Nuts & Bolts of Construction History

Culture, Technology and Society

Vol. 2

Edited by: Robert Carvais,
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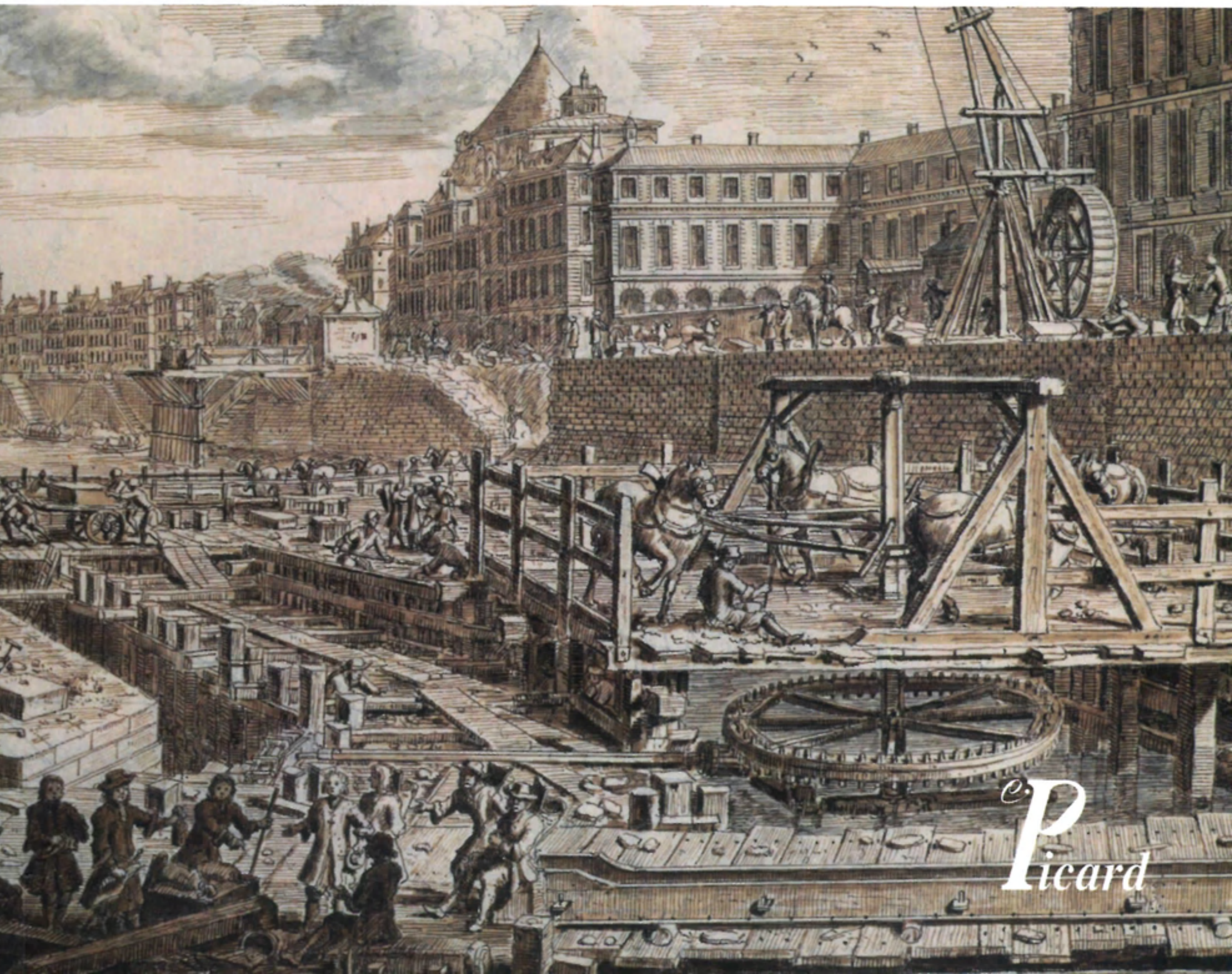
Joël Sakarovitch



Picard

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Cover image : Lieven Cruyl, A view of the construction of the Pont-Royal [1685-1689], black chalk, pen and brown ink, brown and blue wash, 1687, collection Destailleurs © BnF.

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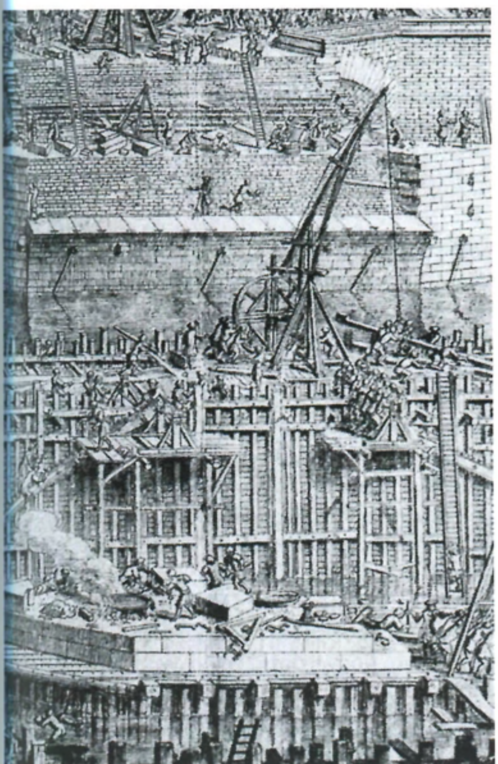

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Manual Abilities and Modern Constructive Techniques in a Building by Arturo Hoerner: The S. A. Supertessile Plant and the System Baroni-Lüling, Rieti-Italy, 1926

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The results of the constructional survey, the retrieval of the original blueprints and photographs of the building site of the S. a. Supertessile industrial plant at Rieti, designed by Arturo Hoerner in 1925, have directed the study towards the identification of the theories, patents and experimentations underpinning a project that demonstrates notable qualities of a constructional nature.

The absence of a project archive for the firm responsible for the reinforced concrete structures, Ing. H. Bollinger of Milan, has been a major obstacle and necessitated the extension of the field of research. This thorough investigation led to the identification of some important specifics, also found in similar projects, which are relevant to the happy association that characterized the work of Mario Baroni[1] and Bollinger during the years of the pioneering experimentation and growing success of reinforced concrete (Colby 1909; Santarella 1926; Santarella 1928).

The planning and construction of the Supertessile plant took place during a decade of crucial importance for the normalization of the use of reinforced concrete. The material became ever more common and, before it became ubiquitous, reached a high level of systematization of techniques of use. This normalization came about as "the technology became accessible to ever greater numbers of construction firms, not necessarily qualified, and thus greater regulation was required, in particular regarding technical execution: the law of 1907, by now out-dated, was modified on several occasions and in 1927 extended to include all buildings, whether public or private" (Iori 2001).

Thus the Supertessile plant was constructed before the definitive normalization of the sector, and this more than anything else explains why it presents constructional and experimental solutions that anticipate the regulation of 1932. For example, there is the construction of ribbed ceilings without concrete topping and other elements, such as the arched trusses with the Baroni-Lüling patent, which we will consider shortly. These can be considered to provide important evidence of

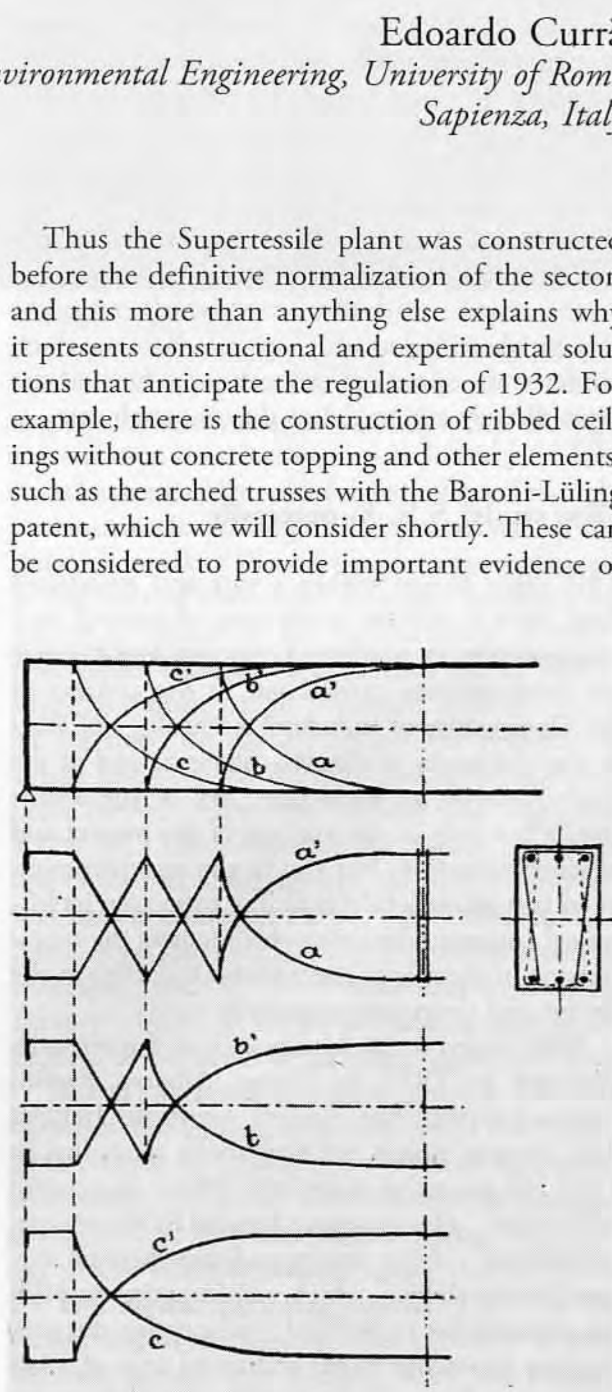

Fig. 1: The Baroni Lüling System (Santarella 1926).

the Italian appropriation of reinforced concrete technique by way of native patents and solutions.

The technology of reinforced concrete was at this stage diffuse and based on a vast work-force of varying degrees of specialization. The crucial figures were the master-carpenter and the metal-workers. Under the instruction of the large group of technicians who made up the site office, they achieved high quality in certain constructional elements which will be described in detail below. The Baroni-Lüling patent (Fig. 1) is in fact based on the design of a complex system of reinforcement which stems from a deep understanding of the tendencies of the isostatic forces of compression and traction. The complex pleats, and the articulation of the reinforcement within the beams, require work-force costs which can probably be identified as un-economic factors, which hindered the spread of the technique beyond the firms directly connected to the two engineers.

Case study: S. a. Supertessile

This study moves within a vast and structured field, both in relation to the state of research into constructions in reinforced concrete and because the investigations carried out in the context of the Observatory of Industrial Archeology of Rieti at the University of Rome – Sapienza and of the State Archives at Rieti have led to significant results not only in the analysis of the project and of its construction, but also in the reconstruction of certain phases of the building process in its historical context. Moreover, this requires the investigation of the role of the leading characters in the design and construction process.

With regard to the history of S. a. Supertessile, founded in 1924 by Baron Alberto Fassini Camossi within the Società Generale Italiana della Viscosa[2] group, we may briefly recall that in 1924 the mayor of Rieti, avv. Mario Marcucci,[3] and Fassini,[4] a businessman favored by the regime, maintained a dense correspondence through various intermediaries, which was intended to push the industrialist to builded a factory for the production of viscose in the industrial area of Viale Maraini at Rieti. The company was looking for a new production site and Rieti found itself in competition with Viterbo, Sulmona and Venice. Among the decisive factors were the free supply of water, sponsored by the town council, and the involvement of major local figures, above all Prince Ludovico Spada Potenziani, in finding a suitable location for the factory.

Once the site had been decided upon, Fassini commissioned Arturo Hoerner, an engineer whom he had often consulted both for business requirements and private projects, to draw up plans. For this angle I refer to the research being carried out by Fabrizio Di Marco at the Osservatorio which is currently revealing numerous new aspects of the partnership between the businessmen and his designer. Hoerner was an assistant at the School of Engineering of the University of Rome to the chairs of *Elementi di Fabbrica*, *Architettura Tecnica* and *Architettura Generale*, held continuously from 1914 to 1943 by Gustavo Giovannoni, who was also Dean of the School from 1935 to 1939. Thus Hoerner was part of the circle of Giovannoni, as is confirmed by his predilection for the historicizing aspects of modern design which place him firmly in the contemporary Italian context. Industrial projects Hoerner carried out for Fassini included textile factories and several other buildings for Rieti, Sagrado [Gorizia], and Naples (Di Marco 2012).

Arturo Hoerner's design: construction and industrial architecture

Hoerner's design (Fig. 2) demonstrates a planimetric design, which adds an elevated architectonic and constructive quality, above all in the interpretation of the city-factory system, to the high standard of building already reached in the textile factories of Pavia and Padua.

The factory is on a long main road, along which the various pavilions are located. Entering by the gate on Viale Maraini, once one has passed the first buildings [porters' lodge and offices], the characteristic overhanging shelters for vehicles and bicycles and the large warehouse pavilions, one arrives at the most imposing part of the complex, made up of two tall structures in reinforced concrete and brick, joined together and aligned on the north side, which were intended to be chemical

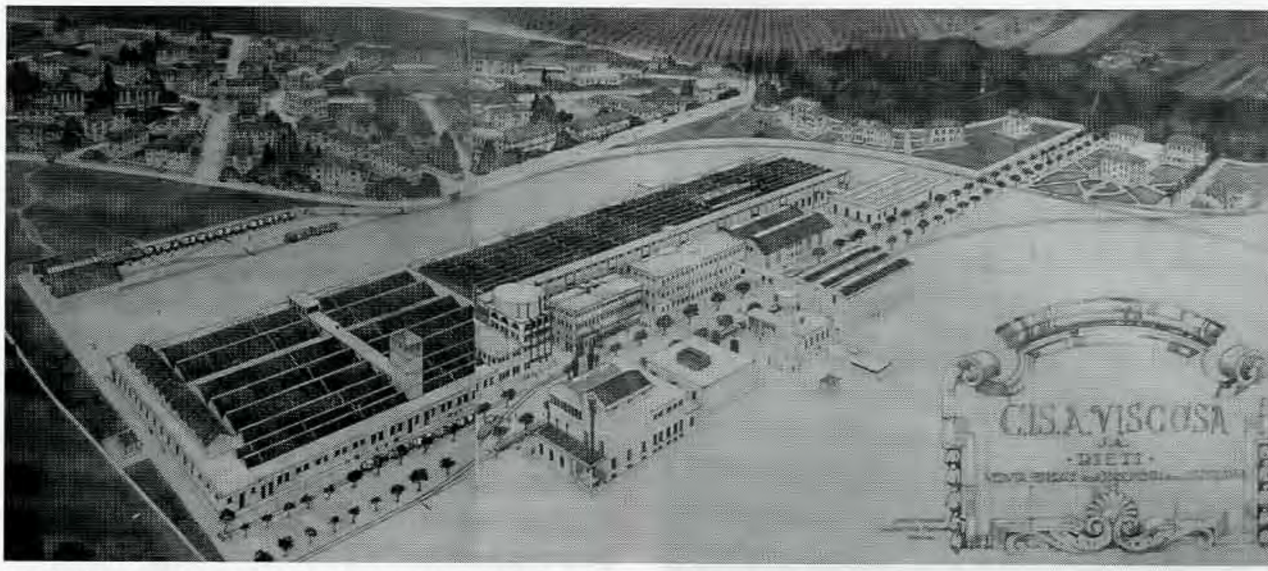

Fig. 2: View of the design of the Supertessile plant, A. Hoerner, 1925 (Formichetti 1996).

laboratories [today the Soda and Alkaline departments]. The second laboratory building, the larger of the two, was connected by a covered walkway – now demolished – 12m. above ground, to the structure that best represents the entire complex, the building for offices and management that is four stories high and topped by a giant water tank (Fig. 3). Finally, parallel to the previously mentioned buildings of this small industrial city, are the sheds for the spinnerets, nearly half a km long.

This covered shed-like structure widens in correspondence to the water-tank building and surrounds it on two sides, reinforcing the typological originality of the composition. While the factory itself was under construction, the project for the first residential buildings for its managers was also begun, and soon after another project followed, also by Hoerner, for the construction of an area of housing for the factory workers at the locality of Madonna del cuore. Hoerner's decisions regarding typological solutions and the constructional apparatus demonstrate his deep understanding of the state of industrial building in 20th century Italy. He reveals himself to be fully aware of the logistical problems posed by planning and was knowledgeable of previous major constructions and of the developments of more recent ones. The projects of the first years of the 20th century, within the context of a greater or lesser autonomous following of the ideas of the Art Nouveau, indicate a general overcoming of the boundary between mere service construction and architecture, which had characterized much of the typological thought on construction during the 19th century. In this sense, the work of Pietro Fenoglio was emblematic in the area of Piedmont. Fenoglio expresses the intents of exhibition and individuation of industrial values through "a combined use of medievalizing motifs [small columns, capitals, roses, etc.] echoed on the elevations, the presence of which leads one to think of the naves of cathedrals turned inside out" (Nelva and Signorelli 1979, 66). These elements are already present in one of his first buildings, the Michele Ansaldi factory on Via Cuneo in Turin [1899], then at *FIAT San Giorgio and Grandi Motori* and its immediate successors, such as the *Termotecnica e meccanica* Factory[5] [1900], in which the development of the rational distribution of the work space is striking.

Hoerner was part of a later generation and, in his work, the historicizing solutions or the Liberty style favored by Fenoglio are replaced by stylizations closer to a proto-Rationalism. For example, if we consider the water-tank building, the *squaring* of the circle is realized using curved brackets and beams perfectly exposed both on the facade and in the interior. The presence of joins between curved and straight lines, the proportions, and the relationship between the squares in which it is possible to frame the elevations and

Fig. 3: The water tank building under construction, 1926 (ASR).

the floor plan, and the cylinder of the water tank, are geometric elements that pertain to the typical and rational classicizing elements of the so-called proto-Rationalism. Indeed it is within the context of the diffusion of reinforced concrete that scholars such as De Fusco place one of the technical factors that allowed the success of the invariant that of proto-Rationalism: a simplified plan of the utmost – constructive, aesthetics and sociological – economy (De Fusco 1974).

This attitude is in line with the decision to give the water tank a cylindrical form, even though it is on top of a square building. Indeed the walls of cylindrical tanks are not subject to bending moments, except in the base joint [...] and possibly with the lid [where they are however quickly reduced] (Oberzinerr, Bertolani and Danusso 1928, 54).

The construction is in harmony with these observations. It displays the logistics of the design and the absence of decoration with clarity, alongside a qualification of the elevation achieved through the correct realization of the constructional components. Reinforced concrete beams, piers, and arches weave a form which, with a certain expressivity, folds at the top of the wall to become the support for the floor at the base of the water tank.

The wealth of constructional solutions for the structures further matured as a result of the exchange of documents and detailed plans between at least three professional figures. On the one hand Hoerner, the designer of the entire complex and the man responsible for the architectural choices and the individuation of constructional typologies. Also present was the technical office of Supertessile, which supported Hoerner and managed relations with the firm responsible for the construction of the works in reinforced concrete, and finally this firm itself, Ing. H. Boellinger of Milan, working with the structural designer Mario Baroni, who respectively concerned themselves with the definitive structural designs and the production of the work in reinforced concrete.

Baroni and the Bollinger company boasted an exceptional curriculum in the construction of industrial buildings of national importance. Among their projects in central Italy, we may recall the reinforced concrete structures of the Centrale Montemartini in Rome (Bertoletti, Cima and Talamo 1997). Theirs was a well-tested partnership at the time of the Rieti projects. Indeed they are mentioned by A. L. Colby at the beginning of the 20th century. Speaking of Italy, Colby (1909, 23) tells that "Six (6) systems claimed to be of Italian origin. (None characterized by the use of special shaped bars) [...] The company *Societa Ing. H. Bollinger*, Milan, is the owner of the Baroni-Lüling system." Clearly, at the time of the construction of the Supertessile plant, the *pioneering* years to which Colby's recognition is linked were past, and the push for reconstruction after the end of the First World War had a major effect on the dissemination of the technique. In particular, the speed of construction was to have a major role in this diffusion, despite significant increases in the costs of materials and labor (Iori 1985, 109).

Constructional characteristics and historical-technological evidence

Hoerner demonstrates a particular sensitivity to the qualities of reinforced concrete in his studies of formal and constructional solutions. As Riccardo Nelva writes, "from the second decade of the twentieth century industrial buildings in cca. have been consolidated in constructional practice and generally the mesh of the structure, put on view, is combined with opaque cladding and windows; indeed designers play with the combination of panels and windows to create specific aesthetic motifs. The combination of red bricks, the grey of the concrete structure, and the reflections of light on the windows is common." This is exactly the combination we find at Rieti, employed in some buildings with particular originality. In the water tank building the reinforced concrete structure geometrically highlights the correlation between the quadrangular structure of the office building and the circular form of the tank, defining it within its superficial boundaries, and making it the characterizing motif of the most recognizable building of the complex.

Throughout the plant, therefore, the construction is characterized by a reinforced concrete framework closed by fair-faced brick cladding, one or two bricks thick, entirely plastered and painted. The window frames are predominantly in metal, but originally there were also some wooden frames suche as the doors frames. The roofs are flat, sloped, and curved, constructed in conglomerate reinforced concrete, covered with Marsigliese roof tiles for the sloped and curved surfaces, and cement tiles for the flat roofs.

Some notable elements emerged from the historical study of construction that bear witness to a method of construction. Other than the necessary values in the nature of the construction – design dialogue, above all in the main pavilions and, as mentioned, in the water-tank building, there are some constructional characteristics that are relevant to a history of the development of reinforced concrete in Italy outlined here.

This concerns the use of the technique of reinforced concrete for the light structures of the technical pavilions. The similarities between the design decisions and previous constructions by the Bollinger company – among which the Tosi Tranformer Assembly Plant [1919-1920] and the Franco Tosi metal-working Factory [1917-1918] at Legnano stand out – are clear (Fig. 4). The Tosi blueprints and a photograph of the reinforcement

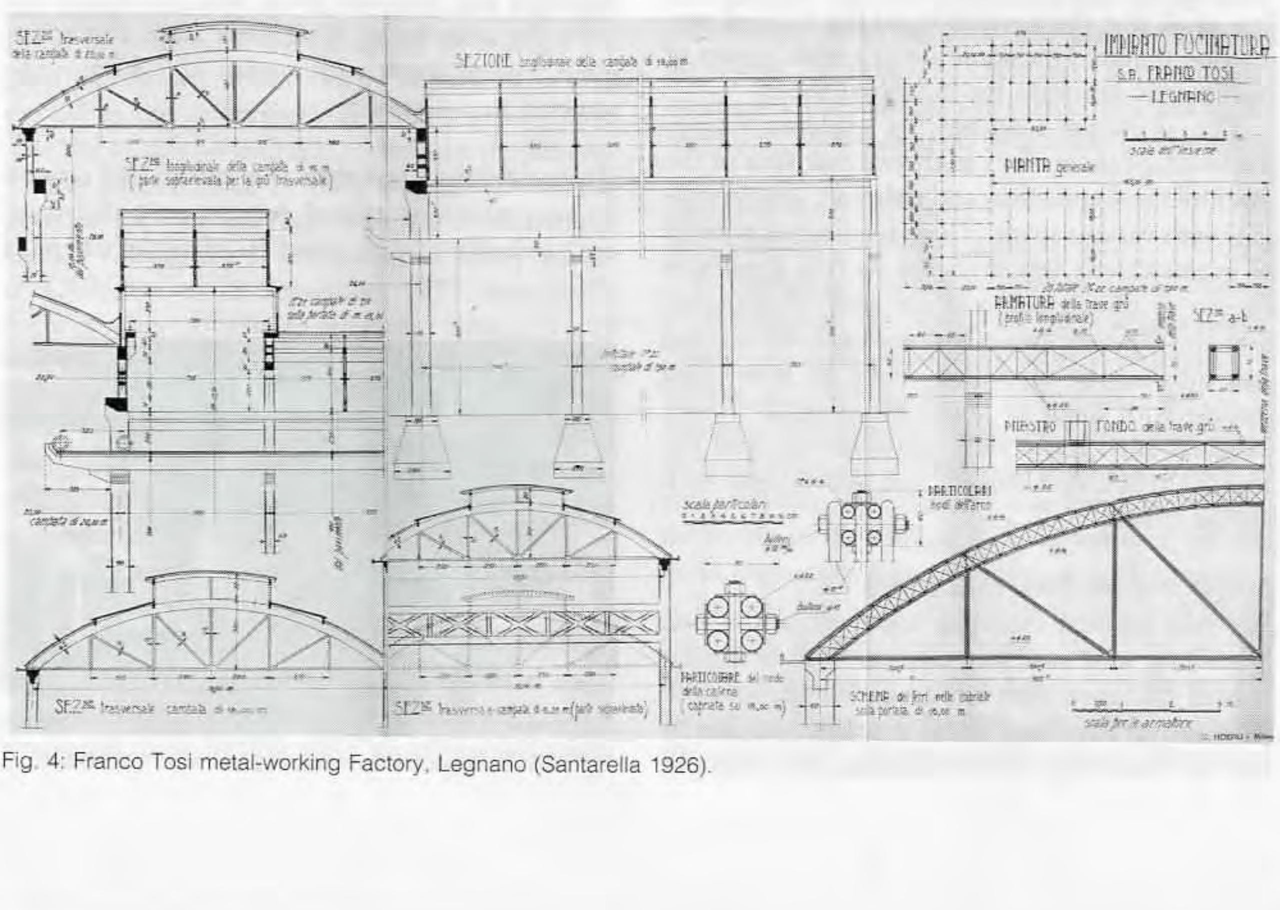

Fig. 4: Franco Tosi metal-working Factory, Legnano (Santarella 1926).

bars of the Supertessile plant, shown below, illustrate this point.

In these projects of the Bollinger company, chosen here to place the constructions at Rieti in context [we may also recall the Necchi Foundary in Pavia, 1922-1923], Baroni is the designer, and a contemporary publication allows us also to assign to him authorship of the supporting structures at Rieti. This is significant, given that until now none of the numerous original documents had come to light, neither had they been referred to by the various scholars who had concerned themselves with the site. Given this scarce documentation, the identity of constructional systems, in semi-rigid reticular reinforcement, and that of constructional detail, such as the typology of the hinge node, which can been seen in the illustration, confirm beyond doubt that the Bollinger company also made reference, if not to the work, then certainly to the technical solutions of Baroni at the Supertessile plant.

Roofing systems on reticulated reinforced concrete beams

Pausing to consider certain elements we can state first of all that the complexity of the cycle of production required the adoption of a wide variety of planimetric solutions for industrial sheds.

The principal load-bearing skeleton frameworks adapt themselves to the various sizes of the machines and apparatus and therefore require ceilings with various spans. Three typological systems of beams closely linked to the roofing typologies chosen to obtain different methods of illumination and different spaces for housing the machines and tubs can be identified. Thus we have: shed roofing with single or multiple triangular trusses, irregular shed roofs with mixed arched and triangular reticulated trusses, and curve roofs with arched trusses.

Single and multiple shed trusses

We find the first examples above all in the *halls of skeining and bleaching* covered with triangular trussed shed roofs with 4m. spans. Numerous similar examples have been found in projects realised by the firm following Baroni's designs. For example, in the above-mentioned Tosi Assembly Plant at Legnano, the flashing also makes up the bridle joints of the reticular beams of the shed, whilst at Rieti these coincide with the upper wing of the load-bearing beams; the structure is closed in brick-concrete mix without concrete topping (Fig. 5).

Alongside this basic outline, throughout the building, we find the double shed solution with a span of 8.5m., necessary for the extrusion and bleaching plant. An elegant arcade allows for the double shed roofing and supports the floor above for the maintenance of the roof. Calculations and the arrangement of the reinforcement bars suggest that the arch is attached to the piers in such a way as to form openings with tie rods. No other projects with arcades of this type have been identified and so, in order to situate the building in context, we must make general reference to systems for multiple shed roofing in use. There are many examples by Baroni as well as, amongst others, Santarella.[6] Multiple shed roofing had been in use for decades, as confirmed by the Michelin plant at Turin, built by S.A.I. Ferrobeton of Rome [after 1907]. In this case the double shed roofs have spans of 14.70m. and, as at Rieti, the structure is of Frazzi[7] type panels and covered in Marsigliese tiles (Oberzinerr, Bertolani and Danusso 1928, 60).

In the complex at Rieti there were also triangular trussed sheds with a span of 7.85m., constructed in the same way.

Arched trusses, and shed roof on arched trusses

In two pavilions arched trusses were constructed, a device already used in many of Baroni's

Fig. 5: S. a. Supertessile, multiple shed roof, 1925 (ASR).

projects, as well as a shed roof on arched trusses [today demolished, they had an interaxial span of ten m.]. Upon these rested very thin ribbed slabs which, as will be illustrated below, allow the maximum reduction of their weight pressing on the beams (Fig. 6).

In their studies of the isostatic forces, Baroni and Lüling had identified a suitable arrangement of reinforcement bars for the schematic reproduction of movement. In this way the reinforcement bars take on a characteristic "X" form with variable inclinations in the areas most subject to shear stress. With respect to this patent, the outline for the arched truss, found in many of Baroni's industrial projects, is less true to the actual stress distribution, but leads to the extension of the crossed reinforcement bars along the whole beam. Thus a lattice of reinforcement bars is created, which is able to provide sufficient resistance, even before pouring, to be handled while construction is underway.

These are "trusses with semi-rigid reinforcement, of the Baroni type," described again by Santarella, "characteristic of metal reinforcement, which is semi-rigid and made up of lattices, of which the bridles are iron square separated by bolts, and the diagonals are iron rods wrapped around the bolts. The trusses are therefore created by preparing the metal centering on the ground and then lifting it together with the formwork to contain the pouring, the formwork having already been connected to the centering itself" (Santarella 1926). The use of this bolting was covered by the Baroni-Lüling patent, both in Italy and abroad. A few years earlier, they had registered patents both in the United Kingdom and in the United States (patent n° 1,390,364 of 13 September 1921) specifically for a system of bolts to maintain distances and angles between the reinforcement bars as determined by the specific plan. The reinforcement lattice was constructed on the ground and could resist being lifted and being placed together with the formwork and it would bear the formwork's weight until shoring took place before pouring.

The other type of shed truss was also constructed following the same principles, but only photographs and drawings survive. This seems to have been the most elaborate constructional component of the roofs. Indeed it was based upon a triangular cross-section shed superimposed upon an arched truss. This superimposition is such to unite the advantages of both structural solutions. The arcade has the principal task of bridging the span and transferring the loads onto the piers by a fixed joint. The triangular frame of the shed roof resolves the technical lighting problem and merges into the truss half way up. The base tie beam is in common, and the remaining part of the shed, which rises above the structural plan, is thus free for a large opening. The truss was reinforced with an upright first installed and then completed by the remaining reinforcement, formwork, and pouring.

Fig. 6: Arched truss pavilion under construction, 1925 (ASR).

Lightweight floors with and without concrete topping

Closing the joists and the vaults, above the various truss solutions, are particularly lightweight floors. These are constructed using a brick-concrete mix typical of applications developed in Italy. The lightness is achieved, working on the potential of the combination between cement and brick, in two different ways. On the one hand, the overall thickness of the ribbed slabs is reduced; on the other the upper concrete topping is eliminated.

In the first case [found in the curved roofs] four-hole bricks [Frazzi type] 10×29cm with a high proportion of hollow space in cross-section are used. The cross-section is reduced, but the ribs are closer together, their step is 36cm and

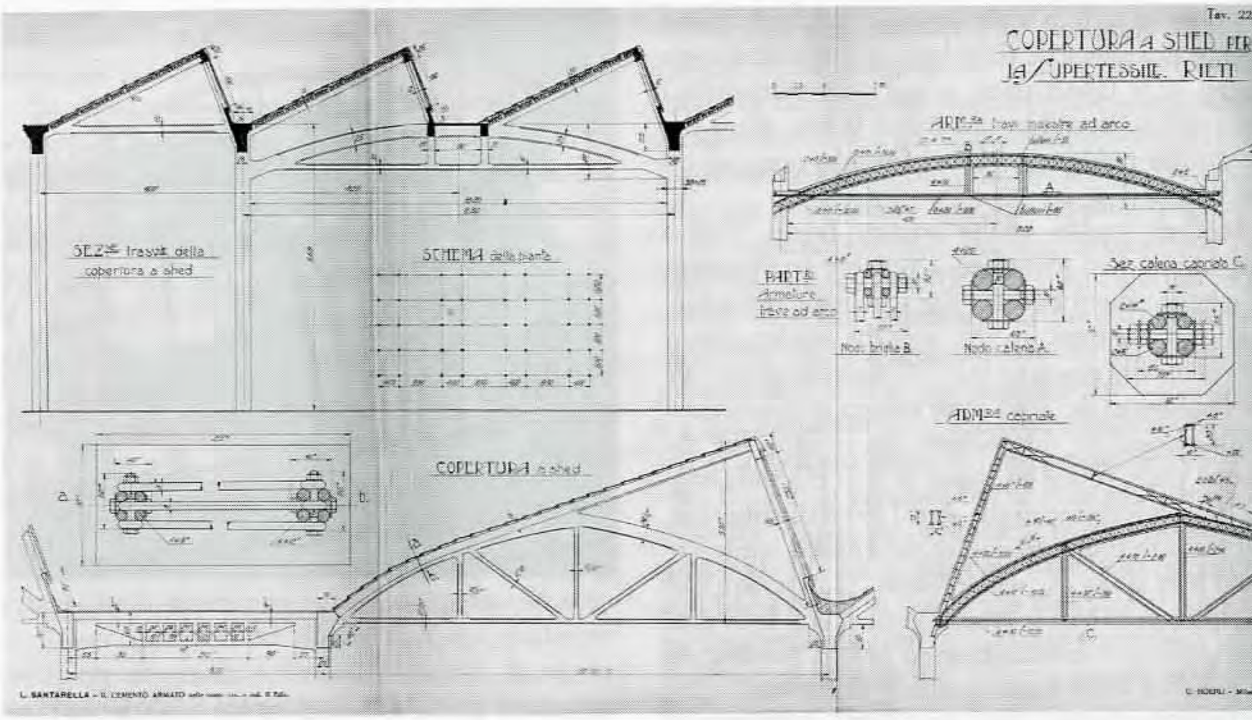

Fig. 7: The final design of some trusses and roofing (Santarella 1928).

the checks are carried out on simply resting slabs, the curvature of the concrete topping and the strength between rows of beams thus constitute an improved safety situation in comparison to the design checks (Arosio [1946] 1957).

The second type of method of reducing weight is found in the inclined floors of the shed roofing. In the blueprints and plates which Santarella dedicates to them (Santarella [1926] 1928), ribbed floors with weight-reducing Frazzi elements identical to those used for thin vaults are found. However, during construction another Frazzi patent was chosen, specifically for ribbed slabs without concrete topping, recorded in the survey of 1934. A constructional detail of the same solution is also found in the spinning halls at Vimercate (Santarella 1926, 559).

In reality the regulation of 1907 does not concern itself with these floors and the provisions of 1924 required the construction of slabs 5cm above every brick-concrete floor, as R. Gulli recalls (2007, 31). Here we are, however, in the period before the extension of the law into the realm of private building, which would take place in 1927. It would only be with the law of 1932 that regulations would be introduced for the construction of floors without concrete topping.

The patented floors of this type did not provide for any external slabs, which would have led to lively discussions between theorists, in particular between Camillo Guidi and Luigi Santarella (Iori 2001; Santarella 1932). Santarella specified that the possibility of constructing floors of this type was founded on the hypothesis that "both the concrete and the brick react to compression to the same extent, a hypothesis justified since […] the brick allows a higher compressional breaking load to that of ordinary concrete, and a higher modulus of elasticity, especially in traction, with little difference between the modulus of elasticity under compression and under traction in comparison to concrete. Furthermore, the adhesion of the brick to the mortar of the concrete is such to guarantee the static collaboration between the two materials" (Santarella [1926] 1928, 14, 51).

In conclusion, the study of the complex of the Supertessile plant at Rieti has brought to light the application of a specifically Italian constructional system, that of Baroni-Lüling, which from the first patent for the construction of beams, led to an important technological development, above all in the field of designing and building lightweight components for large roofs, both civil and industrial. This system, and its applications, can be credited with a notable impulse towards the rationalization of the building project, and the transfer on-site of the manufacture of elements in reinforced concrete. Above all this came about through the original system of spacers between the reinforcement bars with bolts, to create a semi-rigid reinforcement lattice.

Notes

1. Mario Baroni, engineer and university professor. With his professional research activity he brought a significant contribution to the development of reinforced concrete in Italy. Among numerous publications various lectures he gave at the Graduate School of Reinforced Concrete Construction are published – Fondazione Fratelli Pesenti, *Lezioni di Tecnica delle Costruzioni.*

2. Fassini founded S. a. Supertessile on 13 August 1924. The company had a registered capital of L. 60,000,000 in November 1924. In 1940, it took the name CISA Viscosa and, in 1941, definitively joined the group SNIA Viscosa.

3. The lawyer Mario Alberto Marcucci was first mayor [1923-1925] and then, after a brief interruption, podestà [a local authority position appointed by the Fascist regime] of Rieti [1926-1934].

4. Alberto Fassini Camossi, 1875-1942, was director of the cinematographic company Cines [1906] and, in 1912, founded Cines artificial silk for the production of synthetic fibers using the nitrocellulose process. Fassini had joined the Fascist party from 1921 and, in 1924, was created Corporal of Honour by the Fascist Party of Florence. He subsequently held multiple institutional positions in an industrial context.

5. Factory of the Termotecnica e Meccanica company, via Mongrando, Turin.

6. Among the most impressive industrial multiple shed roofs, designed by Santarella, are the triple shed trusses, for a span of 20m., built for the Fossati Garage at Biella.

7. The Frazzi ceramics company, later Eredi Frazzi, was in Cremona. Having specialized in flooring blocks for metal structured floors, during the early 20th century they put Frazzi patents into production, which quickly became part of common practice and entered into the manuals of Italian construction. The records of the Eredi Frazzi are now at the Centre for Business Studies at Cremona.

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