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Architects and Engineers

Modes of Cooperation in the Interwar Period, 1919–1939

Edited by Roland May

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Kulturelle und technische Werte historischer Bauten
Hg. von Klaus Rheidt und Werner Lorenz

Band 7

Roland May (ed.)

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Birkhäuser · Basel

This publication is funded by the German Research Foundation (DFG) in the framework of the Research Training Group 1913 «Cultural and Technological Significance of Historic Buildings», Brandenburg University of Technology Cottbus–Senftenberg; Leibniz Institute for Research on Society and Space, Erkner; Department of Archaeology at Humboldt University of Berlin.

RTG 1913
Research Training Group
Cultural and Technological Significance of Historic Buildings
DFG

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Copyediting: William Hatherell, Jasmine Rice
Layout, typesetting and editing: Sophia Hörmannsdorfer
Cover design: Jörg Denkinger
Printing and binding: Beltz Grafische Betriebe GmbH, Bad Langensalza
Cover illustration: Zeche Zollverein, Essen, main entrance, 2011 (photo by Guido Radig [CC BY 3.0, https://creativecommons.org/licenses/by/3.0/deed.en], adapted by the editor).

Library of Congress Control Number: 2022942558

Bibliographic information published by the German National Library
The German National Library lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data is available on the Internet at http://dnb.dnb.de.

The book is also available as an ebook (ISBN PDF 978-3-0356-2326-0).

ISBN 978-3-0356-2325-3

P.O. Box 44, 4009 Basel, Switzerland
Part of Walter de Gruyter GmbH, Berlin/Boston

9 8 7 6 5 4 3 2 1 www.birkhauser.com

Contents

Italian Modernisms
Structure and Architecture in the Interwar Period

Tullia Iori, Sergio Poretti †

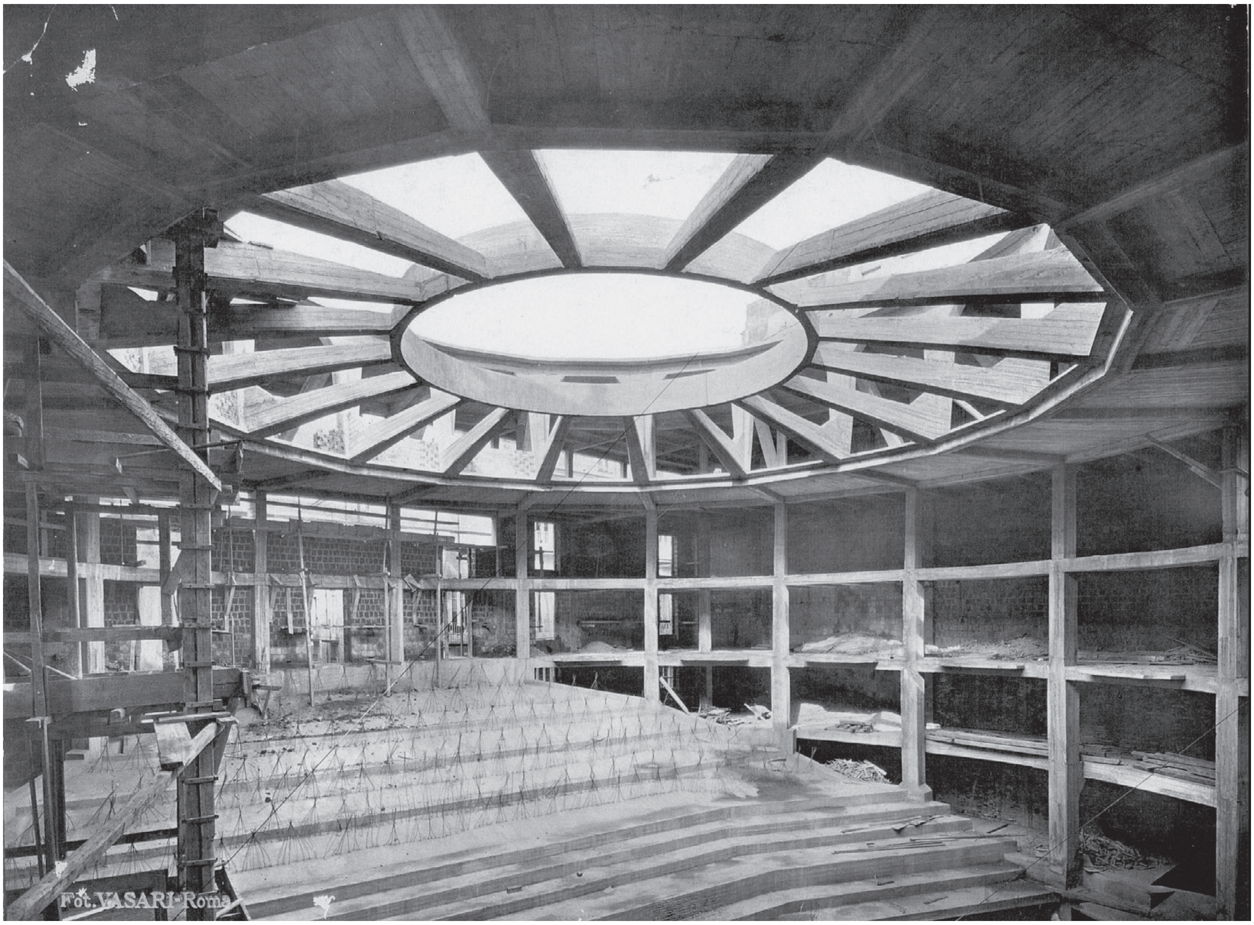
Towards the end of the 19th century the development of reinforced concrete helped to replace the tectonics of masonry with the tectonics of the frame. Italy was no exception to this trend, and this new technique spread very rapidly all over the country. With a difference, however: instead of simply replacing masonry, reinforced concrete was gradually introduced into the construction and used together with masonry, creating a sort of ‹mixed construction›. This was due to the continuity that characterised modernisation in Italy in general and the construction industry in particular, given that most worksites were small and artisanal: reinforced concrete, made on site, could be inserted without causing too much havoc. This also explains the rather unusual fact that the advent of reinforced concrete coincided with the sudden and almost total disappearance of steel frames.

In the interwar years, when Italian architecture turned from an eclectic to a modern language, the reinforced concrete structure of buildings was mostly ‹hidden›. The renewal of architectural language was only indirectly influenced by the new structure, and the modern language maintained a masonry nature. In parallel, however, the figurative strategies used to hide the structure gave rise to a modernist trend where the structure became the key feature of the representation. A repertoire of visionary structures, rarely built, enriched the debate about the relationship between architecture and engineering. In this panorama of hidden structures and structural visions, the works of Pier Luigi Nervi were outstanding, while remaining fully permeated by the same Italian spirit.[1]

Hidden Structures

While their façades remained often in a rather traditional style, the works built during this period masked both regular frameworks and courageous structural solutions. Moreover, all branches of Italian engineering had developed enormously during the 19th century, and in the early 20th century they focused collectively on increasing knowledge about the behaviour of large reinforced concrete structures. Given the difficulty of applying classical elastic theory due to the anisotropy of reinforced concrete and the problems caused by the different nature of its components (first and foremost cracking of the cement in the tension zone), studies immediately began on its plastic behaviour, while research focused on the phenomena of ultimate strength and the effects of the states of co-action. From the very start research moved in two directions: on the one hand supported by contributions by Gustavo Colonnetti (1886–1968), and on the other by Arturo Danusso (1880–1968); although the paths of these two researchers diverged, their work led slowly but surely to the construction of much of Italy's superb post-war building works.[2]

Given this context, it is not surprising that very sophisticated structures were hidden inside architectures still influenced by eclectic styles: for example, the roof of the Banchini Theatre in Prato (1923–25) and the internal structure of the Cinema Augusteo in Naples (1926–29, fig. 1), which were both designed by Pier Luigi Nervi (1891–1979)[3] as a young engineer (and in general the large structures



1 Augusteo Theater, Naples, 1924–29, under construction. A. Foschini (arch.), P. L. Nervi (eng.).

2 The Academy of Physical Education, Roma, 1928–32, the gym under construction. E. Del Debbio (arch.), with A. Giannelli (eng.).

for the roofs and galleries of cinema halls built during that period). Another example is the roof of the gymnasium of Enrico Del Debbio's (1891–1973) Roman Academy of Physical Education (1928–32, fig. 2). The structural design invented for the roof by the engineer Aristide Giannelli (1888–1970) was a series of eight Vierendeel beams joined together by an edge beam to create a plate that was so rigid it could simply rest on slender columns; this made it possible to create large openings in the walls, emphasised by a completely independent system of white Carrara marble architraves, frames and tympana. The structure remained well hidden by a ‹fake› ceiling with a criss-cross pattern.[4]

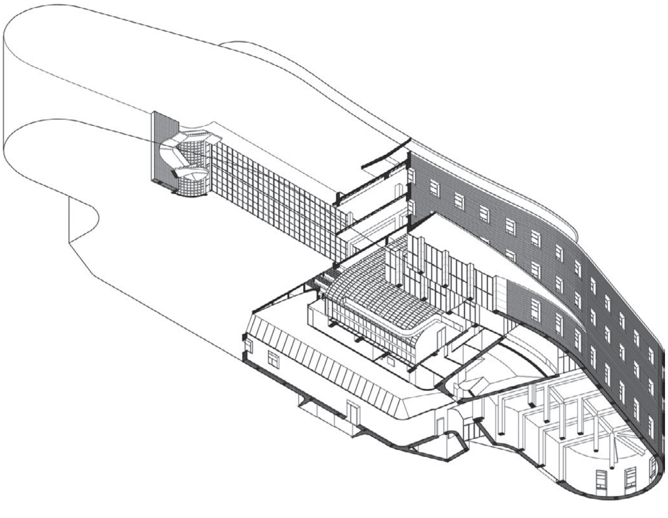
In the eclectic modernisms of the 1910s and 20s, ‹hidden structures› were the result of the fact that architects and engineers worked separately; the architect was responsible for the formal design, which still depended completely on masonry, while the engineer was called on (often by the construction company) after the design had been formalised and asked to solve structural problems.

In the first half of the 1930s, structure played a very different role in modernist experiments. In fact, reinforced concrete structures were considered one of the tools that could be used to overcome historicism in an attempt to achieve a truly modern architecture. This was the key topic of the *Gruppo 7*, a group of Italian architects formed in 1926 by Giuseppe Terragni (1904–43), Giuseppe Pagano (1896–1945) and others. During the first exhibition by the *Movimento Italiano per l'Architettura Razionale* (*MIAR*), to symbolise modernity, the group's manifesto (fig. 3) used a concrete pillar with a visible reinforcement.[5]

3 Manifesto of the first exhibition by the MIAR (Italian Movement for Rational Architecture), 1928.

At the same time, however, continuity with traditional construction had to be maintained, for several reasons: on the one hand, although the construction policy of the fascist regime supported the hegemony of reinforced concrete (and subsequent exclusion of steel frame constructions), it also reiterated the need to maintain the artisanal nature of the worksite with low mechanisation and a large unskilled workforce; on the other, it was the modern architects themselves who insisted that continuity with the past be the distinctive trait of Italian modernism. The figurative nature of architecture was another important element. The disputes between traditionalists and modernists remained within the boundaries of neo-idealism; it was the younger architects who were more forceful in reiterating the fact that architecture was an art and in refusing to ‹downgrade› it to a social science – which instead happened in the modern movement.

This complex web of innovative goals and the desire to maintain masonry as well as the figurative nature of architecture were behind the most important experiments undertaken in the public works entrusted to young architects between 1931 and 1935. It was the designers themselves who explored complex and novel static solutions. However, the structural potential of the elastic frame, especially the chance to create big overhangs, did not lead to the ‹disintegration of the masonry envelope› (and as a result to a novel concept of form and space) which characterised both European rationalism and American organic architecture, albeit very differently; instead, in Italy, the frame led to extremely limited and indirect examples of modernity, part of an architectural configuration which overall maintained its masonry nature.

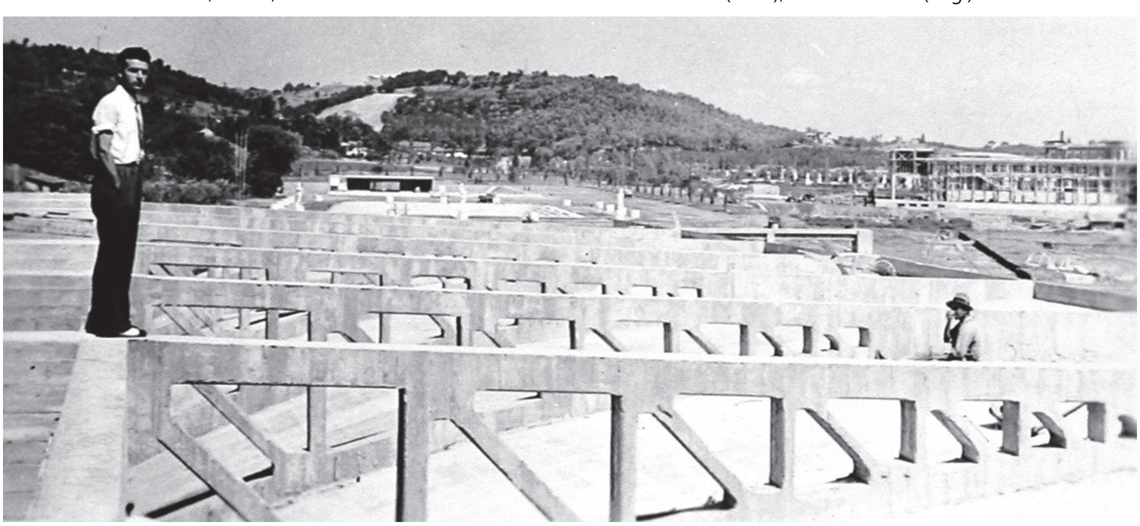


4 The Post Office in piazza Bologna, Rome, 1932–35. M. Ridolfi (arch.), with A. Giannelli (eng.), drawing by G. Capurso.

In the Post Office in Bologna Square in Rome (1932–35, fig. 4) by Mario Ridolfi (1904–84) and Giannelli, for example, the overall image is defined by the external concave/convex wall around the building. The bold structure of the building's middle part is not directly visible. The eight frames in the public hall span almost 10 m, and they continue over the postmen's hall with 10 m-long cantilever beams, tapered at the intrados based on a parabolic curve. In addition, on the two upper floors, the columns along the rear façade are not aligned to the ground floor columns. The architectural repercussions of such a sophisticated structural solution can be found only in some ‹minor› traits: the continuous sloping ribbon window in the postmen's hall, lighting from above on the back of the public hall, and the curtain wall in the centre of the rear façade.[6]

Another no less important example in Rome is the House of Arms (1933–36) by Luigi Moretti (1907–73). From outside this fencing hall looks like a compact masonry block completely covered with Carrara marble slabs; a massive wall is above the horizontal windows. The interior, which is meant to look like a cave dug out of the block, is lighted from above. This enhances the continuity between the walls and the ceiling. In fact, the abstract forms hide an extremely bold reinforced concrete structure (fig. 5), dimensioned by Giorgio Baroni (1907–68). It is made up of two huge staggered cantilevers with completely separate foundations: a very

5 The House of Arms, Rome, 1933–36: the roof under construction. L. Moretti (arch.), with G. Baroni (eng.).



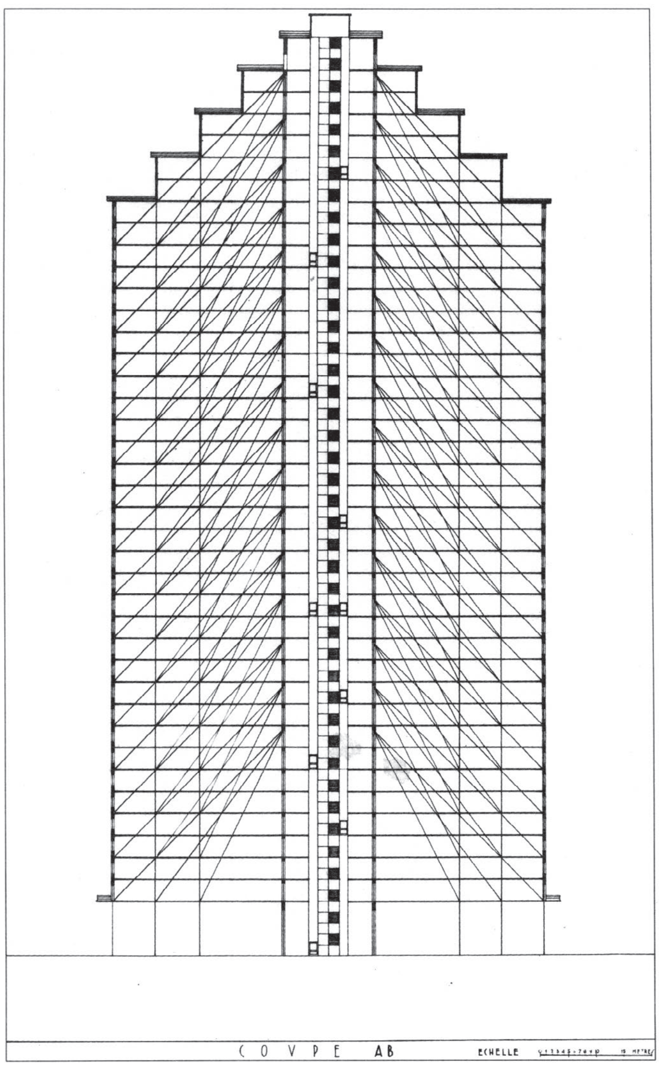
6 Palazzo della Civiltà Italiana, Rome, 1937–43. G. Guerrini, E. Lapadula, M. Romano (archs.), photo from 2017.

sophisticated solution that Moretti had to justify as necessary because a sewer passed right through the centre of the building.[7]

During the ‹autarky period› the role of structure in architecture changed yet again. In 1935 Italy invaded Ethiopia and the League of Nations imposed heavy sanctions: no state was allowed to sell strategic materials to Italy, particularly metals. The fascist regime promptly declared autarky, or economic self-sufficiency, a national goal. The building strategy included in autarky was to increase continuity with tradition and forbid the use of reinforced concrete, which was seen as not being ‹Italian› enough. Even though this directive was often ignored, masonry in architecture was now forced into a more emphatic appearance. In the ‹Littorio style› of this period (a 20th-century variation of the ubiquitous eclectic historicism in urban centres), this approach meant a return to a more traditionalist version of mixed construction – relatively modest spans, more solids than voids, and the absence of thin marble cladding. Peculiar was the situation in the case of monumental works, which were demanded by the fascist regime to have a particularly pronounced rhetoric of autarky, such as the district in Rome built for the planned 1942 World's Fair (E42). Here, paradoxically, the anti-autarkic structure of reinforced concrete served as the hidden scaffolding of a stage set, which intended to make the masonry construction appear more grandiose and to highlight the link with ancient Rome.

One example is the grand loggia in the Civiltà Italiana Palace (1938–43 and 1951–53, fig. 6). Its vaulted system, made with travertine blocks, is authentic and the arches are not fake. But the loggia looks like a colossal masonry structure thanks to a hidden reinforced-concrete frame: This frame not only supports the large floors (spanning 10 m), but also invisibly divides the vaulted system into horizontal sections, supporting it floor by floor.[8]

7 Tensile Structure skyscraper, 1928. G. Fiorini (eng.).

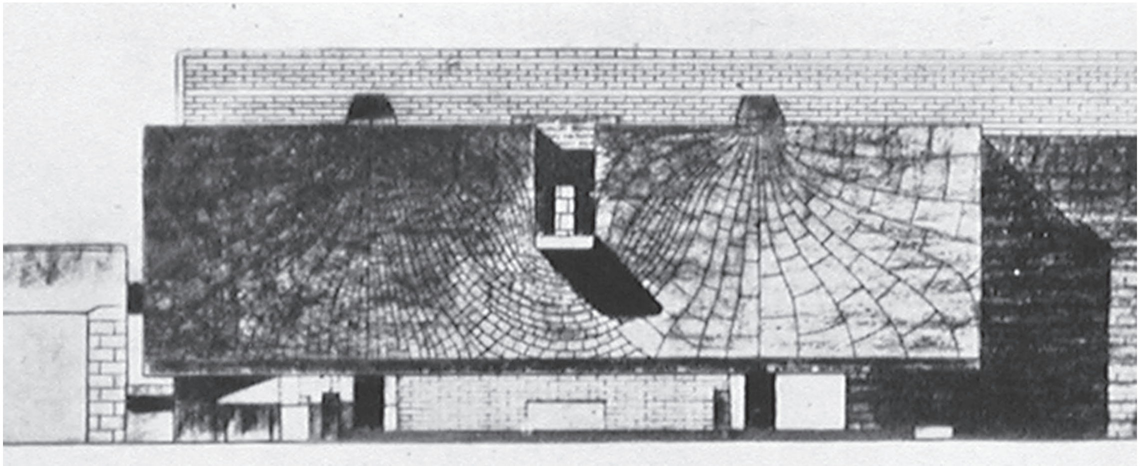


Visionary Structures

Simultaneously, however, the same figurative traits behind the strategies used to conceal the structure gave rise to a modernist trend which we could call ‹visionary›, in which the supporting structure became the key feature of the representation. This recalls the age-old penchant of Italian architecture for a scenographic monumentalism, which became decidedly structural in the drawings of Antonio Sant'Elia (1888–1916) or Virgilio Marchi (1895–1960) and in the more verisimilar but no less fantastic structures imagined by Ottorino Aloisio (1902–86) for a fascist spa (*Terme Littorie*, 1926) or the University of Sport (1928).

From the point of view of pure representation, a modern reinforced concrete structure can prefigure a technological future and yet, at the same time, conjure up a timeless atmosphere of archaic classicism. To understand just how much this characteristic fascinated young architects, just leaf through Adalberto Libera's (1903–63) drawings of structural figures: the reinforced concrete Pantheon (1926), the FIL Isolators Pavilion (1928), the SCAC Pavilion (1928–30, planned for the Milan Fair) and the perspective for the competition for the new Auditorium in Rome (1935), with its close-knit network of tapered frames as a backdrop for the huge statue.[9]

These drawings were quite common in the repertoire of contemporary architects; they reveal the duality between the figurative traits of Italian modernism (reflecting its enduring position among the arts, together with painting and sculpture) and the designers' feelings about the scientific dimension of construction, enhanced by the echo of experiments in the field of engineering. There was no end to the debate about the relationship between art and science (which idealistically sublimates the relationship between architecture and engineering); structural visions were a genuine part of that debate, representing the coexistence of form and technique, yet fully respecting the hierarchical order by which the latter is subservient to the former.



8 Competition design for the Palazzo del Littorio, I degree, 1934: façade along via dell'Impero. G. Terragni et al. (archs.).

The ‹tensile structure› (fig. 7) designed by the futurist engineer Guido Fiorini (1897–1966) was part of this scenario. Fiorini was famous chiefly for having caught the imagination of Le Corbusier. In 1928 the ideation of the «radiator» skyscraper (later, part of the Plan of Algiers), with its floors stayed by cables to a compressed central nucleus, was behind the many ‹architectural visions› initially displayed at the second MIAR Exhibition in 1931 and later published in *Casabella* and *Quadrante*.[10]

The importance of the relationship between art and science, however, was present not only as a key feature in drawings by architects, but also in much more elaborate design experiments. By trying to satisfy the regime's request for a grandiose style, these design experiments significantly enriched the repertoire of visionary modernism.

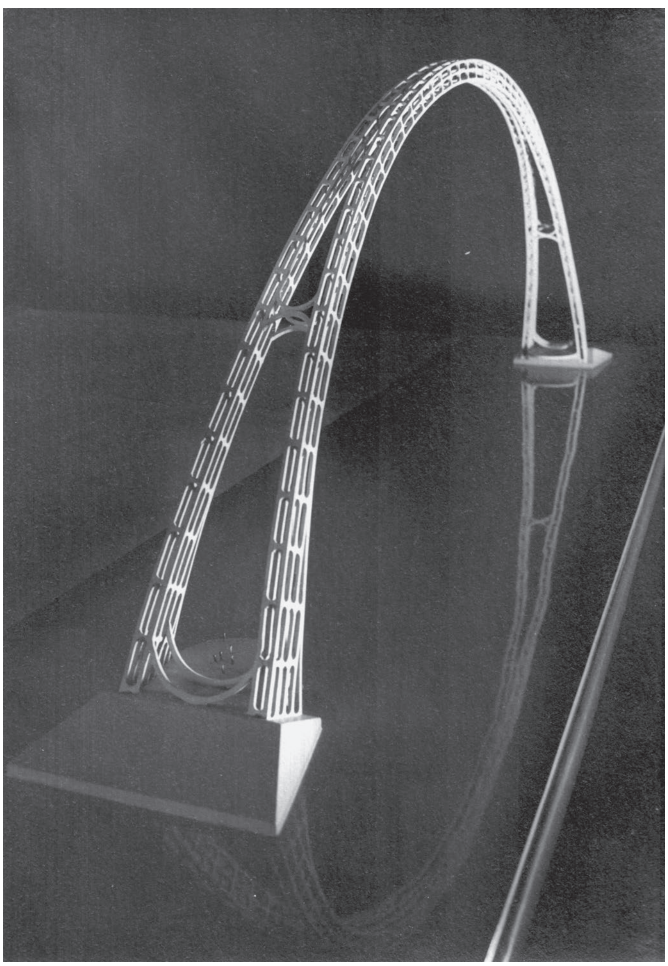
This was the case of the great ‹hanging wall›, submitted in 1934 by the *Gruppo Milanese* (headed by Terragni and Luigi Vietti) for the first degree competition for the Palazzo del Littorio in Rome (fig. 8).[11] Rivalry with the Basilica of Maxentius, a prerequisite of the tender, was entrusted to a huge concave wall of porphyry, 80 m long and 25 m high. Rather than resting on the ground, the wall ‹hung› from the ends of two trusses. The wall, cut in the middle to accommodate the platform from where Mussolini was to speak, was equipped with bundles of tie-rods (in very pure iron) fanning out from the two points of suspension along the tension isostatic lines; porphyry blocks, arranged along the compression isostatic lines, created upside-down arches. The solution combined the intrinsic monumental value of large blocks with the futuristic tensile structure.

The duality between art and science is immediately visible in the representation of the façade. The chance to ‹see› how the internal tension developed was provided by a modern research tool, photoelasticity, which just one year earlier had been tested in the Experimental Laboratory of Models and Construction by Danusso.[12] The design of the façade was generated by scientific study, and only by chance did the isostatic lines – which increased in number towards the platform – accentuate the dramatic effect of the monumental backdrop.

The most spectacular image of visionary modernism is undoubtedly the monumental ‹Arch of the Empire› which was to be built for the E42. It reformulated the problem of the relationship between architecture and engineering as part of the broader issue of autarky.[13]

The first proposal (fig. 9) submitted in 1937 by a team of engineers headed by Gino Còvre (1892–1981) was rejected due to the anti-autarkic character of their proposal. In fact, if such a spectacular, 600 m-span arch (with a panoramic railway, belvedere, restaurant and dance hall) was to be built, the structure needed to be made entirely of steel. By contrast, the second proposal submitted in 1938 by Libera (and the engineer Vincenzo Di Berardino [† 1967]) was ‹autarkic›: It included a smaller arch, with a 200 m span, to be built in concrete without steel. Unfortunately, the tests carried out by Danusso and Nervi (the latter arranged for a 1:10 scale model to be made to study the construction systems and ultimately deposited a patent for a special type of scaffolding) proved it was necessary to introduce a lightweight steel reinforcement.

9 Project for the Monumental Arch in Rome's E42 district, 600 m span, 1937. G. Còvre (eng.).



However, this dilution of the design's autarkic nature led to another decisive proposal: an aluminium arch, proposed by Còvre, with a 330 m span. The autarkic purity of this last version was thwarted in the final drawings. In fact, according to new tests led by Giannelli, the rhomboidal section in Avional alloy had to be made more rigid using inner steel frames; the latter were so close-knit and robust they turned the arch into an aluminium-clad steel structure. Despite the fact that Mussolini liked this solution – which was still an option on April 1940, when he inspected a model in the garden of the School of Engineering in Rome – it was abandoned along with the construction of the E42 itself. The Arch of the Empire passed into history as proof of the collective and contagious character of visionary modernism in the late 1930s.

The Role of Pier Luigi Nervi

In the interwar period, although some daring concealed structures were built and even bolder visionary buildings were imagined, only a few engineers became somewhat relevant to the development of architecture. Most obvious was their influence in the numerous beautiful arch bridges and industrial buildings, in which structure and architecture overlapped. Then, out of this choir, emerged the architectural works by Pier Luigi Nervi.

Nervi's ingenious intuition of the static behaviour of structural forms would emerge clearly with the design of the Berta Stadium in Florence (1930–32, fig. 10), which would soon be recognised as a masterpiece of the new Italian architecture. Its exposed structure – coming out of the blue – actually came about for a very practical reason: The client had run out of money for finishing the building

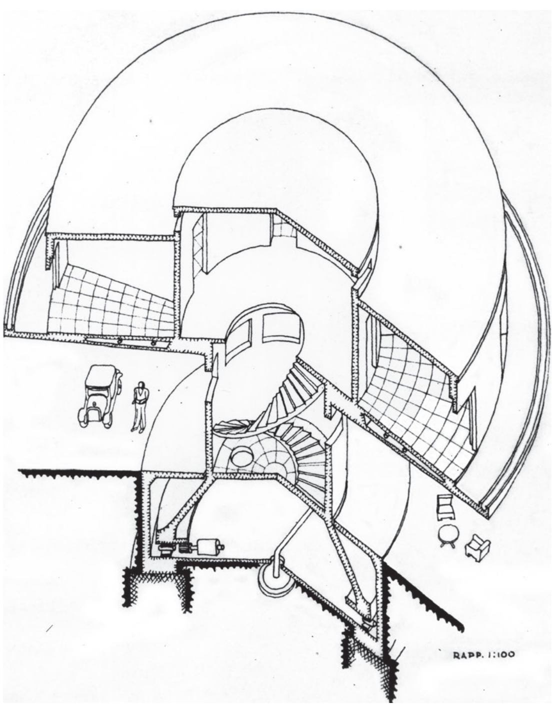
10 G. Berta Stadium, Florence, 1930–32. P.L. Nervi (arch./eng.), photo from ####.

according to the original plan. The 22 m cantilever roof (shaped matching the bending moment diagram), the helicoidal staircases (the criss-cross design of the beams solved a complex torsional problem), and the futuristic marathon tower were regarded as original examples of modern architecture. In leading Italian and international journals, the stadium was judged (by Sigfried Giedion, for example) as a sign of an ‹Italian revival› on the way to modernism.

In the wake of success, Nervi found himself involved in the debate over modernity and innovation that was raging in Italy under autarky. He joined in by writing articles (dealing not only with structural design issues) in magazines like *Quadrante* and *Casabella*. At this point, he designed a series of futuristic-inspired items, real ‹visionary structures›, none of which were to be accomplished: the Floating Hotel (1932), based on an ingenious method to reduce the intensity of wave action and achieve stabilisation; the Flag Monument (1932), a slender tower, 250 m high, which was stabilised by suspending a heavy pendulum on its top; the Revolving House, tracking the sun's position (fig. 11); and the Water and Light Palace (1939), which was among the visionary proposals put forward for the construction of the E42 district.

Nervi's participation as a prominent figure in architectural debates was brought to a close with the outbreak of war, which concluded his first life (Nervi had two more lives: the second dedicated to the *ferrocemento* and the third as a ‹star architect› all over the world).

11 The Revolving House, 1934. P.L. Nervi (arch./eng.).



While the debate over autarky was raging, Nervi went back to explore the unknown potentialities of reinforced concrete by designing some airplane hangars for the Italian Air Force (the first were built in Orvieto in 1936). The structure consisted of two series of arches that were rotated with respect to the imposts of the vault and intersected one another. This design solution allowed him to fully exploit the potentialities of reinforced concrete, and above all its monolithic nature. He overcame inherent difficulties related to the complex mathematical calculations needed for these statically indeterminate structures, carrying out accurate tests on celluloid scale models. This was an absolutely new approach in Italy. It was the first Italian 3D scale elastic model. The trials were carried out in Danusso's laboratory.

A second series of six airplane hangars was built in 1939–42 (two hangars located in Orbetello (fig. 12), two in Orvieto and two in Torre del Lago). Both series featured arches crossing one another, but while in the first hangars they were cast on site with the help of a huge costly timber formwork, in the second they were prefabricated in little parts on the ground, then assembled into place on a light metallic tubular scaffolding, thereby restoring the monolithic conformation and structural continuity of the whole.

This is the real start of the ‹Nervi System›, a completely new way of designing and constructing reinforced concrete structures: structural prefabrication, as Nervi himself called this patented solution, combined with *ferrocemento*, a new material invented in 1943, a more autarkic combination of steel and concrete, producing very stiff and highly elastic slabs that were easy to shape into almost any form and exceptionally economical. After the Second World War, the Nervi System allowed the masterpieces of Nervi's maturity.[14]

12 Airplane hangars, 2nd series, Orbetello, 1940–42, the structure before being covered. P.L. Nervi (arch./eng.).

Conclusion

The interwar period was a bad time for Italy: For almost all the time the country found itself in the grip of the fascist regime, which ultimately dragged it into the catastrophe of war. But, unpredictably, the autarkic period also paved the way for a new birth, after the war. The continuity between the autarkic experimentation and the techniques used in reconstruction, up until the years of the Italian ‹economic miracle›, is crystal clear and this continuity led to the connection between the large-scale works designed by engineers and the architectures of the 1950s and 1960s, which now appear to be one of the mainstays of the unique Italian style.

1 For more information about the topic, see Poretti 2013.
2 Iori 2007.
3 For information about Nervi's work before the Second World War, see Greco 2008 and Iori 2009.
4 Capomolla 2004/05.
5 Iori 2001.
6 For more information about the building, see Poretti 1990.
7 Capomolla 2004/05.
8 Casciato / Poretti 2002.
9 Muntoni 1989.
10 Zorgno 1988.
11 Poretti / Iori 2004.
12 The engineer Italo Bertolini, head of the laboratory (and not engineer Ernesto Saliva, the official member of the design group), applied the photoelastic procedure to a model in phenolite of the wall of the façade and obtained the pattern of the isostatic lines, which was then used to design the wall.
13 Iori / Poretti 2015.
14 Iori / Poretti 2010.

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