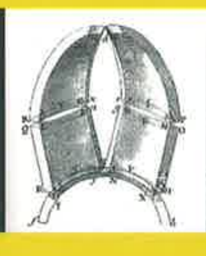
IIIRD INTERNATIONAL CONGRESS CONSTRUCTION HISTORY

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The Golden Age of "Italian Style" Engineering

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ABSTRACT: In Italy the postwar era (1945-1964) was a period of truly exceptional development in the sector of large structures, to a much greater extent than seems to have been recorded in collective memory. For Italian structural engineering, limited to substantial operative stagnation for decades but constantly involved in intense theoretical research, this was the moment to finally test lines of experimentation that had been developing for many years. This led to the appearance in the realization of projects of an original character: an "Italian Style" for structures.

In the history of Italian engineering, the postwar era was a period of truly exceptional development in the sector of large structures. First the reconstruction of destroyed bridges, then the development of the highway network, and later, on the wave of the economic miracle, the facilities for the Olympics in Rome, the pavilions for the celebrations of Turin 1961, the hangars for the new international airports: opportunities abounded for the building of large structural works. For Italian structural engineering, limited to substantial operative stagnation for decades but constantly involved in intense theoretical research, this was the moment to finally test lines of experimentation that had been developing for many years. This led to the appearance in the realization of those projects of an original character, both in the overall production and in certain works that can be seen as exemplary expressions: the large, very tight undulated vaults of Nervi, the stayed bridges of Riccardo Morandi, but also the more sober slab bridges of Silvano Zorzi, some extravagant ones by Sergio Musmeci, the roofings designed by Aldo Favini and Angelo Mangiarotti. Perhaps in a detailed reconstruction of events and a precise reinterpretation of works it will also be possible to shed tight on the paradox by which structural engineering ended up in such an advanced phase of experimentation precisely in a country suffering from a serious delay in technological progress. This should facilitate clarification of the reasons behind the subsequent rapid decline of structural output; and, indirectly, it may offer some explanation on the very timely issue of the extinction (not just in Italy) of the figure of the structural designer. In the meantime, due to the almost total lack of historical studies on the subject, we can only attempt an initial, rapid sketch of these situations (and problems).

THE CHALLENGE OF RECONSTRUCTION

In 1946, when rebuilding in the residential sector was having trouble getting started, in the field of infrastructures concrete operations were already underway: the reconstruction of 2600 bridges destroyed during the war.

What character should the reconstructed bridges have? Granting the hegemony of reinforced concrete, at first the focus went back to the arched bridge, a type already widespread in the period between the two World Wars. And while in Italy the Risorgimento bridge built over the Tiber in Rome by Hennebique in 1911, with its 100-meter span, remained the most daring example (even the version proposed in 1942 by Giulio Krall in the Africa bridge was more cautious), or the international scene there was a significant evolution of this structural solution, explored for both its structural and formal aspects in the extraordinary series of bridges by Maillart, and in spans well over 100 meters in spectacular realizations (La Caille, Plougastel, Sando).

In the postwar period the arched bridge interested scientists as well as Italian designers. This can be seen in a slender line of design research that unwinds inside the folds of the reconstruction, consisting in the return to a very particular version: the slender vault with reinforcing road surface. This is Maillart's expedient, through which the surface, with its great rigidity, absorbs the flex stress; because only the vault is compressed the entire structure functions roughly like an overturned suspension bridge. The elegance of this scheme fascinated theorists, and the "Maillart bridge" was included in what Edoardo Benvenuto defined as the "objects" of the science of construction (along with shelf of Galileo, the continuous beam of the Britannia Bridge...)(Benvenuto 1995, p. 136). It is no coincidence that the first works built in 1947 - the Ponte alle Mole on the Nera and the bridge on the Frigido, designed by Arrigo Care and Giorgio Giannelli - were presented by the theorist Giulio Ceradini (who had worked, in 1943-1946, in the federal laboratory of Zurich where the structural testing was done for the bridges of Maillart), and that the experimentation was resumed in the years toe come by certain researchers of the Neapolitan school, above all Vincenzo Franciosi (bridge on the Corace, bridge on the Vernotico and other works).
While the arch bridge in ordinary reinforced concrete was going through a second youth, another truly innovative line of experimentation appeared in the early years of the reconstruction: the line of prestressing, which was to become more widespread in the subsequent development. In 1949-1951 the first bridges in prestressed reinforced concrete were built, and we immediately find the works of the engineers who were to be the leading players in the development of this technique. Giuseppe Rinaldi designed the first bridge of this kind to be built, the one on the Samoggia, tested in March 1950; Morandi did the bridge on the Elsa, completed in September that same year; the younger Zorzi was responsible for the bridge for the plant on the Mucone in 1951.
But more than the experimental interest of the designers, what led to the immediate adoption of the application of prestressed concrete was the role of promotion and support played by the more theoretical wing of structural engineering. In this initial phase the school indicated the strategic lines and, above all, established a solid link of continuity with the research conducted in the period before the war.
The man who firmly held the long thread of theoretical research beginning in the first years of the century and leading, without interruption, to the development of prestressing in the postwar bridges was Gustavo Colonnetti, undoubtedly the most important exponent (with Arturo Danusso) of Italian engineering, carrying on the work of the Piedmont school that through Camillo Guidi goes back to the great theorists Menabrea and Castigliano.

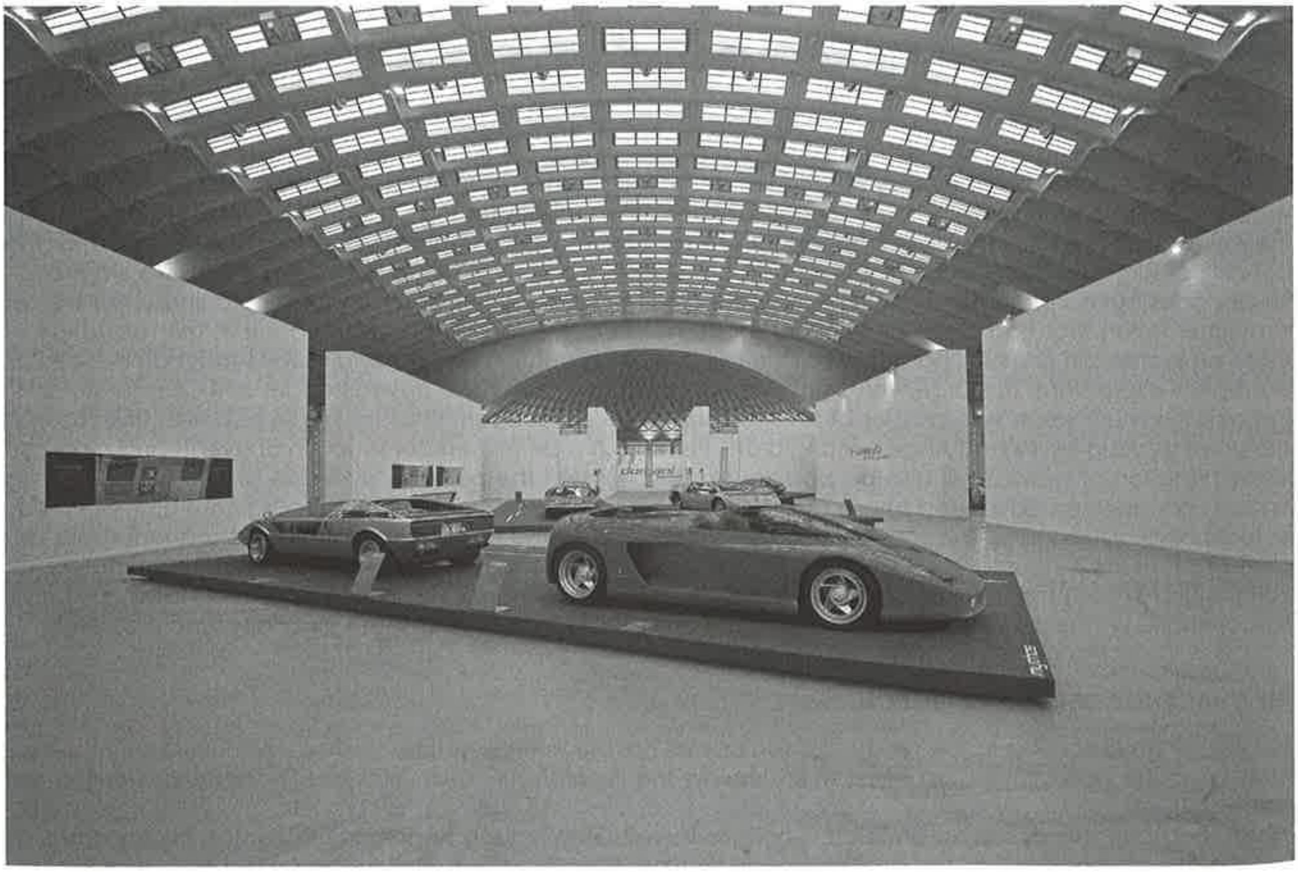

Figure 1: Salone B in Turin Exposition (P.L. Nervi, 1947-1948): interior view; (Photo Sergio Poretti, 2008)

Always firmly asserting the need to extend the investigation "beyond the classical theory of elasticity", in the plastic domain and in the presence of coactions, and convinced that the technique of prestressing (eliminating the problem of cracking of cement under tension) was an indispensable condition for progress with large structures in reinforced concrete, Colonnetti worked on the one hand to spread knowledge of the experiences of prestressing conducted abroad in the 1930s (Freyssinet, Dischinger, Finsterwalder, Hoyer...), while on the other hand he made original contributions whose importance was fully recognized on an international level: many theoretical works on the static properties of elastoplastic bodies, studies on states of induced coactions, patents for the "beams with preliminary stressing of the reinforcements" deposited in 1939.

His exile in Switzerland starting in September 1943 offered a moment of connection, instead of interruption, between the prewar research and the postwar reconstruction effort. The Italian university internment camp he organized at the school of engineering of Lausanne, where he was named rector, became an industrious research center, with the presence from 1943 to 1945, as professors, assistants or students, of many of the engineers who were later to go forward with the Italian development of prestressing: including the exiles Franco Levi. Favini, Zorzi.

Called back to Rome in December 1944 to assume the position of President of the CNR, Colonnetti became one of the great directors of the reconstruction. And in fact no time was wasted in proceeding with the development of prestressed reinforced concrete. In July 1945, under the aegis of the CNR, at the Turin Polytechnic, the "Research center on states of elastic coaction" was founded, under the direction of Levi, and Zorzi was also called in. The work of education intensified: in the conference on reinforced concrete of October 1946 in Turin the theory and practice of prestressing were extensively discussed; the following year the manuals by Carlo Cestelli Guidi and Levi, with Giulio Pizzetti were published. Also in 1947, a decree was issued regulating the use of prestressed structures. In 1949 the Associazione Nazionale Italiana del Cemento Armato Precompresso was founded.

This is the phase in which the combined action of theorists and designers achieved what has been defined as a "genetic mutation of reinforced concrete". In perfect similarity to what happened during the advent of ordinary reinforced concrete, the most important foreign patents for the stretching and anchoring of cables were imported, those of Freyssinet, Magnel, BBRV, while at the same time work was done in the field for a number of Italian patents, already on the market in 1951: the "R" patent of Rinaldi, the patents perfected in successive phases by Morandi, those of Turazza, Favini and others.

Halfway through the 1950s new territory was opened up for the development of prestressed reinforced concrete by another major initiative: the Romita plan for the construction of the highway network. Launched in 1956 with the construction of the Autostrada del Sole (punctually opened for traffic in 1964), the plan continued with the Salerno-Reggio Calabria highway and was then extended to the entire national territory. For structural engineering such a vast program, calling for the construction of a huge number of bridges and viaducts, was an extraordinary motor: comparable to what happened with the Ina Casa plan for architecture.

In the first phase, especially in the mountainous highway segment between Florence and Bologna built in 1954-1960, some very beautiful arch bridges were built with ordinary reinforced concrete, like the bridge on the Merrizzano and the Gambellato viaduct of Krall, the Poggettone and Pecora Vecchia viaducts of Carè and Giannelli, and the viaduct on the Aglio by Guido Oberti, whose twin arches with a span of 164 meters make it one of the most significant works of the entire infrastructure.

But in the implementation of the plan highway bridges and viaducts wound up becoming above all a great testing ground for the technique of prestressed reinforced concrete. This orientation was encouraged by the situation, beginning in 1957, of the crossing of the Po by part of the Autostrada del Sole, near Piacenza.

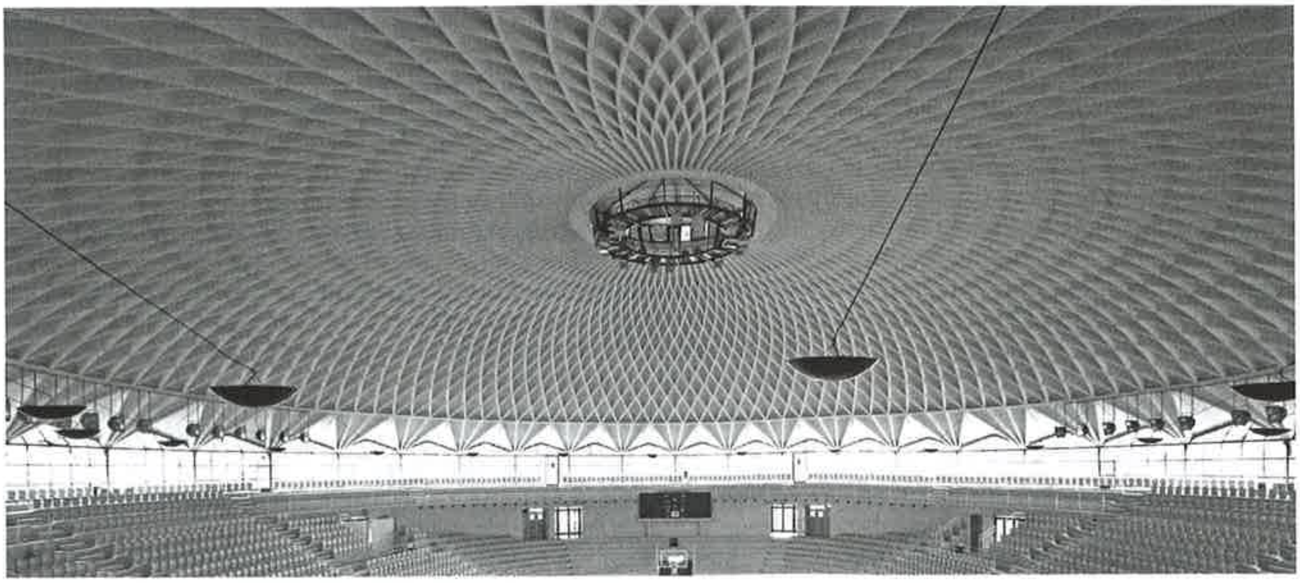

Figure 2: Little Sport Palace in Rome (P.L. Nervi, 1957): interior view; (Photo Sergio Poretti, 2007)

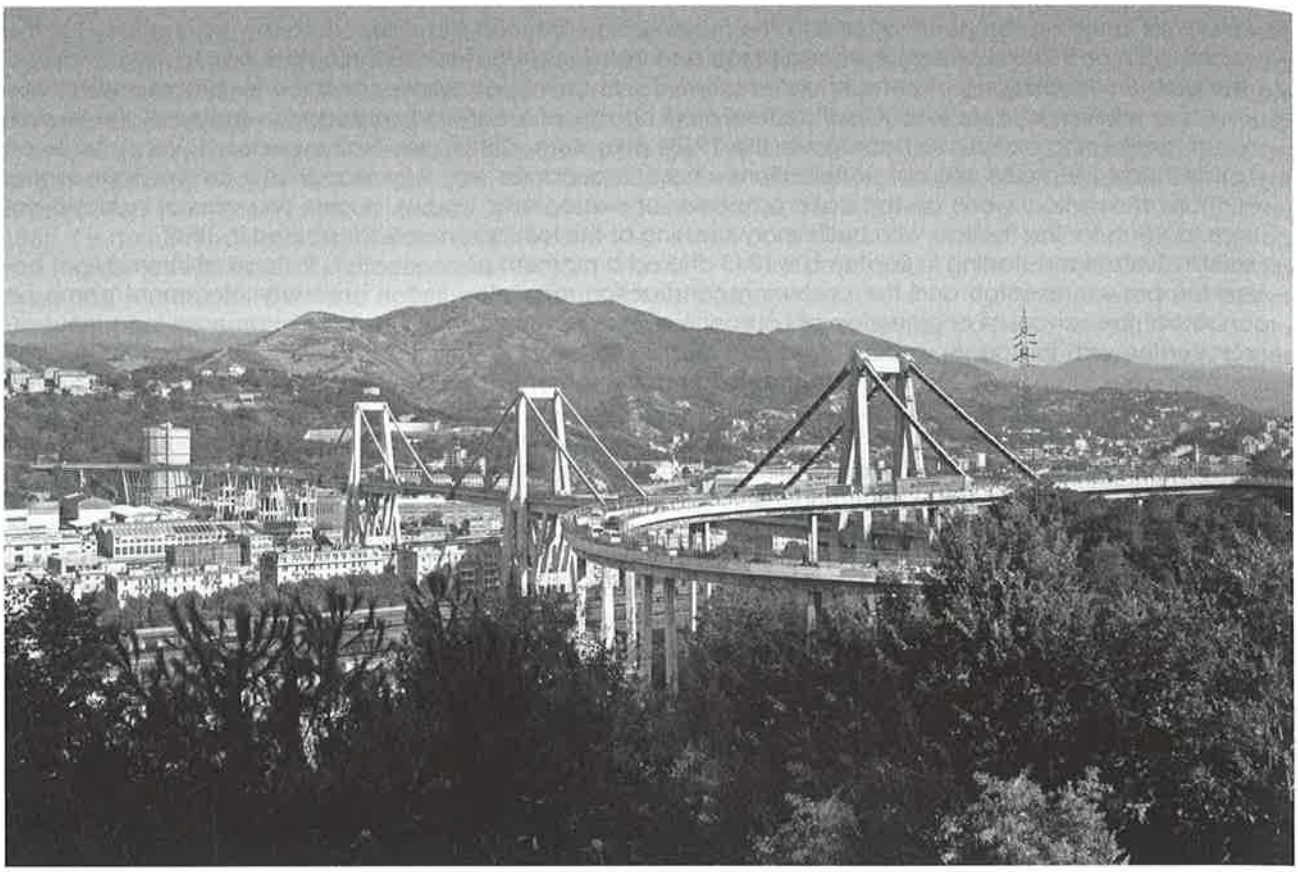

Figure 3: Bridge over the Polcevera river in Genoa (R. Morandi, 1960-1964); (Photo Sergio Poretti, 2008)

The bridge proposed by Zorzi - 16 prestressed beam units, simply rested on the supports - clearly demonstrated the great versatility and flexibility of the linear isostatic scheme, especially in cases where the land was not particularly solid, with the possibility of differentiated settling.
Later, as the intrinsic potential of the beam solution was being explored, research also moved toward more detailed structural schemes. Zorzi himself, in the two bridges on the Arno at Levane and Incisa (1962-1963), developed mixed systems, with an arch-portal in the central, larger span, to support a surface of prefabricated prestressed beams. Morandi (and this is the most evident innovation), in the stayed bridges built on the Polcevera in Genoa (1960-1964) and on the bend in the Tiber at Rome (1963), demonstrated that the prestressing technique made it possible to go well beyond spans of 100 meters, which had been seen as the limit in the construction of those along the Autostrada del Sole.
But the experimentation extended beyond the theme of structure. The intense construction program also became the ideal laboratory for evolution in the way bridges were built. And while in the initial phase the image of the highway worksite was synonymous with dense castles of scaffolding pipes by Dalmine Innocenti (and the rapid movement of the monumental centring to make the twin arch of the viaduct on the Aglio became a spectacular newsreel event), after the Autostrada del Sole construction systems were definitively developed that avoided the need for costly scaffolding. This was substantially a rationalization of the worksite, increasing the use of on site prefabrication of parts, but above all imposing increasingly frequent use of the "equipped mobile worksite", making it possible to "draw" the poured concrete both vertically and horizontally, to make piers with climbing box-moulds and bridge surfaces with sliding overhanging box-moulds.
This worksite evolution leads to the viaducts of the last generation, still characterized by simple, essential lines, but made more monumental by the very tall piers and large spans. The spans were made possible, in some cases, starting in the mid-1960s, by inserting steel parts in the prestressed structures. Thus the Italia viaduct on the Lao River (1964-1970), the highest in Europe with its 255-meter piers, and the viaduct on the Sfalassà torrent (1968-1972), which has the widest span in the 376 meters of its metal portal, became opportunities for the collaboration of metal construction specialists like Fabrizio De Miranda and Gino Covre.

STRUCTURES "ITALIAN STYLE"

Thus far we have discussed the evolution of bridges in the context of the reconstruction and highway plans. The initial orientation, and above all the choice of prestressing, was decisively influenced, as we have seen, by the Piedmont school of engineering, in close continuity with the theoretical work of the 1930s.

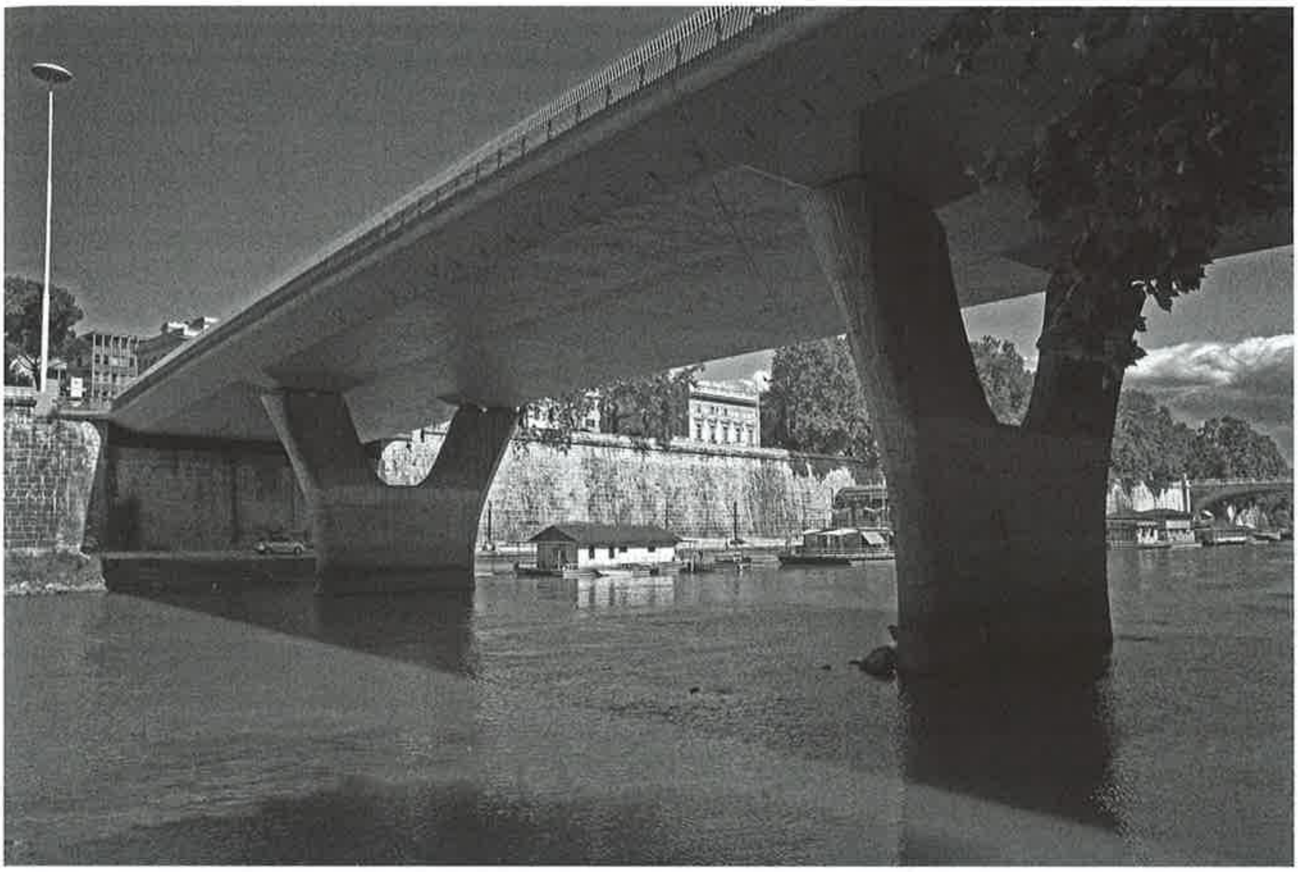

Figure 4: Bridge over the Tevere river in Roma; (S. Zorzi, L. Moretti, 1963-76), (Photo Sergio Poretti, 2007)

But the subsequent developments, leading to the tall viaducts of the last generation, were governed above all by economic and productive factors.

In the meantime, however, the range of structural works in Italy expanded to include an extraordinarily varied field. The theme of the bridge offered other stimulating design opportunities: when it is inserted in the city, for example, leading to works like the Amerigo Vespucci bridge on the Arno by Morandi (1954-1955), or the design by Cestelli Guidi for the Garibaldi bridge in Rome (1956), and the bridge of the subway line over the Tiber by Zorzi with Luigi Moretti (1963-1972); or when it stimulates an eccentric personality like Musmeci to apply his original procedure based on the mathematical determination of the "minimum surface", reaching the paradoxical, evocative result of the bridge on the Basento (1967-1975). And then there is the other classic theme of structural engineering, the large roof: a theme where Nervi, who built very few bridges, had a chance to exploit all the potential of his reinvention of reinforced concrete, known as "ferrocemento", constructing works that are certainly no less important and original than the prestressed concrete bridges.

With this variety, the international renown of Italian engineering soon spread. At the exhibition "Twentieth Century Engineering" at the Museum of Modern Art of New York in 1964, representing a succinct worldwide overview, there were many Italian works, including the already famous masterpieces by Nervi and Morandi, but also works by less familiar names, including many highway bridges. This success couldn't help but influence architectural experimentation in Italy as well. While a widespread current of structural expressionism was grafted, as a basic tone, onto the great linguistic matrix of realism that characterized Italian architecture as a whole in those years, the collaboration between engineers and architects produced some of the most typical works of the period, like the Pirelli tower (Gio Ponti with Nervi and Danusso), the Torre Velasca (the group BBPR, again with Danusso), the Palazzo della Regione of Trent (Adalberto Libera with Musmeci).

So what are the basic elements of the clear identity taken on by Italian structural engineering in these situations? Even the most diverse works share a common trait: the contrast between the advanced stage of structural theory applied in calculation and the artisan character of the reinforced concrete worksite; a character that did not substantially change as the techniques evolved. This is not a contradiction: actually, the development of theoretical research in Italy (constantly aligned with European levels) has always focused on tools of calculation that would correspond more closely, with respect to classical theory, to the structural behavior of an anisotropic, dishomogeneous material like reinforced concrete. Tracing back through the bridges it is clear that the action of Colonnetti and later that of Levi played a concrete role in this direction, contributing decisively to the development of prestressing. If we trace back along the experimental line that led Nervi to his unprecedented roofings in "ferrocemento", we find that an equally decisive role was played by Danusso with his studies on the behavior of reinforced

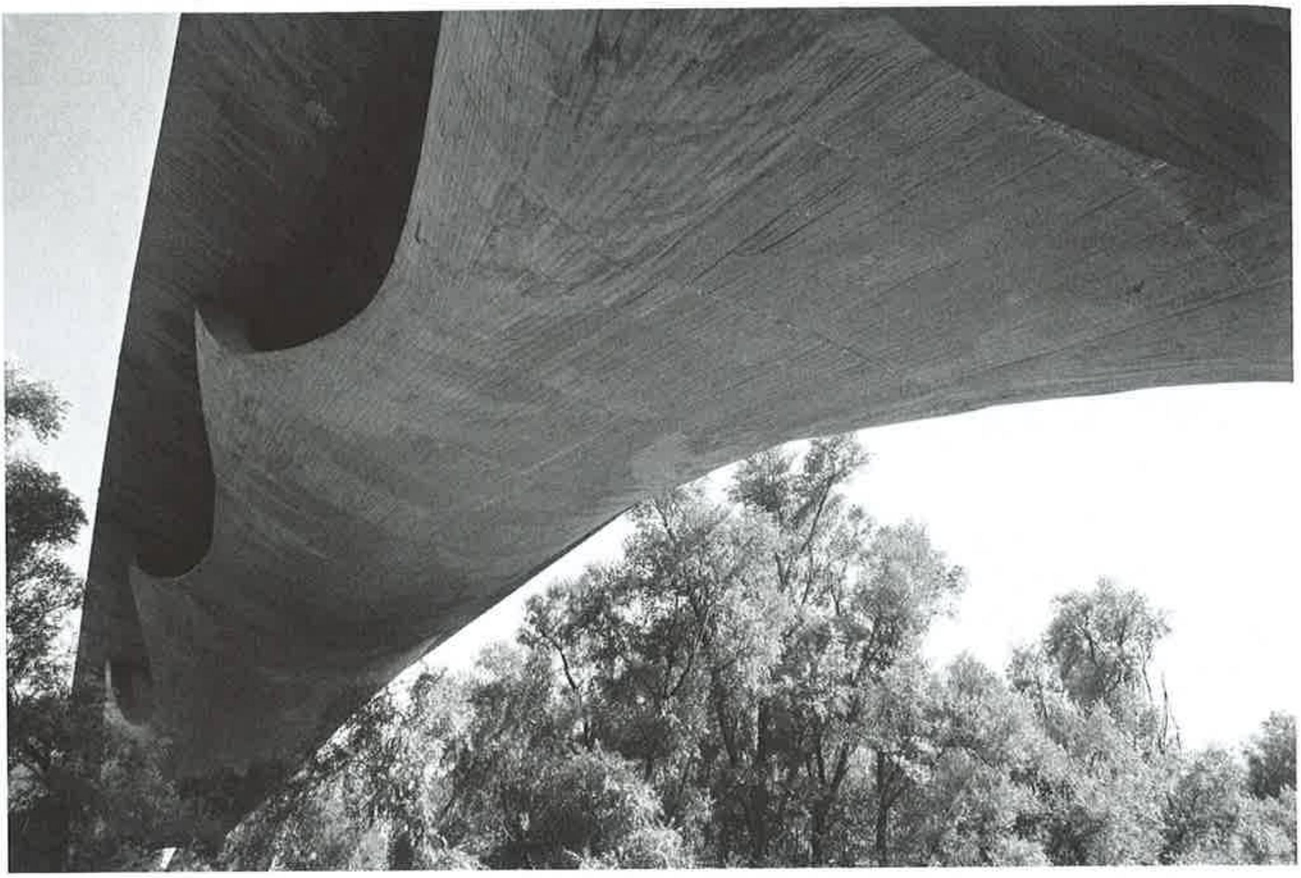

Figure 5: Bridge over the Basento river; (S. Musmeci, 1967-1975), (Photo Sergio Poretti, 2007)

concrete in the plastic phase and the breaking phase, and above all with his insistent urging of complex, hyperstatic structures using first intuition and then trials on structural models in the phases of calculation and testing, for which he organized the Ismes laboratory in Bergamo.

The dualism of science and craftsmanship, therefore, reflects the historical conditions in which Italian engineering was operating. But how is this basic trait reflected in the language of a design, in the characteristics of an individual work?

In Morandi's bridges, from this viewpoint, we can interpret prestressing as an evolved stage of reinforced masonry. The originality of the work lies not in the structural scheme, always familiar, always already used by others - it is the balanced beam of the overpass on the Olimpica in Rome, or the more characteristic stayed system of Polcevera - but in the realization of the scheme in prestressed reinforced concrete rather than steel, as in the original versions. This transposition, and the corresponding need to reinvent the construction procedure, produce the absolutely original character of his structures. Their lightness and elegance are amazing, not so much as compared to the much more slender metal structures, but as forms shaped in concrete and therefore essential belonging to the realm of masonry. With the breaking down into linear elements (struts, tie-rods, beams ...), made clear by leaving the joints visible, Morandi's structure assumes, it is true, the nature of a mechanical device, but it does not sacrifice its character as plastic form, poured on site, evoking all the crafted quality of masonry. In short, prestressing as a challenge to steel, an ideal renewal of the old Antonellian illusion of countering reticular structures in cast iron with the system of reinforced masonry.

In Zorzi's bridges, on the other hand, the prestressing technique is used to rediscover the simplicity of the structural beam, its formal economy. The intrinsic anti-economic flexing of reinforced concrete is conquered from within, by the inner mechanism of cables under tension. Thus the bridge can be reduced or returned to its essential parts: the pier and the surface. The modernity of the image, much more sober than the works of Morandi or Musmeci, is thus entrusted not only to the surprising slenderness, but also to the appropriate design of the single piece. A structural minimalism whose most typical result is perhaps the elegant portal of the bridge at Pinzano, where the caisson beam that tapers toward the key joint seems to effortlessly bridge a span of 163 meters.

The central importance of the design of the reinforced concrete component as a finished, complete object (though part of a structure) reveals, more in general, another particular characteristic of Italian engineering: the special affinity between structural works and Italian design, which was going through a period of international acclaim in those years. The search for historical clues regarding this relationship takes us back into exile, in Switzerland. In the internment camp at Lausanne, in fact, the engineering students of Colonnetti found

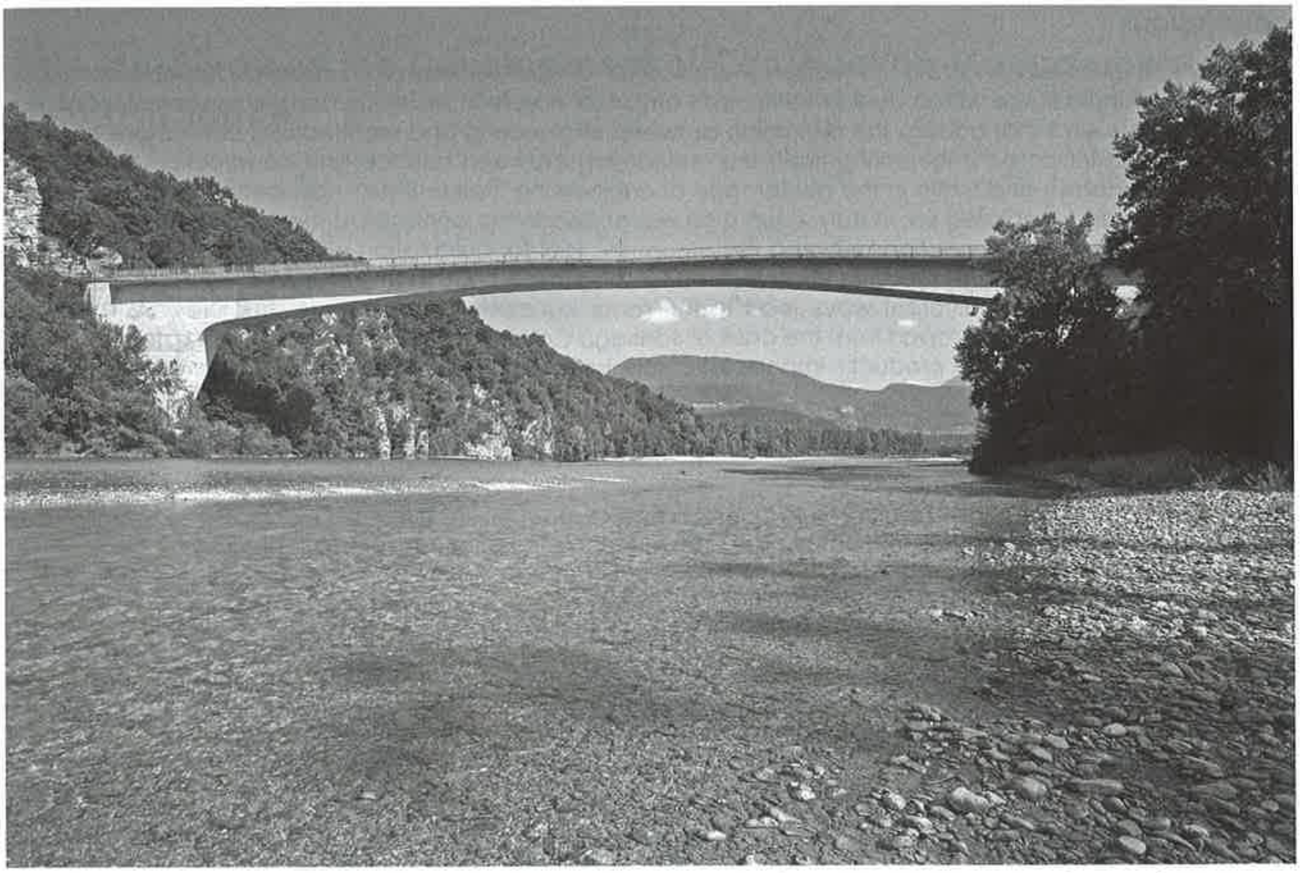

Figure 6: Bridge over the Tagliamento River at Pinzano; (S. Zorzi, 1968-1969) (Photo Sergio Poretti, 2008)

themselves in close contact for months with Ernesto Nathan Rogers and Luigi Zuccoli, as well as young designers of the Milanese school like Alberto Rosselli, Angelo Mangiarotti, Vico Magistretti, Maurizio Mazzocchi. Together they worked on the «Bollettino», published in Vevey and Winterthur from June 1944 to May 1945. reporting on their activities in the Research Center. This can be seen as the prologue to the magazine «Cantieri» they founded when they returned to Italy. This connection would be of purely biographical interest were it not confirmed by subsequent, fertile collaborations, leading to works like the Brion Vega factory at Casella d'Asolo (1964) by Zorzi and Marco Zanuso, the church of Baranzate (1956) and many others. After all, the table and the bridge share a centrality of the structural aspect in their morphology, as well as one of the deepest roots of Italian Style. The conservation of the crafted nature we noticed in even the most sophisticated reinforced concrete bridges can also be seen in the production of small industrial firms. Due to a historical anachronism that may have been completely accidental, the typical product Made in Italy of the years of the economic boom seems to finally give concrete form to the ideal of the first, heroic phase of modernism: to keep intact, in the industrialized object (or, more in general, the scientifically rationalized object) the empirical value of craftsmanship: in the LB7 bookcase by Franco Albini or in the viaduct on the Fiumarella by Morandi, the Lady armchair by Zanuso or the footbridge for Italcementi by Zorzi.

At the end of the 1960s, with the attempts to emerge from the chronic technology backlag in order to finally proceed with industrialization, the golden age of Italian engineering came to a close. The conclusion of the era of great Italian Style structures, as often happens in the history of architecture, was marked by a competition that led to no results: the ideas competition for the bridging of the Straits of Messina in 1969. There is no doubt that in the projects selected (especially the two single-span suspension bridges by Musmeci and Nervi) any trace of that originality found in the works of the 1950s and 1960s has vanished. The fact that the enormous span eliminates the possibility of using reinforced concrete (prestressed or otherwise) demonstrates how the decline of Italian engineering is connected to a more general crisis, after the 1960s, of the large reinforced concrete structures themselves.

But the total disappearance of signature works in the following decades has a more general import, connected to a more profound transformation in the sector of structural engineering, which after progressive rarefaction seems to lead to the extinction of the classic figure of the designer of large structures. A figure, after all, that has always been rare: even in the masonry tradition very few architects were capable of constructing large cupolas. And when, through application of mechanics to construction, the designer of large structures became a specialist, clearly different from the architect, he still remained an uncommon figure, even among engineers. Over the last two centuries only a few, isolated personalities have been able to utilize the potential of scientific theory in the more empirical phases of design (as well as in rigorous analytical testing): Telford, Eiffel, Maillart, Torroja, Candela, Nervi, Morandi.

CONCLUSIONS

Recently further developments in the modes of application of science seem to completely impede control on the part of a single figure with a dual scientific and empirical nature in structural design. As specialization advances (not the kind that caused the distinction between engineering and architecture, but a more capillary variety that has infiltrated engineering itself) the relationship between science and construction technique - which was so intense and fertile in the golden age of engineering "Italian Style"- now becomes, in the best of cases, indirect and mediated (or, in Italy, even a source of academic conflict). At the same time. with the advent of computers the connection between the automatic tool for calculation and the physical-mechanical performance of the structure becomes invisible even for the professionals themselves.

Lines of evolution that, in different ways, lead to the same conclusion: today large structures are rarely the work of an individual author (apart from the case of Santiago Calatrava, which calls for a separate discussion); more and more often it is the product – impeccable, sophisticated but impersonal - of a multinational team of varied specialists.

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