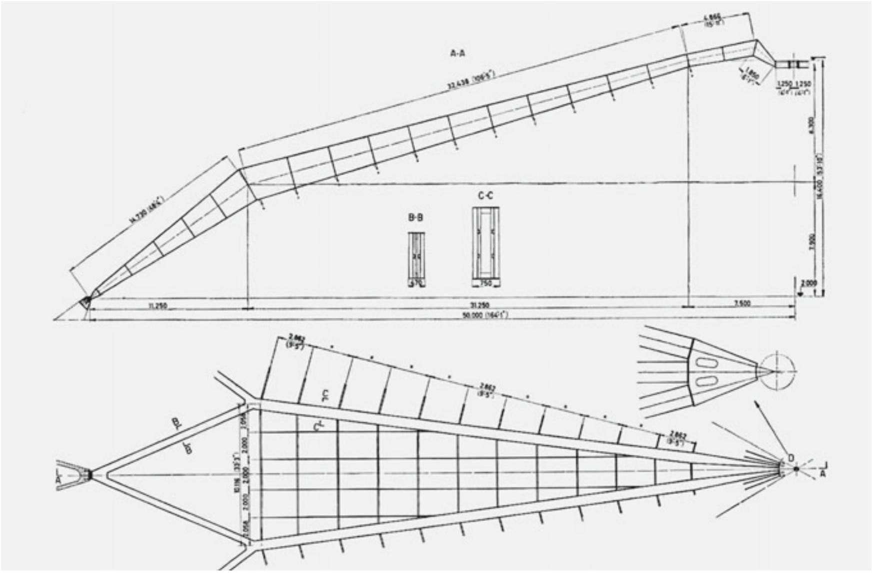

Fig. 6 The Palazzo dello sport in Turin. A. Vitellozzi. 1960–61. Executive design (Paolillo/1961)

2.4 The Palasport in Genoa

The Palasport in Genoa was the subject of a national competition to design a building to house exhibitions, won by the design drawn up by Leo Finzi, Lorenzo Martinoja, Remo Pagani, and Franco Sironi. Construction work began on the building in September 1961 and ended two years later [6].

The building has a traditional central plan, but with original and figuratively significant structural solutions. The main skeleton consists of 48 pairs of reinforced concrete pillars (Fig. 7).

On top of these are grafted the same number of pre-stressed concrete radial beams forming the main weft of the roof jutting 22 m towards the centre and 14 m towards the outer perimeter, which reaches a maximum diameter of 160 m [7].

The 68 m diameter central area, which acts as a skylight, is covered with a sophisticated radial tensile structure: a central suspended body, developing into a paraboloid of revolution, anchored to which are radial ropes connected to a horizontal reinforced concrete compressed ring, connected via tie rods to the floor slabs (Fig. 8).

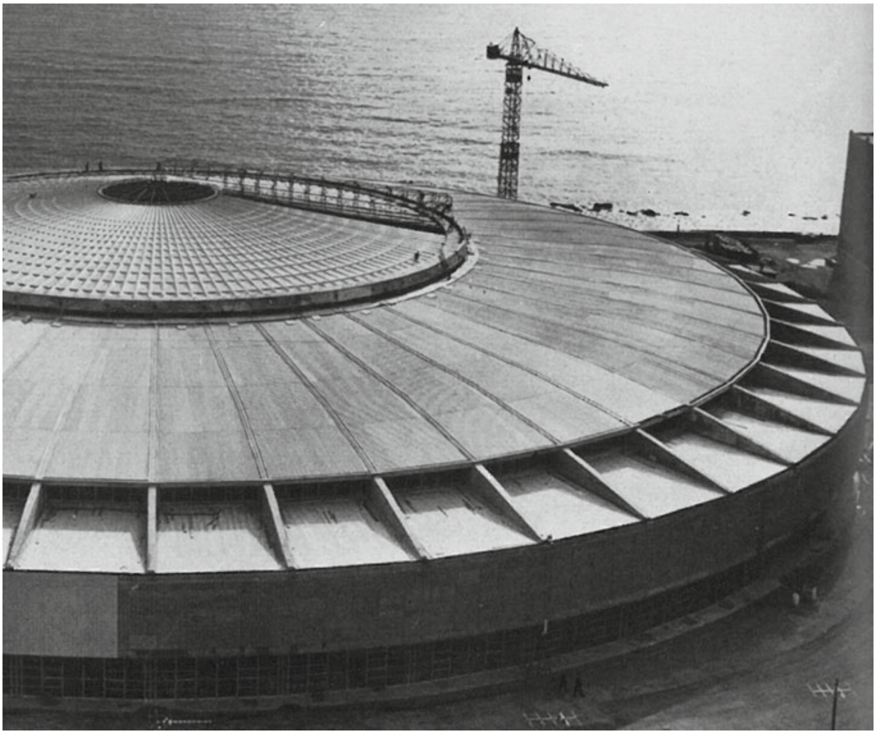

Fig. 7 The Palasport in Genoa. L. Finzi, L. Martinoja, R. Pagani, F. Sironi. 1961–63. Historical photo (Severino/1964)

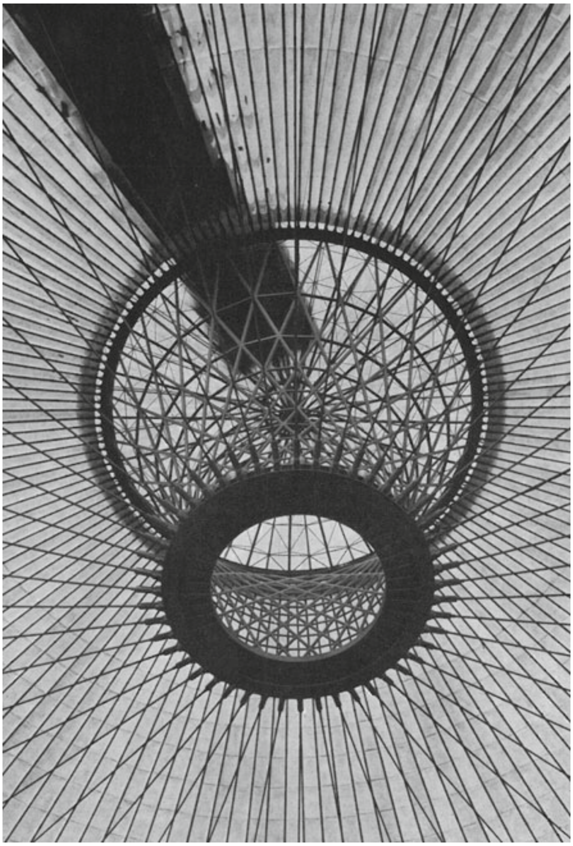

Fig. 8 The Palasport in Genoa. L. Finzi, L. Martinoja, R. Pagani, F. Sironi. 1961–63. Tensile structure detail, historical photo (Severino/1964)

An interesting solution is given to the roof covering the empty space above the central basket constructed from shaped panels of polyester reinforced with glass fibre, laid on a light-weight spaceship-like latticework dome set atop the hyperboloid. The roof covering with the tensile structure is made of "large tiles" in the same material, configured to be laid out on the upper ropes to which they are completely secured using simple plates and expansion rivets.

The type of concept, the technology and the reduced ratio between span and weight that are typical of these works point to affinities with a series of projects completed outside of Italy, where the solutions proposed highlight an important aspect: experimenting with lightweight structures with large spans achieved through the assembly of small industrialized steel pieces, in order to deal with a complex functional problem using structural solutions that are bold and, at the same time, extremely balanced in architectural terms.

3 The Curtain Wall Experimentation in Italian Building Office

In Italy, one of the areas of applied research on which major experiments are focused concerns steel combined with glass, in the study and development of the transparent building envelope. In these years, the curtain wall becomes a technology with specific characters and consequently a well delineated linguistic field for Italian designers. The application of this system is often chosen, in particular, in buildings for offices.

This happens specifically in Rome, where the ENI Business Center is built (1960–1962) by Marco Bacigalupo and Ugo Ratti, which is perhaps the most emblematic work in this concern, and also arise a few exemplary works such as the ESSO Headquarters in Rome Eur by Luigi Moretti (1961–1965), where the outer envelope is marked by protruding elements that form a dense texture, as well as numerous examples of possibly minor importance, although remarkable at the same time, including the RAI Directorate General (1961–1965), the INA complex (1961) and others.

3.1 ENI Business Center in Rome EUR

Designed by Marco Bacigalupo and Ugo Ratti as regards the architectural plan and by Leo Finzi, Edoardo Nova and Carlo Cestelli Guidi as regards the structural plan, this building has very simple volumetric features. It is conceived, in fact, as a great scenic backdrop on the end of the Eur artificial lake. The rectangular drawing gathers the stairwells at both ends and locate the groups of elevators in the middle of the plan. In elevation the building features 21 floors above ground and two basements, for an overall height of about 80 m, from the bases of the pillars to the top. Higher up the technical volumes are located, which are placed on two floors, for further 5.70 m in height. The building is intended to accommodate lobbies, a bank, the data processing center and a multi-purpose room at the ground floor.

The building has a bearing structure made entirely of steel, consisting of a series of frames, set at intervals of 7.20 m and formed by the pillars of the facade and the transverse beams, which support a warp of secondary elements set at intervals of 2.40 m [8]. On such elements a slab of reinforced concrete is cast, whose thickness is 10 cm. The stairs and elevators modules are entirely supported by beams and pillars embedded in the walls (Fig. 9).

They are made of lightly reinforced concrete whose thickness is 25 cm. Even the central structural complex, formed by the groups of elevators, works as a brace, as it has the task of absorbing the actions on the two main facades.

These are made of curtain wall with aluminum windows and glasses of blue-green color, while the heads are blind and clad in travertine (the only exception being a loop of glass which runs to the full height of the building).

The load-bearing function of the facades is carried out entirely by coupling pillars built in extruded aluminum. These are connected to the floor slabs through “bauer”

Fig. 9 ENI business center in Rome EUR. M. Bagicalupo, U. Ratti. 1960–1962. External view (photo by the autor)

type joints, which are adjustable according to the principal axes, thus allowing the walls to not be affected by the movements of the supporting framework [9]. Furthermore the provision of expansion joints in the pillars and the application of special rubber blocks of predetermined deformability in the glazing complement the function of the bauer joint in absorbing the movements of the walls and their differential strains compared to the load-bearing framework of the building. The complexity of this technological system is contrasted by the extreme linearity of the facade geometric development, which is designed by a web of metal columns, suitably arranged to constitute a series of rectangles and squares within which glasses are housed, which are the elements that truly characterize the two main facades. As highlighted by observation of the detail drawings, the fixed span curtain wall system provides for a considerable reduction in the number and size of the profiles used in this building. Nevertheless, as the assembly stage takes place mainly on-site, some of the benefits due to industrialized production are clearly reduced.

3.2 ESSO Headquarters in Rome EUR

In the early Sixties, ESSO Standard Italian entrusts the architects Luigi Moretti and Vittorio Ballio Morpurgo with the architectural design of its new headquarters, to be constructed in the Rome EUR district. The built complex consists of two buildings which are symmetrical with respect to Via Cristoforo Colombo, thus constituting a real gate entrance to the district. The buildings are arranged in a T plan: a main longitudinal body (141 × 21 m) featuring seven floors above ground engages a four storey transverse body (49 × 23 m). Below the ground level there are three basement floors that cover a planimetric extension which is three times as much as the above ground floors. In this area garages are located, as well as utility rooms and a canteen (Fig. 10).

The plan is organized according to a modular network of 1.5 × 1.5 m as regards distribution of the internal space [10], while an element measuring 9 × 9 m defines

Fig. 10 ESSO Headquarters in Rome EUR. L. Moretti, V. Morpurgo. 1961–1965. Historical photo (Fortini/1969)

the modular structural rhythm. All elements of vertical communication are included in two central rectangular areas. The steel frame is developed with girders 9 m long (HE profiles, 50 cm high) and secondary cross beams that cover two 9 m spans and overhang 2 and 1.5 m on the main facades (the overhang is 3 m on the heads).

The secondary beams, whose maximum height is 21 cm, are spaced according to a pitch of 2.25 m and bear floors that are made of corrugated metal sheets, concrete and wire mesh, with a total height of 35 cm. The pillars are constituted by HE profiles whose maximum overall dimension is 36 × 34 cm, interrupted between one floor and another.

The joints connecting the structural elements are made by bolting, while on-site welding is used solely for fixing the corrugated sheets to the secondary beams, as well as the wire mesh panels to the metal sheets. Reinforced concrete is also used in this building, though limited to the basement floors and the lift towers.

In particular, the use of concrete for the construction of the lift towers is decided during the implementation phase, both for economic reasons and to optimize the construction site stages.

These reinforced concrete cores are delegated to absorb the horizontal actions impacting on the building during operation, with the consequent simplification of the joint between girders and pillars, which consequently can be set as a simple hinge. The main feature of the curtain-walls of the facades is certainly represented by the shading blades, made of aluminum coated with a special protective layer. These are blades of three different measures (0.75 × 2.50 m, 0.75 × 1.40 m, and 0.75 × 0.90 m), arranged vertically to the protection of bronze-colored glass panels [11].

3.3 The Palace of RAI Directorate General in Rome

The building occupies a lot in the Vittorie residential neighbourhood in Rome. The location, quite unusual for a building that is conceived mainly for managerial purposes, was chosen as it offered the company a number of benefits: the area was already owned, in the form of state concession, and it was close to the two major production centers located in Via Teulada and Via Asiago (Fig. 11). This premise, however, poses for designers Francesco Berarducci and Alessandro Fioroni the additional difficulty of designing a functional building under the constraint of legislation intended for a residential area. The authors propose a planimetric subdivision into four buildings of seven and eight floors, arranged in orthogonal directions and communicating with each other through narrow passages that are closed by windows.

The four blocks of the complex that are placed on the ground floor share a large rectangular plate in which the company's boardrooms, public spaces and a library are all located and arranged around a central court.

On the upper floors a sample plan is repeated, which is very flexible and adaptable in terms of distribution: the space can be used either as large halls or else, through

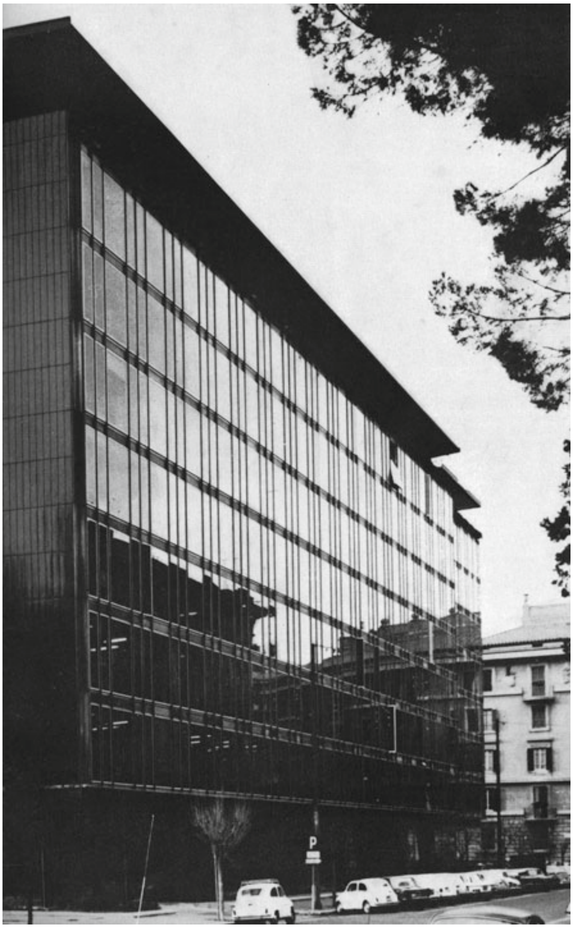

Fig. 11 The Palace of RAI Directorate General in Rome. F. Berarducci, A. Fioroni. 1961–65. Historical photo (Pedio/1968)

removable partitions, divided into individual offices. This character comes from the generality of the building program of the client, which had no specific and accurate indications [12]. The eighth floor (which is present in only three of the four building blocks) hosts a conference room and a restaurant.

The bearing structure is made of metal and is characterized by covering wider spans on the ground floor and the top floor, whereas the middle floors feature bays with shorter spans. The curtain wall is made of anodized aluminum frames of dark bronze color.

Each frame has a central part of double width compared to the two side parts: these three elements repeat all across the facade and determine its basic dimensional module.

The blind parts of the walls are covered with steel panels of dark red color, while the roofs are covered with sheets of copper. The use of metal materials of different colors in the facade cladding creates an effect of chromatic contrast that, together with the modularity of the vertical closing elements, contributes to the figurative characterization of the facades.

3.4 ENI Business Centre in San Donato Milanese

The building is built between 1956 and 1957, as part of the realization of the Metanopoli town. The architectural project is designed by architects Marcello Nizzoli and Mario Olivieri, whereas Leo Finzi and Giorgio Magenta deal with the structural design.

The complex consists of two buildings: a three-storey block services and the main building, which consists of a large 15-storey tower 55 m high. This is basically an office block, in whose ground floor some shops and exhibition spaces, as well as a post office are located [13].

The hexagon, a module whose side measures 12.5 m, is the basic shape from which, by repetition and juxtaposition, the maps of the building blocks are derived. The load-bearing structure is solved by means of a steel skeleton, set as a fixed-joint frame whose elements are connected by means of onsite welding (Fig. 12).

The foundations consist of isolated plinths on poles that are fixed 12–14 m deep. The pillars at the sides of the hexagons are connected by means of I-shaped girders that are 48 cm high, while IPN beams 30 cm high form the system of the secondary beams. Fire protection is achieved by coating beams with concrete and pillars with plaster on wire mesh.

The floors are made of brick and concrete cast onsite with no use of props, through the use of formwork hanging on the secondary beams. The facade system is constituted by vertical elements of tubular section, to which crossbeams are mounted with joints performed in such a way as to allow horizontal scrolling. Pillars are connected to the rear steel frame by means of brackets that provide for absorbing any possible inaccuracies of the main structure.

Although they are interrupted at each floor (that is every 3.4 m), pillars are mutually connected, so as to both assure the structural vertical continuity and, at the same time, provide for that possibility of movement that might be possibly needed in order to absorb any distortion. The need to facilitate the welding of nodes, the installation of vertical closing elements and the casting of concrete-made parts requires a careful study of the project execution phases [14].

4 Cable-Stayed Bridges and Experimentation. The Bridge on the Arno in the Area "l'Indiano" in Florence

As in other countries also in Italy, in the field of Civil Engineering and Architecture, steel structures represent a chance for innovation and steel bridges stand out as the

Fig. 12 ENI business centre in San Donato Milanese. M. Olivieri, L. Finzi, G. Magenta. 1956–57. Historical photo (Fortini/1959)

most representative realizations, where the research and the experimentation of new systems reflect, the complex, and effervescent panorama of the last fifty years.

In this context the authoritative figure of Fabrizio de Miranda, Neapolitan engineer and one of the major Italian scholars, emerges with his studies and realizations in Italy and abroad [15]. In the late Sixties of last century, he started an intense experimentation on long span cable-stayed bridges; the first, suggested in collaboration with F. Leonhardt, for the crossing of the Strait of Messina, anticipates the center of his latest production represented by the bridge on the Arno in the area “l’Indiano” in Florence (1969–1978), by the crossing of the rivers Paraná de las Palmas and Paraná

Fig. 13 The cable-stayed bridge over the Arno river. A. Montemagni, P. Sica, F. de Miranda. 1969–1978. Full view (Archive "Studio de Miranda Associati")

Guazú in Argentina (1970–1976), the bridge on the Rande Strait of Spain, near the city of Vigo (1973–1977) and many others.

Among these, the work that best represents, in Italy, the research field in question is, without doubt, the extraordinary crossing "Indian way" near Firenze, the first steel cable-stayed bridge realized in Italy (Fig. 13).

This work is the result of the brilliant synergy between the architects Adriano Montemagni and Paolo Sica and the engineers Fabrizio de Miranda and Vittorio Scalesse, who developed a project for Finsider, a metal construction company. This project won the competition called by the City of Firenze for the realization of a new viaduct on the Arno river in the area "l'Indiano" [16].

Sica and Montanari, starting from the analysis of the natural setting, proposed to cross the river with a single span.

A formal and constructive experimentation, where the design effort is, without any doubt, linked with the demand to exceed, by the architectural point of view, the pure and simple functional demands.

Starting, therefore, from a natural bond formed by the need to maintain the integrity of the perception of open space identified by the riverbed designers choose a solution that allows you to not invade the river with supports that otherwise would interfere with the width of flow of two rivers, the Arno and the Mugnone in their confluence. The place, therefore, is taken as an element to preserve and enhance the usability. In fact, the foot traffic is separated from vehicular dividing paths and bringing pedestrians at a lower level, also formally released from the driveway and put in direct contact with the river and the green.

From the outset, the project goals go beyond simple functional aspects to invest and co-ordinate systems and different areas, taking shape as a real urban zip.

The decision to place the crossing at the confluence of two rivers also presents interesting ideas in terms of environmental setting up a proper lookout along the Arno Valley. The technical choice, with widespread use of steel connects to various environmental, planning and linguistic reasons.

Fig. 14 The cable-stayed bridge over the Arno river. A. Montemagni, P. Sica, F. de Miranda. 1969–1978. Image during the realization (Archive "Studio de Miranda Associati")

From these design constraints, certainly very strong and determined, the unique technical solution is developed by Fabrizio de Miranda (who is in charge of the steel structural design) [17] which provides for a suspended span of 206 m, realized with one steel girder stayed on two antennas placed at a distance of about 189 m (Fig. 14).

The work, awarded in Helsinki in 1978 from the C.E.C.M., is designed to avoid excessive dimensions of the central span. The deck is obtained coupling together two trapezoidal box-girders, one for each carriageway. The stays are made of steel wires with a diameter of 7 mm, variable in number from 262 to 365 for an overall diameter, including the sleeves, which ranges from 18 to 26 cm [18] (Fig. 15).

The foundations of the main stacks are independent from those of the pylons, and consist of large diameter piles located at short distance from them.

Finally, the pylons, about 55 m off the plan of campaign, are made of welded plate, rectangular box-section of impressive size, and are stiffened by welding of half beams IPE, placed, some inside and others outside of the box (Fig. 16).

The "Indian way" bridge is the first example of a long span cable-stayed bridge anchored to the ground and still is one of the largest cable-stayed bridges in Italy (Fig. 17).

It demonstrates as the design process is not concluded with the correct application of a structural model, but also with the harmonization of the human work in an environment, both natural and historic, that will benefit the peculiar shape of the design, as well as by its structural strength and economic features.

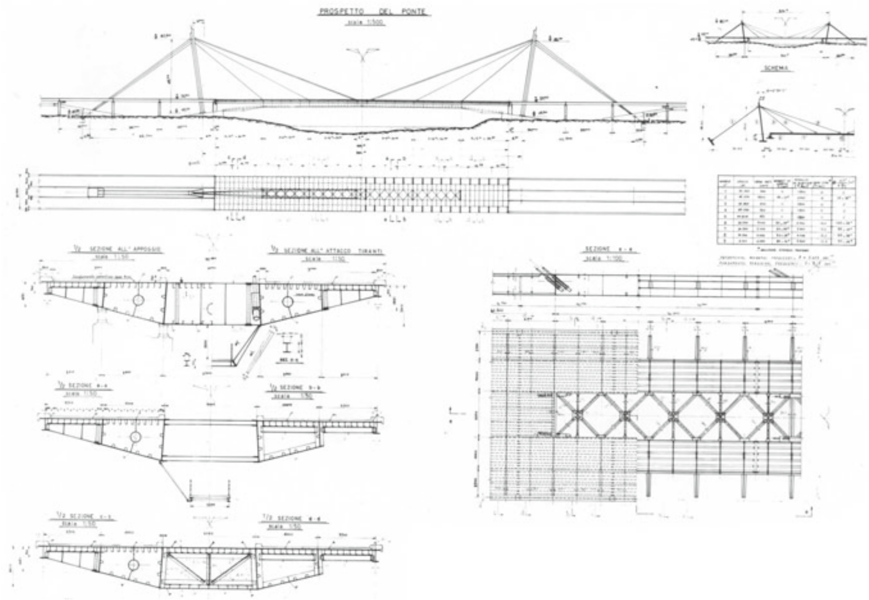

Fig. 15 The cable-stayed bridge over the Arno river. A. Montemagni, P. Sica, F. de Miranda. 1969–1978. Executive design (Archive “Studio de Miranda Associati”)

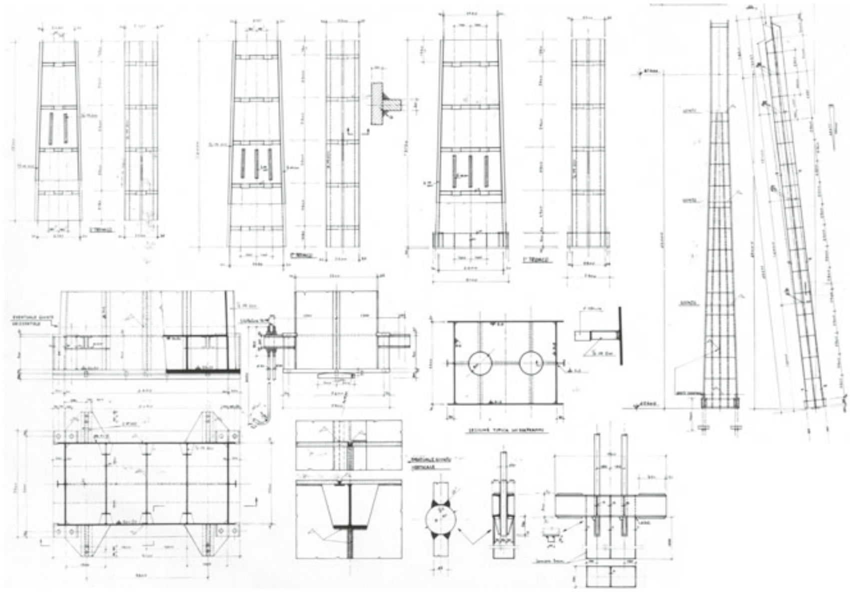

Fig. 16 The cable-stayed bridge over the Arno river. A. Montemagni, P. Sica, F. de Miranda. 1969–1978. Executive design (Archive “Studio de Miranda Associati”)

Fig. 17 The cable-stayed bridge over the Arno river. A. Montemagni, P. Sica, F. de Miranda. 1969–1978. Executive design (Archive "Studio de Miranda Associati")

5 Conclusions

Works in steel, such as those analyzed, highlight the singular relationship between the metal construction and the more general Italian building panorama, in a historical period particularly rich in experimentation.

Individual buildings whose critical analysis allows to frame a made in Italy path (but with marked references to the international context), full of experimentation often stimulated by the intense activity of authoritative designers such as Nervi, Covre, Finzi, Vitellozzi, de Miranda, etc.

Within this general framework, which undoubtedly constitutes one of the most important milestones in the history of Italian metal construction, emerges the singular attempt to industrialize the building sector, with particular reference to the steel material, on which from the sixties onwards, there is much debate and in parallel an intense activity of research and experimentation very interesting both at academic and professional and productive level.

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