Skyscrapers in Milan after World War II. A reinforced concrete design exploration

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Following World War II there was an immediate need in Italy for housing and the case of Milan is quite interesting. At the time, it was quite curious to talk about high-rise buildings in Milan: "be they the Lancia Tower at Porta Venezia, the nearby Swiss Tower or the residential tower blocks overlooking the Parco Sempione, the 'Piazza Diaz Tower' or the clump in Piazza Argentina or Melchiorre Gioia"[1]. The only serious exceptions, as reported by Cecilia Bolognesi, were Velasca and Pirelli towers. "Neither set out to become icons – they were designed as good honest architecture"[2]. Despite initial controversy, both have, in the course of time, become architectural landmarks, essential parts of Milan's image of itself. Moreover, these two exceptions, as well as the Grattacielo di Milano in Piazza della Repubblica, were the first to tacitly exceed the inviolable height of the glistening gold Madonna atop the Duomo.
We have to wait for the post World War II, thanks to the U.S. influence, for the first skyscraper to raise in Milan. The Milan skyscrapers built after World War II testify the willingness of the *miracolo economico* middle class to forget the twenty years of the fascist regime, the war, and post-war stress. They look to the tall buildings of U.S. cities as an idea of modernity, new technologies, and a new way of life, more international and adequate to boost a fast-rising economy.
In the Centro Diaz the architect, Luigi Mattioni, was inspired by Rockefeller Center in New York hosting on the last floor of the tower the famous Terrazza Martini, the reference location for most of the high-life events of the subsequent decades in Milan. In this context, the driving ideas in the design of the Torre Velasca were instead the concept of inclusion of extraordinary volumes in the existing urban fabric. This approach was at the time not usual because both the city managers and designers looked at rupture elements.
As the last example, we mention the Torre Galfa, designed by Melchiorre Bega, characterized by a simple design where the no-standard element was given by the split-disposition of the continuous window frames and, finally, obviously the Pirelli tower.
The Grattacielo di Milano in Piazza della Repubblica, designed in 1950 by Luigi Mattioni and the Soncini brothers, is a landmark in the his-

tory of modern architecture in Milan, resulting from a synergy between technical knowledge and business skills. The work was also a turning point with regards to city-planning, thereby constituting the first exception to the height limit of Duomo's "Madonnina" and breaking municipal conventions, which called for the construction of a massive volume, a mirror-image of the building designed by Mario Bacciocchi in the Thirties and located on the opposite side of viale Vittor Pisani. The image of Mattioni's tower, inspired by the model of the American skyscrapers, is the incarnation of the dreams and ambitions of its time: by replicating its model in a futuristic urban view, Luigi Mattioni elaborated a study for the construction of thirteen reinforced concrete towers arranged in a circle around the city center, on top of which the stops of an aerial circle-cableway were to be placed, with carriages transported by strained wire ropes from high-rise to high-rise.
Seventy years later, the image of the Grattacielo in Piazza della Repubblica is still a symbol of modernity, keeping its visual centrality against the jagged skyline of a city that is once again seeking change. The project has been realized by the Studio Architetti Soncini and the Studio Architetti Mattioni while the direction and the general organization were by Pio Capelli. The project consultants were Danusso, Portaluppi, and Setti with Sozzani, Papini, and Rognoni for the design of reinforced concrete structures, and Piccinino for the technical plants. With reference to the construction process, all classical systems used in reinforced concrete buildings were implemented, but with some significant improvements, mainly with respect to the cranes (implementing some ideas from those used in shipyards) and prefabricated components.
The Torre Velasca was built in 1956-58 and is protected as a cultural heritage building since 2011. The BBPR studio (architects G. L. Banfi, L. Belgioioso, E. Peressutti, and E. N. Rogers) was a preminent design firm in the country. The architects justified the choice of a tall building to be in agree with the theoretical positions of the Modern Movement and to create a new relevant episode, in the city center, that was qualified from an architectural point of view (as the post-war buildings had flattened and uniformed the skyline of Milan). Moreover, the development in height of the building allowed to gain more space at the ground level for the plaza (that could be used for parking and city services) and a better view inside the offices and apartments.

Luigi Mattioni, Eugenio Soncini, Ermenegildo Soncini, Grattacielo di Milano, 1950-55. Construction works [Fifties]

BBPR, Torre Velasca, Milano, 1950-58. Construction works, 1956

In an interview, Belgiojoso said that the tower design was a very long process that lasted almost ten years while the realization took just three. The form-finding process took into consideration different solutions: from a W shape tower with a smooth façade and a terrace on the top, to a T-plan tower with a dark band to visually separate the functions inside the building. The uncertainty about the image that the plaza had to achieve is documented by several sketches that the architectural firm developed at the same time. The two main ideas were quite opposite: one considered the plaza as a parking lot space while the other, more romantic, was mainly a pedestrian area.
In the following form-finding step, the plan of the tower became rectangular, and the wider part of the tower was abruptly separated by the lower thinner part of the building. At this stage, BBPR started building scaled models to study the final shape that the tower had to assume.
In the beginning, the Velasca has been designed to be in steel and presented a structure with eight columns on the longest side and four on the other. In the next step, the columns became seven and wider (*costoloni*), supporting the overhang above. The connection part is made of V-shape struts (*a forcella*). The exigence to underline the verticality of the building through the structural elements, led to avoiding the dark band that originally was imagined for dividing the offices from the studio/apartment. Moreover, thanks to the models it has been possible to note that even the entrance has been subjected to different solutions. An interesting aspect of the design process was the change of the structural material after having chosen the shape of the tower. After having notified the amount of steel needed for the construction and the overall cost, it was evident the expensiveness of this solution. Realizing the same structure in reinforced concrete would have been cheaper, by about 25%, than in steel. The saving gained by the reinforced concrete solution led the architects and the clients to prefer this material instead of steel. So, Arturo Danusso, a "concrete enthusiast"[3], became the chief engineer of the project.
From a structural point of view, the structure was really challenging and innovative as it was composed of a central core (*nucleo*) and a set of sixteen columns along the perimeter. For the first time that the bracing function was entirely supported by a unique element: the core. Moreover, the columns had a trilobite cross-section that presented several uncertainties about the structural behavior.

Danusso did some tests at ISMES in Bergamo in relation to the wind-bracing system (the core) and the reinforced concrete floors that had the longest span. Important references for this project were the high-rise buildings realized in Brazil, in San Paolo and Rio, as it was the only country in which reinforced concrete skyscrapers had been already realized.
Another important issue was the design of struts that had the essential role to sustain the wider part of the tower. Moreover, a model of an entire column was realized (with a length of 90 meters) in order to verify the construction procedure and its shape through photographic images that portrayed it in different perspective effects. So, the final version of the project was the result of a long debate between the architects and the engineer. This synergic iterative process shows that the architectural and engineering aspects are inseparable in the design. Even the roof design had a long gestation: the form was designed to satisfy several criteria such as solving the problem to hide the technical volumes on top of the tower, maintaining the idea of a traditional mansard roof, and defining the inclination of the pitches from the street view. Torre Velasca's design provoked a sort of furor in the international press because of its historicism. On the contrary, Gio Ponti (the architect of the Pirelli building) admired and loved the presence of the Torre Velasca in Milan. Yet, the major interest is here the structural concept, based on the concrete walls of the stairs and elevators block located in the central area, associated with the concrete frames located at the façades and resulting in a lattice enveloping the entire building. The system is one of the first realizations of the tube-in-tube scheme, which will have great development in the following years particularly in the U.S.. It is worth remarking that the Torre is one of the first reinforced concrete buildings reaching a height of 106 meters. The structure was designed by Arturo Danusso. The scheme, and the double symmetry, will prove effective to seismic response. Traditional brick infill walls were used inside and precast panels outside. The inclined struts at the top expansion apply compression to the lower floor where they connect, and tension at the upper one. Beams with pre-tensioned cables have been used in the tension zone, while the compressed slab is thicker than regular ones.
The Pirelli building, known for long in Milano as "Grattacielo Pirelli", was built between 1956 and 1961 for the Pirelli company and in some ways symbolized the vital and energetic post-war industrial character

of the region. Prominent architects and engineers worked on the project. The architectural design is by Gio Ponti, the slender and elegant structure was conceived by Pier Luigi Nervi and developed and realized once more by Arturo Danusso. The Pirelli building can be considered a *manifesto* of the post-war industrial development in the Lombardia region. It displays the sign of new technological progress and the faith in the future, modernism, and ambition of Pirelli company to become the emblem of their philosophy.

The design and construction team presented the architect Gio Ponti and some of the major architects and engineers of the time like Antonio Fornaroli, Alberto Rosselli, Giuseppe Valtolina, Egidio Dell'Orto, Pier Luigi Nervi, and Arturo Danusso. Nervi and Danusso were charged with the design and computation of the structure while Pirelli company became the construction manager of the project with the help of Bonomi e Comolli firm as a consultant. So, in this building, we find both the synergy between the form-finding by Gio Ponti and the structure by Nervi and Danusso. The two souls of the project are the Olympic and crystal-like shape by the architect and the dynamic structure by Nervi. The adaptability of reinforced concrete to any shape meant freedom in the form-finding process. However, the architectural shape had to express it in its materiality the flowing of stress inside the structure itself. The skyscraper in Ponti's view is an *opera* fixed forever in its perfect shape in the urban landscape. For this reason, Ponti believed that architecture is a metaphor to achieve purity, order, vital force, stillness, eternity, silence and enchantment: "di forme chiuse, dove tutto [sia] consumato nel rigore dei volumi e d'un pensiero"[4]. Architecture as *forma di sostanza* and not as *forma di forma.*

The skyscraper stands on a basement in reinforced concrete, extending along the perimeter with 31 floors (including the technical volume on the top), 127,1 meters high and rounded on three sides by lower volumes. The characteristic lentiform, elongated shape of the building, 70,4 meters long and 18,5 meters wide, created several static problems because of the elevated height of about 127 meters. It was at the time of its construction the tallest reinforced concrete building in Europe. Its plan dimensions, of 70,4 meters by 18,5 meters account for its slenderness, which posed statics problems. The 18,5 meters across for a height of 127 meters was an unusual ratio in high-rise buildings. The figure shows the building outline and the plan, with the characteristic

tapered extremes, the "tips". The statics challenges posed by geometry brought to design a mixed structure, where the area of the tips presents stiff boxed vertical structures, that contained also stairs and elevators. Additional load bearing structures were the four concrete walls positioned two by two transversally at a distance of 24 meters. The walls actually had openings that permitted the use of the floor as open space. The slender structure, by Nervi's design and made executive by Arturo Danusso, was composed of four bearing walls ("setti portali trasversali") that emerged two by two on the external view and by two triangular-shaped volumes, called "punte", that hosted the distributive systems (lifts and stairs). The bearing walls, 24 meters spaced out, allowed the setup of large open spaces for offices. The roof, designed by Ponti as a plane, stands on the last floor and seems to fly on the underlying volume. In Ponti's words: "librarsi leggera […] come un'aureola che avrebbe finito poeticamente la torre sul cielo"[5].
The main view, instead, shows wide curtain walls, with aluminum frames, partitioned by the structural system (the triangular volumes at each end and the bearing walls) and lined with brilliant ceramic tiles. The floors for joining the curtain wall had to be tapered off at the extremities in order to reduce their thickness and avoid the creation of string courses. The aim was to give a free continuity to the glass façade towards the sky. However, Ponti regrets that the continuity is weakened by the presence of opaque glasses at the bottom part of the windows. The "punte", whereas, are characterized by openings with only "damned balconies"[6] ("dannati balconi") that the architect disliked instead of Pier Luigi Nervi, who considered them useful for static purposes.

Note

1. C. Bolognesi, *Tall buildings in Milan*, in “Domus Speciale Grattacieli”, 2003, p. 3.

2. *Ibid.*

3. As defined by Adrian Forty in his book *Concrete and Culture: A Material History*, Reaktion Books, London 2012, p. 112.

4. F. Brevini, *Grattacielo Pirelli*, Touring Editore, Milano 2004, p.16.

5. G. Ponti, *Si fa coi pensieri*, in “Domus”, n. 379, giugno 1961, pp. 1-30.

6. *Ibid.*