Proudhon, writing of the Halles Centrales markets in his *Du principe de l’art et de sa destination sociale* of 1865, said: «for a market where perishable products are stocked, the ideal would be to be situated in the open air. Since the uncertainties of our climate do not permit this, it would be better for the roof to be in some way suspended from a hook, high overhead, like a lamp from the ceiling; . . . the columns that hold everything up should occupy as little space as possible.»

Proudhon’s remarks point to at least two circumstances. The first concerns the growing demand throughout the 19th century for buildings with large covered spaces, freed from bulky vertical supports to permit the new functions that had come to enrich the urban panorama to proceed unimpeded: from exposition halls to warehouses and covered markets, from railway stations to commercial arcades, from museums to libraries. The second is more specifically concerned with a method—and one which was certainly alternative to those in current use—for covering large spans: the technique of suspending roofing framework directly from straight ties or cable-stays. First used for bridges, this technique was then successfully extended to roofing, though the number of examples constructed up to the 1940s was fairly limited (Zordan, Morganti, 1996, 9–67).

In Italy, it was not until the second half of the ‘40s that the first suspended cable roofs appeared, first for temporary pavilions erected for national trade fairs, and later for buildings that were intended to be far more durable, as they were designed to house aircraft. Indeed, both the restrictions imposed by the Fascist regime’s policies of economic self-sufficiency between 1935 and 1943 and a cultural climate which was anything but well-disposed towards attempts to push too far beyond the familiar ensured that this particular type of roofing was able to strike root in Italy only after the end of the Second World War.

The Milano trade fair in particular was one of the most active proving grounds for new departures in modern architecture, which was only rarely able to try its hand at such highly specialized enterprises. Almost all of the Rationalist architects then working in Lombardy made several appearances at this venue, where the pre-war group that included such names as Nizzoli, Albini and Carboni was joined from 1946 onwards by the young De Carlo, Gardella, Figini and Pollini, and Zavanella.

At the 1948 fair, one of the most noteworthy of the modern buildings was the Officine Meccaniche pavilion, designed by Renzo Zavanella following an earlier study carried out together with Bruno Negri and constructed by the contractors Feal of Milano. The pavilion provided a splendid setting for the futuristic «Belvedere» railcar, a brilliant new conception that set new standards for speed and comfort, and whose interiors were also designed by Zavanella.

Years later, in a letter of March 6, 1978, Zavanella wrote as follows to Roberto Zannotti, author together
with Marcello Cruciani of a monograph dedicated entirely to the railcar: «OM contacted me directly, appointing me to design and oversee the work involved in outfitting the railcar in question, as my work at the time had already earned me a certain reputation among the architects of the Rationalist avant-garde». As the Rationalist architect he saw himself as being, Zavanella thus designed the interiors of the railcar that was said at the time to practically fly above the rails. But his assignment also included designing the pavilion that would protect the railcar from the elements. For this pavilion, Zavanella opted for a type of roofing that was at once agile, lightweight and permeable to light, with a design centering entirely on the interplay between elements in tension: a design that conveys the idea of a rarefied mass entrusted entirely to a singular «poetics of the filiform» that takes its cue from Rationalism «explodes in the kind of plastic exuberance that finds a welcome stimulus to compositional freedom in the promotional nature of the advertising message.» (Irace, 1987, 64–73).

Six tubular lattice steel masts with removable connections of the same kind used for temporary scaffolding, positioned to one side of the longitudinal axis of the pavilion’s rectangular footprint, angle upwards above the wooden decking, which is likewise inclined and interrupted by six circular holes through which the masts pass. Converging at the top of the masts are the thin cable-stays —two main suspension cables and one backstay— whose unsymmetrical fan arrangement further reinforces the intentional dissonances that mark the structure as a whole. An angled tie closes the main direct suspension system used for the roof. The spindle-shaped masts are connected to each other by a three-dimensional framed truss located on the outer side of the roof deck. The braces that assist in suspending the roof framing and in stabilizing the entire structure are secured to this truss.

At the 1950 Trade Fair, Zavanella topped his 1948 exploit with an even more daring and imaginative roof design, where indirect suspension replaces the direct suspension system. The expressive force of Zavanella’s second design contrasts strongly with the wood and steel cable-stayed roof which the architect Scoccimarro —author together with Sironi of the cityscapes produced for Fiat at the 1936 and 1949 trade fairs— covered the open areas of the Turin automaker’s pavilion, whose icily schematic approach prevails over any ineffective cravings for form.

Zavanella’s architecture embodies a playful structuralism, entirely foreign to the technologically-minded «vernacular Esperanto» extolled in the 1946 Manuale dell’Architettura and to the culture that produced it (Tafuri, 1985, 18). In completed and highly original form, this is an architecture that expresses a degree of technological eminence that does not cut itself off from the subjectivity of the design act, and whose power would seem to spring from the desire to liberate itself from the geometric rigors of the new objectivity, undaunted by the unresolved issues that might be seen as a denial of one’s cultural identity.

By its very nature, the context in which Zavanella was called upon to work —city of spectacle and wellspring of modern complexity— spurred the architect to marshal, with bold aplomb, the new signs of Italy’s industrial society on the threshold of post-war reconstruction: in giving formal shape to his «tension machines», a personal re-reading of the Rationalist penchant for rigor, his creativity seems to

Figure 1
Officine Meccaniche Pavilion at the 26th Milano Trade Fair (R. Zavanella 1948): Sketch (Domus 229: 7)
draw new strength from the work of the Russian Constructivists of the Twenties — Victor Vesnin and Anatole Ludwig paramount among them — and from that done in the Thirties by Le Corbusier who, though on a different scale, suggests using a cable-stayed roof for the stadium of a national sports and recreation center capable of accommodating up to 100,000 people.

In 1957, Officine Meccaniche participated in the 35th Milano Trade Fair with an open-sided pavilion constructed entirely of steel tubing which once again featured cable-stayed roofing. This time, however,
there seems to be little room for the witty and imaginative exercises that distinguished Zavanella's work: here, we have an inextricable tangle of steel pipes for the piers and trusses, with a roof deck suspended from the slenderest of cables and whose structural members are all located on the exterior side. As a promotional statement, the pavilion still manages to hold its own, but its communicative power no longer springs from the originality of the roof design, but from its sheer size and exuberance as a showplace.

Of the proposals advanced at the Trade Fair, city of spectacle and chosen stage for all that was most modern in Italian culture and architecture, few indeed were taken up by the real city. Thus, the suspended cable roofs of the early Fifties, including that by an unknown hand that protects the parking area and buildings of a gas station on the extreme outskirts of Milan, now look like alien fragments, meteors come crashing down from some other world.

«On the international architectural scene of the late Fifties, the idea of the large structure took on a new and unaccustomed prominence. Experimentation in structural engineering, which, though by no means abandoned, had remained on the margins of architectural debate between the two wars, returned to center stage, thrust back into the limelight by the enormous growth of infrastructures . . . Underlying this widespread move to a new structuralism, we can see a renewed demand for internationality . . . In the international setting of the Fifties, in fact, while the overall backwardness of the construction industry is all too apparent . . . and while architectural culture stands accused of «retreating from the modern movement», Italian structural engineering assumes a leading role.

That this should be so is one of the paradoxes that have dogged Italy in this century. And there can be little doubt that it is a paradox that can be explained, at least in part, by the massive investments that were
poured into infrastructures (the sector hardest hit by the war), and by the presence of designers of large structures of the caliber of Nervi, Morandi and Musmeci (Poretti, 1997–1998, 96–102).

These are the contexts that gave rise to the first important uses of the directly suspended roofing technique in Italy, which not surprisingly took place between the end of the Fifties and the early years of the next decade. In our country as elsewhere, these applications were linked to the enormous growth of air transport.

With the construction of the Fiumicino international airport in Rome at the time of the 1960 Olympics, Italy’s first aircraft hangars were built. This was an opportunity to propose the first suspended cable roofs capable of covering large spans without obstacles on the interior or at the aircraft entrance, and which could be extended if necessary along their major dimension. Umberto Venanzi and Gianfranco Vannacci, followed somewhat later by Riccardo Morandi, used this type of roofing in their designs, selecting the simple cantilever static layout that had been in common use in the United States for several decades as the most straightforward approach.

The first tender competition was announced by the Ministry of Public Works in 1958. The tender was awarded to Castelli Costruzioni Edili S.p.a. of Rome, who subcontracted design and fabrication to the Centro Carpen teria Tubolare Dalmine, where Venanzi and Vannacci worked as structural engineers. Once initial uncertainties concerning which type of solution was most appropriate had been overcome, a roofing design was chosen that made use of cable-stayed three-dimensional framed main trusses of various heights, all 52 meters long. Fabricated from tubular structural sections, the trusses rest on a steel lattice pier and are suspended from a rigid rod, whence forces are transferred to the ground via a mast and a bottom brace. Venanzi and Vannacci, however, did not go beyond a purely engineering approach to the project: once they had decided on steel, they were able to avoid wasting too much time on the details of the structural members, allowing the full constructional rationality of a building that was required to be both functional and economical to surface. The two Italian engineers’ extremely pragmatic approach is in line with that which their American counterparts had been using for some years in dealing with the same constructional issues applied to similar types of buildings, employing highly sophisticated steel load-bearing systems and modifying them according to the size of the aircraft involved.

The second tender competition, announced in 1960, concerned a complex of hangars, storage facilities and office buildings for an Alitalia aircraft maintenance center to be located on a site adjacent to that occupied by the recently completed hanger. While Castelli submitted a bid for a design which was considerably less daring than that constructed two years earlier, the tender contract was awarded to Astaldi–Lodigiani–Salvi (A. L. S.), who had presented a design by the Roman engineer Riccardo Morandi.

Morandi approached the project in the belief that, as he wrote after the work was completed, “... the most modern advances in the art of building with reinforced or prestressed concrete are well able to rise to the challenges posed by the enormous mass of formal, technical and executive problems involved in this area” (Morandi, 1964, 695–710). In the final design, two symmetrically paired hangars surround the office buildings, and the central space is occupied by the maintenance shops. For the roofs of the two hangars, Morandi brings all of the design intuition he showed in his cable-stay bridges into play, showing a masterly balance between boldness and rigorous design control that is nowhere more evident than in the spatial arrangement and configuration of the structural members.

The challenge of covering spaces of over 12,000 square meters with no structural obstructions of any kind was brilliantly solved through the use of curving beams of prestressed reinforced concrete divided into three elements linked by articulations and suspended from stays consisting of bundled steel cables protected by concrete sheaths, which are also prestressed. As in the earlier American examples—which Morandi appears to have drawn on to some extent—the gap between the beams is spanned by ribbed reinforced concrete panels prefabricated on site in a workshop which also produced the beams and paired masts that were located on the firewall in order to transfer cable loads from the tops of the internal columns.

But Morandi’s experience with suspended cable roofing did not end here. At the end of the Sixties, he worked with the same contractor in designing and
constructing Alitalia’s Boeing 747 Maintenance Center, again at the Fiumicino-Leonardo da Vinci intercontinental airport. This time, the two hangars do not face each other to form a symmetrical organism, but are placed side by side: together, they form two large spaces, each around 6000 square meters, covered by a reinforced concrete cable-stayed tension structure with workshops and service buildings at the end. Morandi made the most of this new professional opportunity: rather than limiting himself to reproducing the 1960 design, he takes wide-span reinforced roofing another and even bolder step forward. Technologically, Morandi’s performance here was so exceptional as to take on all the semblance of an «austere monumental archaism» —fruit of a highly distilled reinterpretation of the «neo-Expressionist structuralism» that Morandi had espoused some years earlier with his design for the underground exhibition hall for the Torino Motor Show (1958–1959)— emphasized by the imposing tapered columns that rise past the horizontal line of the thick beam crowning the structure. From the tops of these columns, the cable-stays extend in a radius pattern, upholding the roof deck consisting of reinforced concrete strips ending at two sturdy precompressed trusses and connected along their length by ribbed concrete sheets.

Another of the major achievements made in the field of suspended cable roofing during the Sixties carries the signature of Sergio Musmeci, a Roman engineer who received his training between 1948 and 1953 at the offices of Riccardo Morandi and Pier Luigi Nervi, from whom he absorbed the first rudiments of the structural designer’s craft. By the years between 1963 and 1967, when he designed and built the Italtubi warehouse in Rome together with Livadiotti, Stegher and Cogiaia, he had already collaborated with architects of the stature of Vaccaro, Libera, Vitellozzi, Quaroni, Zevi and De Carlo. Though he was the only prominent figure involved in the Italtubi project, the occasion was exceptional, not so much because of the building’s importance, but because of the material selected and the type of roofing used. Abandoning concrete for the time being, Musmeci discovers the charms of steel and chooses the direct suspension technique for the roof. The building, now irremediably altered and virtually unrecognizable under a cladding of lightweight prefabricated panels, was essentially a simple canopy of corrugated fibercement sheets in a hexagonal layout using triangular grid elements, supported by three massive tapered compound-section central columns placed along the axis of longitudinal symmetry. Anchored to the top of the columns are the eighteen cables supporting the roof decking, which consist of formed and prestressed wire rope.

This was to be the only structure where Musmeci applied the direct suspension technique: the cable-stay bridges which he designed for Rwanda in 1978, in fact, were never built. It is nevertheless a building in which a highly personal view of the technological side of the Italian structuralism of the Fifties comes to terms, though perhaps in an over-simplified, mechanical spirit, with one of the motifs that organic architecture in Italy seemed almost duty-bound to follow in the same decade: the use of the triangular
Figure 9

Figure 10
DC9 hanger at Fiumicino Intercontinental Airport, Rome (R. Morandi 1960–62): Positioning the curving beams and rigging the cable-stays (Morandi archives, Rome)
grid as the basis of a structure’s layout. There can be no doubt, however, that constructional functionality and static efficiency are here expressed in visible form, so much so that the building exemplifies what Musmeci himself called «structural architecture» (Nicoletti, 1999).

In the second half of the Sixties, we see the beginnings of the extensive research conducted by Leonardo Savioli at the School of Architecture in Florence. This research was to lead to the design for the new Pescia flower market developed together with Danilo Santi and others in 1970 at the time of a national competition sponsored by the municipal administration, though the market was not constructed until eleven years later. The cable-stayed roof of the main market hall derived from the architects’ idea of using steel technology to evoke memories of past feats of engineering — the 19th century’s suspension bridges, greenhouses, railway stations and exposition pavilions — which would blend with the more straightforwardly commercial intention of designing a building capable of standing

Figure 11

Figure 12
Italtubi warehouse, Rome (S. Musmeci 1963-1967): Plan view of the suspended cable roof (Musmeci archives, Rome)

Figure 13
out from its surroundings and achieving landmark status. The careful attention devoted to the concepts of flexibility, adaptability and expandability resulted in a roof design featuring five independent portions, each part of a three-dimensional macro-module which is repeated to generate the main market hall. The primary structural system for carrying vertical loads consists of circular-section columns joined in groups of four and tapering upwards, while the flat roof deck, suspended from flexible steel cables with backstays anchored to the ground, is most noteworthy for its mixed configuration: the cladding, in fact, is supported by a space grid at the center and by one-directional framing at the sides. This is another aspect that makes the building—which represented years of painstaking work by Savioli and Santi, who were assisted by Cesare Pesenti and Luigi Nusiner in performing the calculations for the primary structural system—one of the most exceptional, in size as well as in design, ever erected in Italy. Elsewhere in Europe, its forerunners included the Soviet Union pavilion at the Brussels Exposition of 1958, which can be said to have contributed a number of construction concepts. For Savioli, the Pescia flower market was an important experience which, as part of an output dominated by exposed concrete, opened the door to further occasions for using steel, as it denoted a new way of looking at this construction material.

This work ended a decade and began another in which suspended cable roofing would once again find itself excluded from current design and construction practice in Italy, perhaps more than in other countries. From the standpoint of engineering calculations in particular, suspended cable roofing involved a series of unconventional problems that at first sight made it appear more complex than the issues engineers were ordinarily called upon to confront. On the design front, the calculation difficulties, which have now been largely overcome by increasingly sophisticated information technology, were joined by the problems involved in working out construction details and in planning building operations at the drawing board, which are closely linked to them. As regards operating practice, uncertainties remained concerning construction costs, not least because the lack of a well-established tradition in this area could easily lead to cost overruns.
Seemingly, suspended cable roofing is not destined to become part of the modern Italian construction site's repertoire. Nevertheless, and precisely because of their experimental and pioneering nature, the buildings we have illustrated exemplify a typical condition of modern architecture, freighted with unresolved problems, but also with an undeniable Utopian potential. Those who designed them—engineers or architects—though differing widely in background and culture, all worked in the full consciousness of devoting their professional energies to a sparsely populated field, and with the primary goal, not so much of setting unattainable records, but of finding their own voice amongst the clamor of avant-garde rationalism, technical pragmatism, organic structuralism or inspirational technology, as the case may be.

As for the future of this type of roofing, there is a widespread awareness that steel has surpassed reinforced concrete for wide-span roofs. In Italy, it will thus be the material of choice for all those who are called upon to deal with design issues of this kind in the coming decades (Zordan, 1996, 119–131).

**Reference List**


