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## Mass Housing and Prefabrication in Modernist Architecture

Regine Hess, Inbal Ben-Asher Gitler, Tzafrir Fainholtz, Yael Allweil (eds)

Leuven University Press

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*Edited by*

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## PART 3 — EXHIBITIONS AND PROTOTYPES: ARCHITECTURAL MEDIATION THROUGH PREFABRICATION

CHAPTER 9

# The Milan Triennale Exhibitions

## and the Debate on Prefabrication in Postwar Italy

*Ilaria Giannetti and Stefania Mornati*

In the global perspective offered by the present book, the "experimental" conceptualizations, production methods, and prototypes showcased at the Milan Triennale Exhibitions constitute a significant case study for exploring the impact of prefabrication on modernist architectural languages, focusing on the relationship between the technological advances and design processes, at the scale of the single construction system.

In the aftermath of World War II, rebuilding as fast as possible was a priority in most of Europe, and applying the patterns of industrial processes to building appeared to be the best approach in terms of both efficacy and cost. However, owing to frequent clashes between private enterprise and public policy in regard to the societal and economic issues involved in urban planning, building industrialization in Italy was a delayed and less systematic process than elsewhere in Europe. Nevertheless, experimentation and the spread of information about new construction methods played a vital role in architectural culture in Italy. The exhibitions of the Milan Triennale, an institution founded in 1923 by Giovanni Marangoni, were the principal showcases for experiments in Italian postwar prefabrication.

The first Triennale exhibition—the International Exhibition of Decorative Arts—opened in 1923 at Villa Reale in Monza. The event planners' primary goal was to promote links between the new artistic trends and the world of industry. This initiative, at first scheduled every two years, immediately gathered eminent personalities around it. From 1930 on, it has been known as the International Triennial Exhibition of Modern Decorative and Industrial Arts, becoming a triennial event. In 1933, the venue was moved to the Palazzo dell'Arte in Milan, specially built according to a design by Giovanni Muzio. Interrupted by the wartime events in 1940—and with it, the series of competitions, conferences, and collateral events—the Trienniale was resumed in 1947 and, albeit at irregular intervals, continues to this day.

Technological innovation in construction and the relationship between architecture, industry, and urban planning are the themes of the cultural debate that has been fostered by the Triennale since the second half of the 1930s. During the 1940s and the 1950s, the urgency of postwar reconstruction fostered the widening of the architectural section of the exhibition. Within this framework, the Triennale became a showcase for technological experimentation in the construction sector, in line with the intentions of the Milanese construction industry.

In this chapter, we focus on the eighth, tenth, and twelfth editions of the Triennale: the successive exhibitions served to update the state of the art of building prefabrication and industrialization culture in Italy, from the postwar reconstruction to the economic miracle years. The Triennale's historic archive was the key source for our study.

## VIII Triennale: The Mass-Housing Plan

In order to reduce housing costs in the heyday of reconstruction, independent contractors, construction companies, and public bodies and institutions in Italy sought to devise building systems that would be both more efficient and faster. On October 17, 1945, Piero Bottoni, Commissionaire of the Triennale, announced the creation of the *Quatiere dell'Ottava Triennale* (QT8) experimental district within the VIII Triennale exhibition in 1947, which was designed to introduce a suitable state-planned process along the lines of foreign models.[1] The QT8 district featured an area financed by the Ministry of Public Works where fully industrialized construction systems could be tested.

The VIII Triennale bears witness to the vigorous debate on building industrialization to solve the serious postwar housing shortage. The sections on unification, modulation, and industrialization in the Triennale's building exhibition were curated by the architects Paolo Chessa, Ignazio Gardella, Enrico Gentili, Vico Magistretti, and Carlo Rusconi Clerici. As the curators noted, the exhibition, hosted in the Palazzo dell'Arte, highlighted that "house construction has reached the point of inflection between a craft technique and an industrial technique." Furthermore, they elaborated that while the artisan technique "characterized by on-site construction and wet construction… requires long periods to make the house habitable…, the industrial technique allows for the elimination of waste, the reduction of working processes, and high-quality and low-cost products."[2]

The exhibition *Unification, Modulation, and Industrialization* focused on applying an integral industrialization process to housing construction. Although it was based on unification, mass production, and scientific organization, the process was to respect the uniqueness of the architectural work. The curators stressed, "Unification does not mean limiting individual value and freedom but

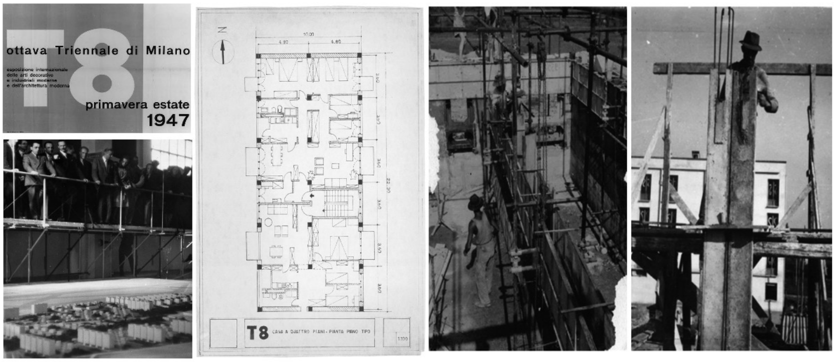


**Fig. 9.1.** Milan Triennale VIII, 1947: Cover of the exhibition catalog, physical model of the QT8 experimental district showed at Palazzo dell'Arte, standard plan of the "prefabricated house," construction site of the Breda-Fiorenzi house and the Gaburri house, 1948. Triennale di Milano-Archivi, Milan.

only coordinating them in the interest of the work of the community."[3] The theoretical approach relied on the exhibition's presentation of a project for a modular wall structure of a housing unit with unified measurements (by architects Carlo Rusconi Clerici, Luigi Frattino, and Luigi Mattioni) together with the 1:1 scale prototype of a prefabricated house by Gabriele Mucci, designed in cooperation with nine other architects, including Ernesto Nathan Rogers, Mario Terzaghi, and Augusto Magnaghi. The purpose of this prototype was to prepare the ground for "the achievement, with modest means, of the best conditions of well-being and civil living," as the architects noted in the catalog of the exhibition (fig. 9.1).[4] From a technological point of view, the prototype demonstrated the application of the PM Bogliardo prefabrication system with double-wall reinforced concrete load-bearing panels and beam elements.[5]

Alongside the Palazzo dell'Arte exhibition, the VIII Triennale inaugurated the construction site of the experimental QT8 district. Only one building type was shown, namely a four-story block consisting of forty-two rooms that had been prefabricated. It was to become the basic framework for the approach—and for comparisons—among different building systems. The funds allocated by the Ministry of Public Works amounted to little over 100 million lire, which allowed for the construction of five buildings.[6] Five systems were chosen for the comparisons. The first was the Breda-Fiorenzi system, which utilized a process of mechanization of concrete casting using metal formworks that could be assembled and lifted by means of Innocenti tube and coupler scaffolding. The second one was the Mariani system, which combined reinforced-concrete hollow elements with post-tensioned cables. This was followed by the Ciarlini system, a hollow cylindrical-pole structure with shelf-shaped elements and prefabricated beams. Then came the Gaburri system, which included a series of three hollow elements—plinths, pillars, and beams—as precast parts with concrete on-site finishing to create a framework structure. The last one was the C.G.T. system, a metal structure devised by architects Aldo Cassinelli, Eugenio Gentili Tedeschi, and Mario Tedeschi, which had not yet been utilized.[7]

The Centro Sperimentale dell'Abitazione (CNR), a research group created at the Milan Polytechnic, was tasked with monitoring the building yard.[8] Owing to inadequate means, only the Breda-Fiorenzi and Gaburri systems were subjected to careful scrutiny: the former afforded the sampling and evaluation of cast-in-place mechanization, and the latter offered the chance to prove it was possible to do without the formworks of the traditional frame system. In contrast, both the Mariani and Ciarlini systems proved to be quite unwieldy, owing to both the choices of the contractors and to some faults in the construction that led to the Mariani building project being aborted.[9]

Construction of the four buildings began in 1947 and ended in 1949. In the same year, the launch of the INA-Casa plan, which linked the construction site to the national blue-collar employment program, cut industrialization out of public housing planning and relegated experimentation to private initiative.[10]

## X Triennale: On Industrial Design

In 1951, the IX Triennale dealt with the subject of prefabrication and industrialization in building. The social benefits of industrialized construction in the context of planning for public housing, proposed at the VIII Triennale, evolved, step by step, into a broader discussion on the collaborative relationship between the world of the arts and industrial production.[11] In 1954, the X Triennale witnessed this shift in the cultural debate on building industrialization. Prefabrication, unification, and industrial design constituted the leitmotif of the event: the lines of research on building technology, in accordance with the industrialization section of the VIII Triennale, were developed, as noted by Ivan Matteo Lombardo, the president of the Triennale, on autonomous authorial and productive initiatives in the context of a "vastly experimental" exhibition of "what has not yet been tested."[12] Within a debate on the role of art in the industrial process, for Lombardo "architecture stands as a moment of perfect correspondence, and almost reversibility, between technique and expression." He went on, noting that "industrial production takes place in the form of industrial 'shape,' as the most appropriate expression … that spontaneously arises in the system, in the utensil, in the mass-produced object when these are consistent with the technique."[13]

In accord with this concept, in addition to the exhibition of construction elements set up in the Palazzo dell'Arte, the most innovative building prototypes were installed in the Parco Sempione. The park was suitably reorganized and arranged by the architect Marcello Grisotti to host the other exhibition sections, including examples of buildings complete with their furnishings, each erected using a different construction system. The focus there was on "the industrialization of the building detail itself and construction in general, with special reference to the single-family home."[14] The construction systems presented—all Italian, except for Richard Buckminster Fuller's Geodesic Dome dwelling—bear witness to the use of experimental construction elements, processes, and traditional systems, enhanced by new production processes and the focus on light prefabrication techniques.

Among the prototypes presented, the engineer Giovanni Varlonga, founder of the FEAL company, presented the so-called *Elemento di casa verticale industrializzata* (Industrialized Vertical House Element): a single-story dwelling—with a floor area of approximately 120 $m^2$ and a floor-to-floor height of 2.90 m—stackable on a steel skeleton. The components of the skeleton were hollow Dalmine steel tubes, I.L.V.A. steel laminates, which were standard products for Italian buildings, combined with atypical construction details (fig. 9.2). The project was drawn up by Varlonga in collaboration with the engineer Fabio Fratti of the FEAL Technical Office and the architect Ippolito Malaguzzi Valeri. The prototype pioneered a unique joint that enabled a mechanical connection between the Dalmine tubes, arranged with spacings of five and two meters, and the horizontal beams of the slabs. The structure was completed by cast-on-site reinforced concrete slabs. The joint could be produced in series as the external diameter of the supporting structure remained constant. The necessary reduction of weight from the upper floors in the multistory version was achieved by reducing the thickness of the lamination. Prefabricated inner walls—of aluminum or wood—were installed after the linoleum floor had been laid. The bathroom-kitchen block was also prefabricated and its windows and sliding doors were made of aluminum. Eraclit panels provided thermal insulation with an air chamber, finished on the outside with light-alloy enameled sheet metal. The main qualities of the system were its economy, its speed of construction owing to the radical reduction of on-site work, its lightness, and the fact that it could make use of components already on the market, for example, the standard components of the steel load-bearing structure. The sample building, considered by the Italian Office of Industrial Patents and Trademarks as one of the most interesting proposals of the exhibition, was the subject of an industrial patent that was filed in 1955.[15]

In a project along the lines of the Varlonga prototype, architects Gio Ponti, Antonio Fornaroli, and Alberto Rosselli proposed a single-family house about

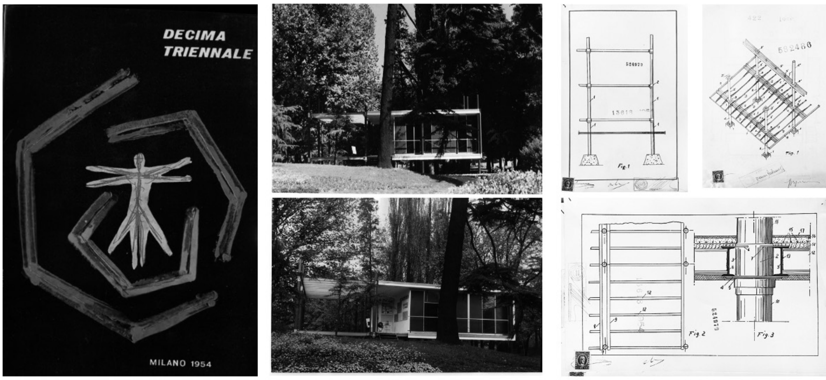


**Fig. 9.2.** Milan Triennale X, 1954: Cover of the exhibition catalog, G. Varlonga. F. Fratti, and I. Malaguzzi Valeri: *Element of the FEAL Vertical Industrialized House* in the Sempione Park, patent of the system. Triennale di Milano-Archivi, Milan.

120 $m^2$ in size. Its metal structure was made of standard steel profiles, exploiting a construction system designed by the engineer Leone Togni.[16] The plan was articulated on staggered floors to underscore the high flexibility of distribution obtained with mass production. The Togni prefabricated block resolved the plant engineering part relating to the bathroom and kitchen.

Architects Lucio Baldassarri and Marcello Grisotti designed several different projects: a prefabricated mountain house, an industrialized country house, and a prefabricated wooden house. They concentrated on innovative construction systems and modifying traditional ones for local or regional solutions in the light of modern technologies. For the prefabricated mountain house model presented at the Triennale, the designers' object was to "technically develop a structure that is as 'universal' as possible."[17] Thus, they employed the thermal-insulating laminated panel by the Salvit company. The use of that panel ensured the join between the two outer asbestos cement layers and the inner asbestos cement-perlite layer. It could be combined with any structural solution to form the envelope for internal partitions and, if supplemented by a cross reinforcement, could also be used for the horizons.

In contrast, for the industrialized country house model, the designers used a load-bearing construction system called ER-Cal, which erected the wall box using a reinforced concrete casting with two Eraclit panels inside to improve the thermal insulation of the walls. The door and window frames were embedded in the casting. A monolithic structure that was erected in a rapid on-site process both served as a load-bearing element and ensured adequate thermal insulation. Baldassarri and Grisotti also exhibited their prefabricated wooden house. The prototype was an example of "integral" prefabrication, using some traditional materials: the wooden truss became the generator module and featured a drawn aluminum carter to provide structural cohesion and protection.

The prototypes discussed here testify more than others to the experimental nature of the X Triennale, which was all about the relationship between the arts and industrial production. This was further emphasized by the experimental character of the Geodesic Dome dwelling by Richard Buckminster Fuller and the Experimental House by architects Mario Ravegnani and Antonello Vincenti in collaboration with the painter Bobi Brunori. The former was made with sheets of waterproofed cardboard; the latter, characterized by a structural module based on an equilateral triangle, featured the assembly of mass-produced elements, demonstrating the possibility of reducing costs while ensuring functional efficiency and aesthetic consistency.

## XII Triennale: The Mass-School Plan

In the 1957 XI Triennale, prefabrication and industrialization in buildings was only a side issue that dealt in a very limited fashion with the developments of the construction sites in QT8. It was not until the XII Triennale in 1960 that industrialization and prefabrication was again a central theme.

In 1958, the Italian government proposed a draft law for a "Ten-Year School Development Plan (1959–1969)." Paragraph 1 of the document was devoted to buildings. In the same year, the Centro Studi della Triennale, together with Ministry of Education technicians, drew up an initial program for the twelfth edition of the Milanese exhibition, which reflected the decision to adopt the thematic exhibition model for the first time.[18] In the framework of the draft of the ten-year plan, the design and construction of school buildings were politically urgent topics.[19]

In September 1960, the public entered the Triennale, greeted in Parco Sempione by the model of a school constructed using a state-of-the-art industrialized process: the full-scale prototype of a primary school, built with the CLASP system, designed by architect Dan Lacey and donated to the City of Milan by the British Ministry of Education. The *School Exhibition* was mounted in the Palazzo dell'Arte: two full-scale models, a "multi-classroom unit" and a "classroom–common-room unit," showcased a novel conception of a school space based on the latest pedagogical concepts (fig. 9.3).[20] At the same time, design competitions for school furniture, industrialized building elements, and pilot primary schools were held to involve architectural research in the design of school buildings. In particular, the Competition for the Study of Industrialized Elements for Elementary School Construction reflected the state of the art of the building industry's production possibilities for the


**Fig. 9.3.** Milan Triennale XII, 1960: Cover of the exhibition catalog, cover of the book *Britain New Schools*, British CLASP school in the Sempione Park, 1960. Triennale di Milano-Archivi, Milan.

construction of industrialized school buildings within a public funding-based program.

The competition call, launched in October 1960, was defined by the Centro Studi in agreement with the ministry and the newly established Italian Prefabrication Association (AIP). The competition involved Italian companies in two distinct areas. The first was called "single elements" and sought innovative solutions for "opaque or transparent external closure elements and simple internal closure elements, with fanlight, door or services," as specified in the competition announcement.[21] The second one, with the theme "combined elements system," required the "project for a single- or multi-classroom school building' as a prototype for fully industrialized construction systems."[22] The competition's organization confirmed its promotional purposes: no building application was planned, but the selected companies were asked to send together with the project and cost estimates a full-scale model of the most significant nodes of the system presented for a final show in Palazzo dell'Arte.[23] The engineer Pier Luigi Nervi, who had recently become very well known in the field of structural prefabrication, chaired the jury that guaranteed the validity of the selected systems.

Among the jury's criteria, one aspect was considered fundamental in evaluating the projects: the capability of producing individual elements combinable in both industrialized construction and, even more so, in traditional construction.[24] Engineer Giuseppe Ciribini suggested one criterion that was far-sighted and particularly suited to a production structure made up of small, highly specialized companies.[25] With this approach, fully industrialized systems could be achieved through temporary production company associations. The actively engaged architects and engineers played a fundamental role in the association of construction firms. They were defining new building systems

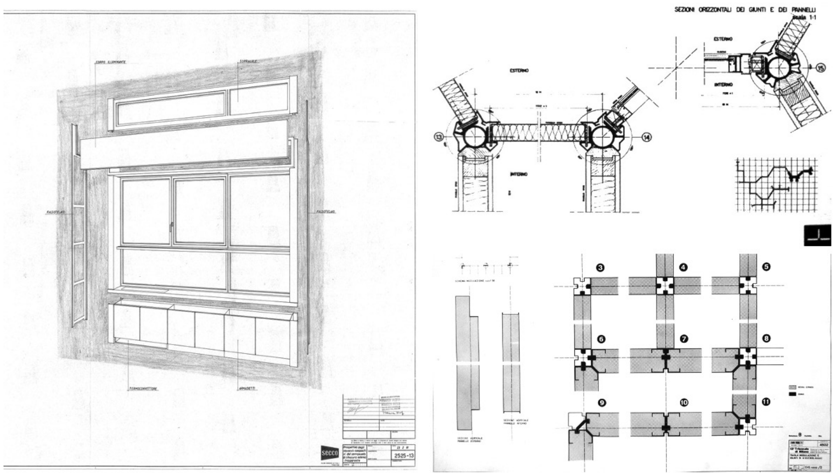


**Fig. 9.4.** Milan Triennale XII, competition: F. Albini and F. Helg, SECCO firm: transparent wall-unit (patented), BBPR Architects, SAIRA-SADI-LuxaFlex: pluridirectional joint for the assembly of prefabricated panels (patented), M. Terzaghi and A. Magnagni: SNAM, joint for the assembly of prefabricated panels. Triennale di Milano-Archivi, Milan.

derived from the assembly of standard elements available on the national building market.

In this sense, the competition featured promising prototypes. As such, we explain them in detail below: (1) the samples of individual elements proposed by the Aldo SECCO company, based on a design by architects Franco Albini and Franca Helg; (2) the grouping of companies SAIRA (*Smalteria Metallurgica Veneta*), SADI, and LUXAFLEX Alluminio, based on a design by the BBPR design studio; and (3) the integrated system, delineated by architects Augusto Magnaghi and Mario Terzaghi for the SNAM Progetti group (fig. 9.4).

## The Prototype by Albini and Helg for SECCO Company

From among the competing building elements, the committee chose the prototype presented by the Aldo SECCO company, a transparent wall package consisting of variously combinable elements. Each element functioned as a single component embedded in a traditional building or as base module of a fully prefabricated construction system. The structure consisted of a series of galvanized steel sheet profiles that framed the components of a wall unit (lockers, opening frames, and fanlight). Between two so-called false-frames, two external C-shaped sheet metal profiles functioned in the same way as joints for the coupling of two modules and as a counterframe for the insertion of the wall unit into the traditional masonry walls. After the competition, the SECCO company filed two new industrial patents to manufacture unique metal window frames called Monobloc, "complete with frame, shutter and relative box, preassembled in a single block."[26] The industrial inventions focused on the two design themes addressed by the Albini-Helg project on which the proposal was based: a prefabricated window unit, embedding the components of the traditional window frame, and its installation in both conventional construction and integral prefabrication systems.

## The BBPR Prototype

Taking part in the same section of the competition, the association of the companies Smalteria Metallurgica Veneta, Officine SAIRA, SADI, and LUXAFLEX Alluminio in connection with the design studio BBPR proposed the project of a "single element." Unlike the projects presented by the other companies in that section focusing on the definition of individual elements, the prototype designed by BBPR featured a joint with which assembly angles between panels could range from 90° to 180°. The connecting element allowed for standard components of panels and window frames within a system with a large degree of freedom of aggregation. As evidence of the various combinatorial possibilities enabled by the connection, the designers offered a series of floor plans showing the arrangement of the perimeter panels and the internal divisions based on five different angles (90°, 120°, 135°, 150°, and 180°). The jury considered the prototype an "element of good design and excellent functional performance," embedding "excellent solution of both the frame and the elements and moldings."[27] The model was also very successful with manufacturers, who realized its potential in the construction market. During the competition, the designers filed an industrial patent for a "joint allowing two or more prefabricated panels to be joined at different angles."[28] The invention involved a joint for connecting panels at different angles, which was similar to the Triennale prototype but also offered some additional features. The system consisted of a hollow tubular mullion that connected elements between the upright and the panels, and a series of "cover strips" that concealed the gaps between the components. The mullion, whose diameter could vary according to the thickness of the panels, was made of steel and flanked by connecting elements composed of extruded aluminum profiles. The latter was the core of the invention. By exploiting the extrusion technique, which allows for very complex shaping, it was possible to configure sections that would enable nine different assembly angles between the panels.

The prototype bore witness to the general interest of the designers of the time in studying the extruded joint within the framework of light prefabrication systems. The production of shaped profiles at relatively low costs enhanced the possibility of using a wide range of standard products, safeguarding the expressive autonomy of the construction detail.

## The Prototype by Magnaghi and Terzaghi for the SNAM Progetti Company

For the "combined elements" section of the competition, the jury highlighted, among other issues, the proposal submitted by SNAM Progetti with the Flli Greppi company and the architects Magnaghi and Terzaghi. The proposal, accompanied by a detailed study of assembly times and operations, relied on a metal framework and lightweight panels system. The project focused on the "industrialization of the individual elements with which to compose the building," instead of defining a "specific solution that would lead to the industrialization of a type of building."[29] Thus, the project represented an "open system" of elements and connections that allowed for different planimetric configurations based on a dimensional module (M = 10 cm) and its multiples (3M, 6M, 12M, 24M, and 30M). SNAM's proposal featured a model of a "general construction cycle," precisely defined in all its phases, and the design of a unique mullion, whose section also allowed for the connection between panels. Like the "single element" designed by BBPR, the Magnaghi-Terzaghi mullion joint was made of extruded sheet metal: two subsequent concepts led to the design of a hollow flower-like mullion, which allowed for an interlocking connection with the panels.

## On the Italian Way: Histories of Successful Building Systems

Among the prototypes presented at different Triennale exhibits, only a few found practical applications in the national building market. The Gaburri system, presented at the VIII Triennale, and the FEAL system, shown at the X Triennale, were the main success stories, and both were widely adopted in Italy and abroad. The Gaburri system supported the integration of prefabricated systems on the traditional Italian building site by decomposing the concrete frame into hollow elements to be completed on site. The FEAL system presented an entirely industrialized system, combining standard products of excellence from the Italian steel industry with the ingenious customized designs of the construction details and assembly processes.

## The Gaburri System

The Gaburri system, implemented at QT8, was the product of three industrial patents filed by construction expert Leon Battista Gaburri between 1941 and 1945. A technical memoir published in the magazine *Cantieri* in 1947 described the original patent as follows:

> The patented CEP system allows for the construction of any type of single- or multistory building, such as minimal, medium-sized, and luxury dwellings, rural constructions, villas, seasonal cottages (also in the high mountains), hotels and industrial buildings, sheds, docks, railway stations, warehouses, canopies, shelters, pylons for power lines and cableways, piles, piers … as well as offering the possibility of quickly restoring collapsed floors of damaged buildings, since the slab can also be used on traditional types of buildings.[30]

On the QT8 construction site, the chronometric test of the Gaburri system verified the inventor's predictions in terms of efficiency for the large-scale construction of residential buildings. As C. Rusconi Clerici noted in a later edition of *Cantieri*, "Considering that each mold produces two castings per day and that each room requires approximately two pillars and two beams, with ten pillar molds, ten beam molds, and two plinth molds, the load-bearing structure required for the assembly of 1000 rooms can be prefabricated in 100 working days."[31]

In 1947, at the same time as it was being exhibited at QT8, the system was used abroad for the first time. Gaburri moved to Argentina, where he was awarded the contract to build housing districts as part of the Plan quinquenal de obra publica (1946–1951). While in Italy, in 1949, the launch of the INA-Casa plan prevented the system from being used in the public housing sector, the Argentina experience was a test case for the large-scale verification of the advantages and limits of the proposed procedure. In 1952, with the second Plan quinquenal de obra publica (1952–1957), the Gaburri system was used in the Barrio 17 Octobre on the outskirts of Buenos Aires, featuring heterogeneous building types from cottages to schools to multistory buildings. After this large-scale application, the system was enhanced by revisions and refinements, as can be seen by patents filed in the 1950s.[32] The system, perfected in use, consisted of internally hollow columns and beams characterized by a rapid and robust connection system with the beams. Its columns and beams, completed by filling and solidifying nodes, formed a frame. Different terminations characterize the pillars: "In practice, each pillar can carry one or more beams and therefore four types of termination have been studied," thus obtaining "a row pillar," "a corner pillar," "three-beam pillars," and "crossing pillars."[33] The terminations also

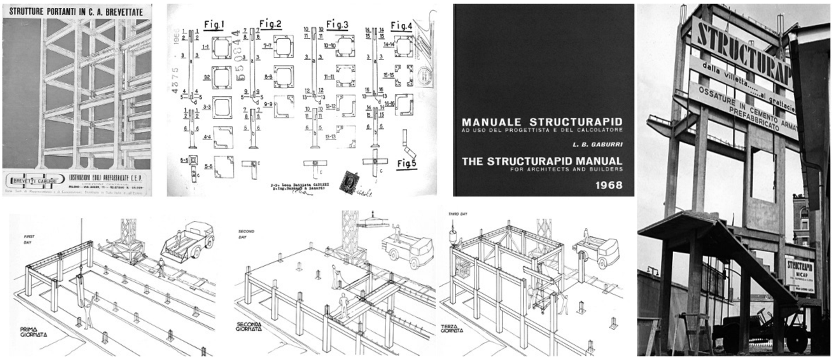


**Fig. 9.5.** The STRUCTURAPID Gaburri system: cover picture of the system patent, 1947, drawing of the system patent, 1956, cover pictures of the handbooks of the Gaburri system, 1968, promotional model of the system and representation of the assembly steps, 1968. Courtesy of Iris Gaburri, Iris Gaburri Private Archive, Alassio.

allow for the connection of beams that "coming out of a pillar should form angles between them of 90° and 180°," guaranteeing better spatial articulation of the structure. To complete the frame, the beam, T-section throughout its extension, had two rectangular-section ends that allow it to be inserted into the column cavity. The variation of the terminations was in contrast to the modularity of the structural solutions: coupled standard components rather than "special pieces" were used to deal with significant structural tasks.[34]

In 1956, the system took on the new trademark STRUCTURAPID (building element materials, precast reinforced concrete load-bearing structures).[35] The patent extended to sixteen countries, including the United States, Indochina, and countries in South America and North Africa.[36] In Italy, eighteen construction companies acquired the STRUCTURAPID patents, providing for the production and marketing of the system throughout the country.[37] In 1963 a large-scale entrepreneurial project coordinated by the Montecatini Edison Industrial Group supported the extensive spread of the system in different building market sectors.[38] In 1968, the publication of the *STRUCTURAPID Manual for the Use of the Designer and the Engineer*, a technical manual for the use of the system in Italian and English, promised economy of time and cost and enhanced the system's commercial success in Italy and abroad (fig. 9.5).[39]

## The FEAL System

The FEAL integral prefabrication system designed in collaboration with the architects F. Fratti and G. Pozzi and engineer C. Castiglioni was named VAR/M3, which combined the initial letters of its inventor, Varlonga, and the number 3, derived from the measure of its dimensional module, which was 300 mm.

The prototype introduced the 300-mm module, which had already been adopted internationally. The structural device, arranged according to regular spans of 5.10, 11.10, and 3.30 m, consisted of simple, unified, and standard elements such as profiles or hollow tubes, completed by pairs of tie rods. Welded steel joints ensured the connection between the components. The floor consisted of a concrete slab, reinforced with an electro-welded net cast in special recoverable steel formworks, which had shaped opposite edges that rested on the lower wing of the beams and did not require temporary supports. Like the prototype exhibited at the X Triennale, this system was also the subject of a patent (no. 582486, 1958) and was included in the FEAL catalog.[40]

Among the lightweight prefabrication proposals presented at the Triennale, FEAL experienced the most significant application in Italy. The system, accompanied by numerous patent applications, was tested in the 1950s for single-story school buildings. In the 1960s it was employed in the construction of multistory schools (there were at least 154 so-called FEAL schools built in Italy between 1960 and 1963) and residential buildings.[41] The system's high level of industrialization, which included maximum standardization of components, accelerated assembly times, and accelerated concrete casting, accounted for its uniqueness on the Italian scene of those years. Characterized by mixed structures of steel and concrete, extruded aluminum completions, and steel plate panels, the FEAL system demonstrated a high degree of flexibility, which meant that it could also accommodate other finishing materials.

In addition to its advanced specialization of individual components, FEAL adopted some very unusual construction-site procedures. The metal frames of the floor slabs were assembled on the ground and stacked one on top of another. Each frame was then raised to the design height, sliding on the load-bearing metal columns that acted as guides. Reinforcement bars were set, and the concrete was cast in recoverable metal formworks; the cast-on-site slabs were later replaced by reinforced concrete prefabricated slabs, called *predalles* (prefabricated reinforced concrete slabs). An example of the versatility of the FEAL system was the residential complex for the company's members in Via Laveno in Milan, designed by architect and designer Marco Zanuso (1916–2001) and built by the Edilvar cooperative between 1961 and 1963. On that occasion, Zanuso actively collaborated with the FEAL company to evaluate the possibility of pursuing more distinctly figurative outcomes through modular systems for different building typologies, exploiting natural materials and dry assembly techniques.

Zanuso designed two identical buildings, articulated on three floors beyond the ground floor, rotated by 90°, and set on a primary geometric grid. The grid guided the alignment of the structure, windows, and internal partition walls. The square staircase block and the lift functioned as a hinge for the living space distribution. An offset of 1.65-m height of the three-level structure contrasted with the modular conception of the plan, generating an irregular and very articulated volumetry of the building.[42] The whole project was based on the adoption of the integral VAR/M3 construction system, which involved extending the industrialized methods to the organization of the working phases and to the casting procedures. The system used HE steel columns with dry-connected main and secondary beams. The internal partitions consisted of 6-cm-thick fitted walls, made of metal, plaster, or wood, which were dry mounted. Of particular interest on the technical-architectural level was the solution adopted for the envelope, which combined technological updating and construction tradition. The wall was made of the FEAL panel, which consisted of a double metal steel plate inside and aluminum outside with an interposed insulating layer of expanded polystyrene. Its total thickness was 6 cm. The panel was connected to a series of secondary aluminum posts anchored to the floors. An 8-cm gap separated the panel from the external finish, which was made with 3-cm-thick slabs of gray Piperino trachyte. The slabs were inserted dry into natural anodized aluminum profiles, which were fixed to the rear structure.

The vertical arrangement of the slabs, the staggered horizontal joints, and the rhythmic scanning of the visible metal profiles contributed to accentuating the upward thrust of the facade, which contrasted with the horizontal lines of the balconies and the crown molding. Furthermore, the technological solution referred back to the curtain wall as a light surface that was independent of the building's primary load-bearing system, which in those years, especially in international models, more than other elements signified the new evolutionary processes in construction. In Zanuso's works, the finishing materials were also standardized; thus, the stone claddings featured a precision cutting treatment that was more akin to industrial processes than craftsmanship in adapting to the minimum tolerances allowed by the steel framework. The residential complex in Via Laveno bears witness to the conception of the traditional middle-class house as an industrialized product, based on the fully integrated approach between industrial research, construction-site evolution, and novel aesthetic values. The industrialization processes—often oriented to provide an adequate response to the need for housing—took on a singular specificity in Via Laveno, offering the technological repertoire to support and enrich the architectural language renewal (fig. 9.6).

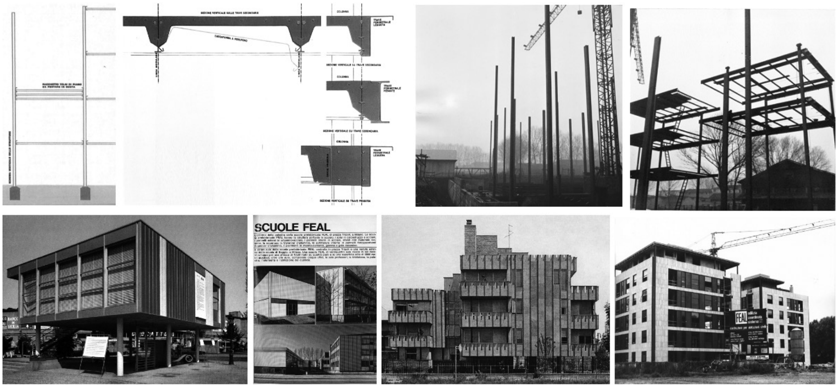


**Fig. 9.6.** The VAR/M3 FEAL system: construction details of the structure, steps of the assembly process, FEAL school prototype, 1958, M. Zanuso: House in Laveno street, Milan 1961–1963 and House in Solaroli Street, Milan, 1970–1971. *FEAL 1960*, Catalog, Milan: Crespi, 1960.

FEAL also exported its construction system: in 1960 foreign orders accounted for approximately 30 percent of its production.[43] The FEAL 1960 information brochure listed the completed constructions from 1955 on, divided into categories: in addition to the Milan and Pomezia plants, the list included thirty-five exhibition buildings (twenty-two of which were abroad), more than a hundred office buildings and industrial complexes, forty residential buildings, nursing homes, cinemas, hotels, barracks, garages, and schools. The catalog of industrialized construction elements was later extended to vertical closures, roofs, false ceilings, internal partitions, and even plant blocks, thus completing the system components.

## Conclusions

Between 1947 and 1960, the Triennale fueled a vigorous architectural debate around industrialization. Its outdoor and indoor exhibitions served as a driving force for the application of exhibited construction systems in actual building practice and for the spread of technical innovations in the sector. Although QT8 did not yield the expected results in terms of the application of industrialization to mass housing, the prototype experimentation had a mobilizing effect on shaping a technical culture around the technological evolution of the building process. In particular, the involvement of the Institute of Architecture of the Milan Polytechnic in monitoring the QT8 construction sites promoted research on construction experimentation and the transfer of industrial methodologies into construction. Giuseppe Ciribini was especially influential in the developments that led to the establishment of the Italian Committee for Building Productivity and the first course in Building Site Organization, under the auspices of the Chair of Building Architecture at the Milan Polytechnic in the 1950s.

Alongside the most compelling experiences of the VIII and X Triennale, significant echoes of the discussion on light prefabrication systems could be found in the "Proposals for Construction" section of the XI Triennale. The exhibition unit curated by Ponti was designed to demonstrate the "relations established by the various industrial productions toward construction architecture," as it reads in the catalog.[44] The "indication of technical coherence resolving itself into stylistic coherence" was the central theme of the exhibition unity.[45] Among the many objects on display was the FEAL industrialized house element, which demonstrated the evolution of the "vertical house."

In addition to the successful Gaburri and FEAL systems, some authorial examples bear witness to the application of the more experimental prototypes presented at the Triennales. These include the Corte di Cadore mountain village, which was commissioned by ENI (Ente Nazionale Idrocarburi) in 1955 and entrusted to architect E. Gellner. The village featured the use of the ER-Cal system, presented at the X Triennale, and based on the use of Salvit panels. The Salvit panel size of 122 cm, adopted as the building module, ensured perfect adherence to the demand for standardization of construction elements envisaged by ENI's top management.[46] Further, the ER-Cal system optimized the thermal state of the walls, which was particularly important for the alpine climate. The village, inaugurated in 1958, represented a model of typological innovation and a clear example of constructive evolution.

The Triennale exhibitions devoted to industrialization between 1947 and 1960 contributed significantly to the architectural culture debate around the evolution of building techniques and the technological upgrade of the building site in Italy. The prototypes presented recount the various paths along which investigation developed in the transition from the urgency of reconstruction to the years of the economic miracle, framed in a delayed and fragmented process compared to such foreign experiences as those of the French and the English. On the one hand, the prototypes demonstrate the design of metal light prefabrication systems via the integration of standard components through the authorial design of the construction details. On the other hand, they document the integration of prefabricated reinforced concrete elements in the cast-on-site-based construction site. Lastly, they document the general similarity between the building industrialization process and the product design approach, and feature the designer's active role in all production phases.

In this sense, the Milan Triennale Exhibitions, framed in the section of this volume devoted to the role of display in the development of prefabrication, were showcases for the specific Italian design approaches in the international discourse on building industrialization.

## Notes

1. Anonymous, "La ricostruzione edilizia ed i quartieri sperimentali del Ministero dei LLPP," 1949, typewritten original report, Milan, Triennale Archive (ASTRN), Milan.
2. Anonymous, "T8," in *VIII Triennale, catalogo della mostra* (Milan: Crespi, 1947), 81–82.
3. Ibid.
4. Ibid, 88–91.
5. Ibid.
6. Anonymous, "La ricostruzione edilizia."
7. Piero Bottoni, "Il quartiere sperimentale QT8. Le case prefabbricate," *Metron* 26 (1948): 148.
8. Gaetano Ciocca, "Punto di partenza," *Cantieri* 2 (1946): 2–4.
9. See letter of Cristoforo Nider to Piero Bottoni, July 3, 1947; letter of Luigi Ciarlini to Piero Bottoni, December 21, 1948: "I would like my method of building wall to be followed, without scaffolding, in just 8 days"; letter of Piero Mariani to Piero Bottoni, March 21, 1949: "Everything is done by hand [and] not being able to recover the shapes one ends up making a jet a day, therefore maddening slowness!", ASTRN, VIII Triennale, Milan (translation by the authors).
10. Sergio Poretti, "Le tecniche edilizie: modelli per la ricostruzione," in Paola Di Biagi, ed., *La grande ricostruzione: Il Piano INA-Casa e l'Italia degli anni Cinquanta* (Rome: Donzelli, 2010), 113.
11. A heated debate on the role of the designers in the industrial process emerged in Italy in the 1950s and 1960s alongside discussions of industrial design developments, involving art historians, architects, and artists. For insight on this topic, see Vittorio Gregotti, *Il disegno del prodotto industriale: Italia 1860–1980* (Milan: Electa, 1986).
12. Ivan Matteo Lombardo, "Propositi e realtà della X Triennale," in *X Triennale, catalogo della mostra* (Milan: Crespi, 1954), 21.
13. Ibid., 22–23.
14. Ibid.
15. Giovanni Varlonga, patent n. 524970, 1955, Italian Central State Archive (ACS), Italian Office of Industrial Patents and Trademarks (UIBM), Rome.

16. Ivan Matteo Lombardo, "Propositi e realtà della X Triennale," in *X Triennale, catalogo della mostra* (Milan: Crespi, 1954), 21–23.
17. Ibid.
18. Anonymous, "La Casa e la Scuola," in *X Triennale, catalogo della mostra* (Milan: Crespi, 1954).
19. Ibid.
20. Ilaria Giannetti, "*La scuola è aperta a tutti*: Esercizi di industrializzazione alla XII Triennale di Milano (1960)," *Annali dell'Accademia Nazionale di San Luca* 1 (2015): 193–203.
21. Competitions, Announcement of the Competition, 1960, ASTRN, XII Triennale, Milan.
22. Ibid.
23. Ibid.
24. Competitions, Report of the Jury by Pier Luigi Nervi, 1960, ASTRN, XII Triennale, Milan.
25. Competitions, Report of the Jury by Giuseppe Ciribini, 1960, ASTRN, XII Triennale, Milan.
26. Aldo Secco, patent n. 681952, 1963, ACS, UIBM, Rome.
27. Competitions, "Report of the Jury," 1960, typewritten original document, ASTRN, XII Triennale, Milan.
28. BBPR, patent n. 675627, 1962, ACS, UIBM, Rome.
29. Mario Terzaghi collection, XII Triennale, Competitions, SNAM Progetti, Centro di Alti Studi sulle Arti Visive (CASVA) Archive, Milan.
30. Lucio Castiglione, "Case prefabbricate in cemento armato. Italia, sistema CEP brevetto Gaburri," *Cantieri* 6 (1947): 5–16.
31. Carlo Rusconi Clerici, "Prove di rendimento del sistema CEP Gaburri," *Cantieri* 20 (1950): 5–20.
32. Leon Battista Gaburri, patent n. 550844, 1956, ACS, UIBM, Rome.
33. Leon Battista Gaburri, patent n. 392951, 1941, ACS, UIBM, Rome.
34. Leon Battista Gaburri, patent n. 550844, 1956, ACS, UIBM, Rome.
35. Leon Battista Gaburri, *Manuale Structurapid ad uso del progettista e del Calcolatore* (Milan: Tip. Abbiati, 1968).
36. Ibid.
37. Ibid.
38. Ilaria Giannetti, "The Design of a System: Industrialized Schools in Italy (1960–1975)," *Tema* 1 (2016): 134–44.
39. Gaburri, *Manuale Structurapid*.
40. FEAL, *Var M3. Sistema coordinato di edilizia industrializzata*, Milan, document without date, ASTRN, Milan.
41. Giannetti, "The Design of a System."

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Tzafrir Fainholtz earned an undergraduate degree and a PhD in Architecture and is a Researcher in the HoPE Project, Åbo Akademi University, Turku. A Teaching Fellow at the Technion-Israel Institute of Technology, Haifa, his primary research interests are the history of architecture in the twentieth century and the spread of modernist architecture. He is a member of the Scientific Committee for 20th Century Heritage, ICOMOS, and DOCOMOMO Israel.

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Alberto Franchini earned a PhD in the History of Architecture and Urban Planning from the IUAV University of Venice in 2019 with a thesis on Giancarlo De Carlo (awarded the L'ERMA-C Prize and published in 2020). He was a Fellow of the Alexander von Humboldt Foundation at the Architecture Museum of TUM from 2021 to 2023, a Postdoctoral Researcher at the Archive of the Modern (USI) from 2019 to 2021, and an Instructor at Milan Polytechnic from 2020 to 2022. He has been a Research Assistant at the Chair of Modern Heritage Conservation at Technical University of Muich (TUM) since February 2024. His interests focus on understanding the role of the user in the design and modification of built heritage.

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Liat Savin Ben Shoshan, BArch, PhD, studied architecture at the Bezalel Academy of Arts and Design and Bar Ilan University. As a Postdoctoral Fellow at the Technion-Israel Institute of Technology, Haifa, she focused on the architect and town planner Yitzhak Perlstein and his cinematic documentation of his works. She writes and lectures on film, culture, and space, and on writing and filming as research methodologies in architectural planning. She has published papers on the window as a cultural and virtual space, the interrelations of urban space, memory, and cinematic space, documentary diary films and the city, and architecture and its reflection in film in the mid-century eras, particularly related to the postwar context and nation-building.

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Maria Tassopoulou, PhD, is an architect with interests in architectural and urban history, urban politics, and modern urban heritage. With a passion for interdisciplinary research, she explores the intersection of urban management, politics, and expertise, while also delving into the potential of digital archives in architectural research. She recently edited an open-access collective volume titled *City Politics and Architecture 1974–2004* (Athens: ΕΙΘΑ, 2023).

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Anna Wilczynska, PhD, is a researcher in the HoPE Project and Lecturer at the Chair of Landscape Architecture, Estonian University of Life Sciences. She is interested in citizen science and landscape perceptions and bottom-up urban development. She was involved in the project and activities associated with the preservation and development of the Jazdów neighborhood of Puutalo houses in Warsaw.

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