ARCHITECTURE HERITAGE and DESIGN

Carmine Gambardella

XVIII INTERNATIONAL FORUM

Le Vie dei Mercanti

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Collana fondata e diretta da Carmine Gambardella

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Structure/external envelope relationship in the Monte dei Paschi di Siena headquarters in Colle Val d'Elsa (SI) by Giovanni Michelucci

Frida BAZZOCCHI[1], Cecilia CIACCI[2], Vincenzo DI NASO[3]
(1) Department of Civil and Environmental Engineering, University of Florence
frida.bazzocchi@unifi.it
(2) cecilia.ciacci@unifi.it
(3) vincenzo.dinaso@unifi.it

Abstract
The new MPS headquarters in Colle Val d'Elsa (SI) is one of the latest works in which the Archt. Michelucci was directly able to attend both to the design and to the construction. It represents a symbolic building that contains many significant features of the master's design, both as regards the design philosophy and in relation to the technical and technological features of the construction.
The most characterizing element of this project is certainty its load-bearing structure. The building basically consists of two volumes for which Michelucci chose different structural solutions: a steel structure for the main volume and a steel-reinforced concrete one for the tower of the stairs. The first solution is undoubtedly more interesting from a technological point of view. From the first sketches the architect's willingness of declaring the steel load-bearing structure arises and in according with this solution he decided to use a dry solution for the external envelope. Nowadays these design choices lead to obvious problems of thermal discomfort inside the building.
This work aims at analyzing in detail the technological system of the external envelope of the building, to identify the critical energy issues mainly related to the relationship with load-bearing structure and to develop possible corrective measures.

Keywords: Michelucci, Modern, MPS, cultural heritage, envelope

1. Introduction
The headquarters of Monte dei Paschi di Siena in Colle Val d'Elsa is one of the last works in which Arch. Michelucci was able to intervene directly in both the design and the construction of the work [1].
The research group had almost exclusive access to the archives of Arch. Bruno Sacchi (AABS), who had been Michelucci's close collaborator since the early 1970s. It was also possible to consult both the Archives of the Monte dei Paschi di Siena Foundation (AFMPS) and those of the Municipality of Colle Val d'Elsa. This has made it possible to reconstruct the entire building process from the master's first study drawings to the construction of the building [2].
The first sketches of the work are dated 1973-1974 (Fig.1) and they contain the entire design idea which was then developed by Michelucci, assisted by Sacchi, for the drafting of the project. In particular, Sacchi officially held the role of Artistic Director on this site, as can be seen from the documentary material at the Monte dei Paschi di Siena Archives.
The first definitive project dates back to 1975, followed by four variants dating back to 1977, 1980, 1981 and 1982. The work was completed in 1983. In 1987 an authorization was requested for the installation of sunscreens and for a small enlargement, when the work can be considered really finished.

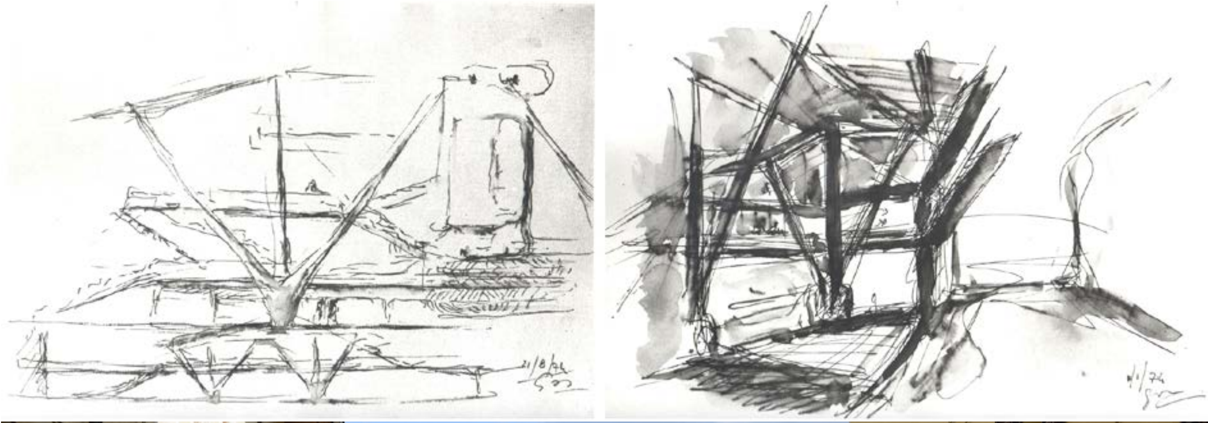


Fig. 1 e 2: (top) Sketches by Michelucci dated 1974 (AABS) and (bottom) view of the building that relates it to the context.

The building contains many of the founding elements of the master's work. As in most of Michelucci's works, the building is an integral part of the city. The building aims at creating an extension of public space by inserting a covered square on the ground floor and several terraces accessible by the upper floors. The relationship with the city is also found in the building formal research and materials. In particular, the use of travertine, bronze, steel and concrete in the construction is evident in this last aspect, in a search for exaltation of their material honesty.
The relationship between structure and shape is certainly one of the most interesting work elements.
Compared to the urban morphology of the context characterized by a compact aggregate, the building presents a very fragmented, almost tormented volume (Fig. 2). The building is built through aggregations of volumes that maintain an identity connotation, but at the same time manage to create a very unitary whole. The mending is almost always entrusted to the steel structure, always strongly exhibited, which visually supports and connects all parts of the building. Michelucci himself wrote [3] "in Colle Val d'Elsa I tried to get to the shattering of every concept of monumentality, not to the destruction of the Shape but to the conception of it as an expanding force rather than as the envelope that contains it" and specifically to the question of the shape/structure relationship for the new bank he said [4]: "yes, the point that always leaves me perplexed is precisely this of the Shape-Structure, the relationship with the Shape. I consider space as a determining element of an architecture, very different from Shape: therefore, when Space characterizes architecture, it reaches its purpose, Space, therefore! Here, the whole discourse must be based on Space; what is Space? It is a path, it is something particularly related to man's needs and to man's movement. But Space must be considered, in my opinion, the creative element of the whole architectural process, the creative moment: in the moment in which the thought of a space is born the specific attributions are born; that Space is destined to a particular function: that Space will create certain sensations so that the individual will approach that Space or occupy it bringing a contribution to its definition. I mean that the space as it is defined clarifies its own characteristic and therefore its own

function: its own Shape. When the architect thinks of a space he actually thinks of the Shape of that Space, which is not born if the expansion of a specific function is not already attributed to Space". The search is therefore more about space than about shape.
As mentioned above, the steel structure exhibited in minium colour, to respect the principle of declaring the authenticity of the material, is the element that most distinguishes the building. The structure used as an element of formal characterization and definition of space is shown in many of Michelucci's works such as the Highway Church, the Chapel of the fallen in Kindu or the Tavern Gambero Rosso (Fig.3). With regard to the choice of steel for the supporting structure, Sacchi stated [5]: "steel is the material to be used today for an intervention in an old town centre", being a material with an "ancient flavour" but which obviously at the same time guarantees a recognizability of the intervention. An exception to this is the portion that houses the stairwell/elevator block, which is served by a mixed steel/reinforced concrete structure and is covered with Sienese travertine walled with *opus incertum*, with which the designer sought a greater connection to the old town.

2. The supporting structure

The main supporting structure of the steel portion consists of 5 large portals, which behave statically like three-hinge arches. The pitch of the portals is 8.00 m and they are hinged on the head of the reinforced concrete pillars that serve the ground floor slab (Fig. 4). Great attention has been paid to the design of the knots detail , such as the hinges at the base of the portals that "lean against" on a base covered in travertine, of which it is necessary to emphasize the formal cleanliness and architectural significance, as if to represent that the steel structure is born from the old city.
The portals are made of double C-profiles, coupled at a distance of 300 mm. The webs of the profiles taper from 634 mm at the base, to 200 mm at the ridge hinge, while the flange of the profiles remains constant and equal to 220 mm. The thicknesses do not vary and are 30 mm for the web and 50 mm for the flanges [5]. The formal research in the structure therefore respects the structural logic: the tapering of the elements sections follows the reduction of the stresses to which the membranes are subjected as you climb towards the top of the building. The portals were pre-assembled in the production workshop, so the only operation required on site was to position the two semi-arches on the base hinges and then connect them by means of a pin in the ridge hinge. This made it possible to assemble one portal per day, using only one operator to insert the pin. The beams supporting the storeys on the various floors are inserted in the gap between the two C-profiles. The steel portals pass through the volumes and they are exhibited outside on the ground floor and on the façade, as well as part of the beams (Fig. 5). As we shall see, this is one of the causes of internal discomfort.

Fig. 3 e 4: (top) Images of the structures respectively of: Highway Church (V. Di Naso), Chapel of the fallen in Kindu (V. Di Naso), Tavern Gambero Rosso (Restaurant Gambero Rosso). (below) Photos of production workshop and building site during the assembly of the supporting structure, in the central image Michelucci is present during an on-site inspection (AFMPS).

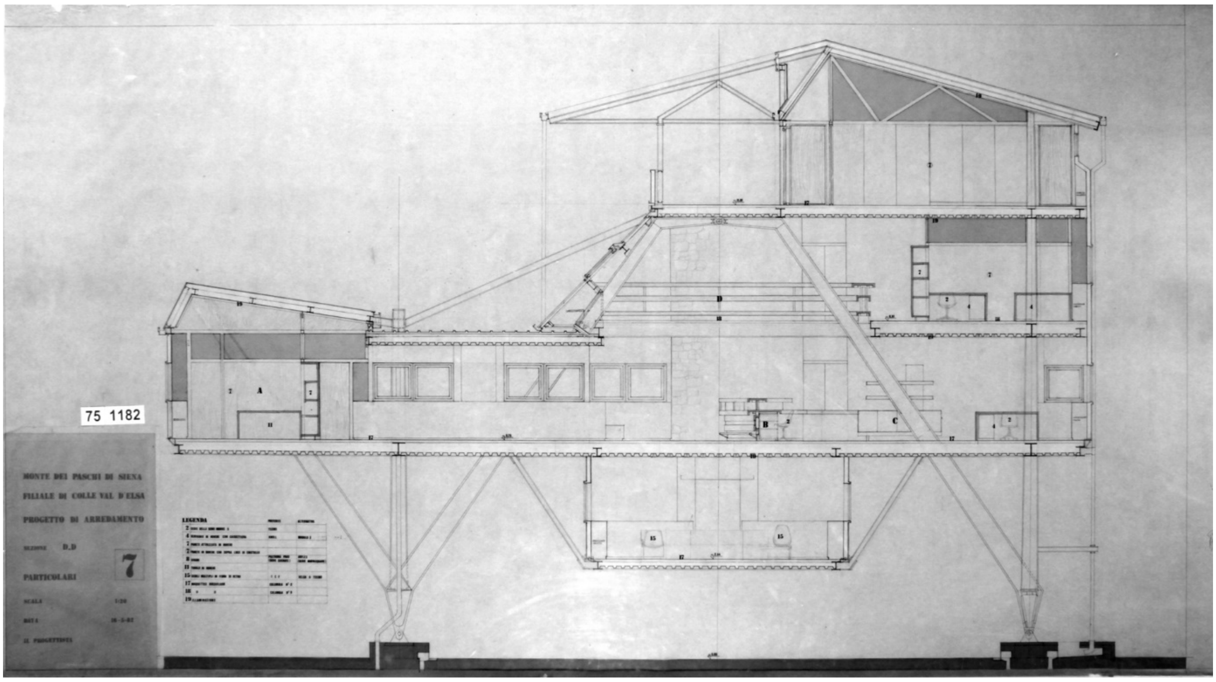


Fig. 5: Cross section contained in the design of the 1982 variant of the building that highlights the relationship between the portals and the building volumes (AABS).

As far as the slabs above the ground, including the one above the public square on the ground floor, are concerned, these are generally made with the use of a galvanized corrugated sheet metal type EGB 800 with ribs of 70 mm height and wheelbase 185 mm, which in almost all cases acts exclusively as a formwork, to make a reinforced concrete slab with a total thickness of 36 cm, lightened by polystyrene blocks such as to obtain rafters spacing of 37 cm, all completed by a load distribution slab reinforced with an electrowelded mesh [5]. The slabs thus made usually cover an entire field between two portals, then an 8.00 m span. There is no false ceiling for these floors so the metal sheet is always exhibited, even indoors.

To conclude the structure there are: seven steel trusses that support the roof of the top floor and inclined steel beams for the other roofs.

3. The envelope

The envelope of the portion with steel structure of the bank, with the exception of the structures of the roofing slabs and those overlooking the public square on the ground floor, is made with dry-type technology.

3.1 The external wall

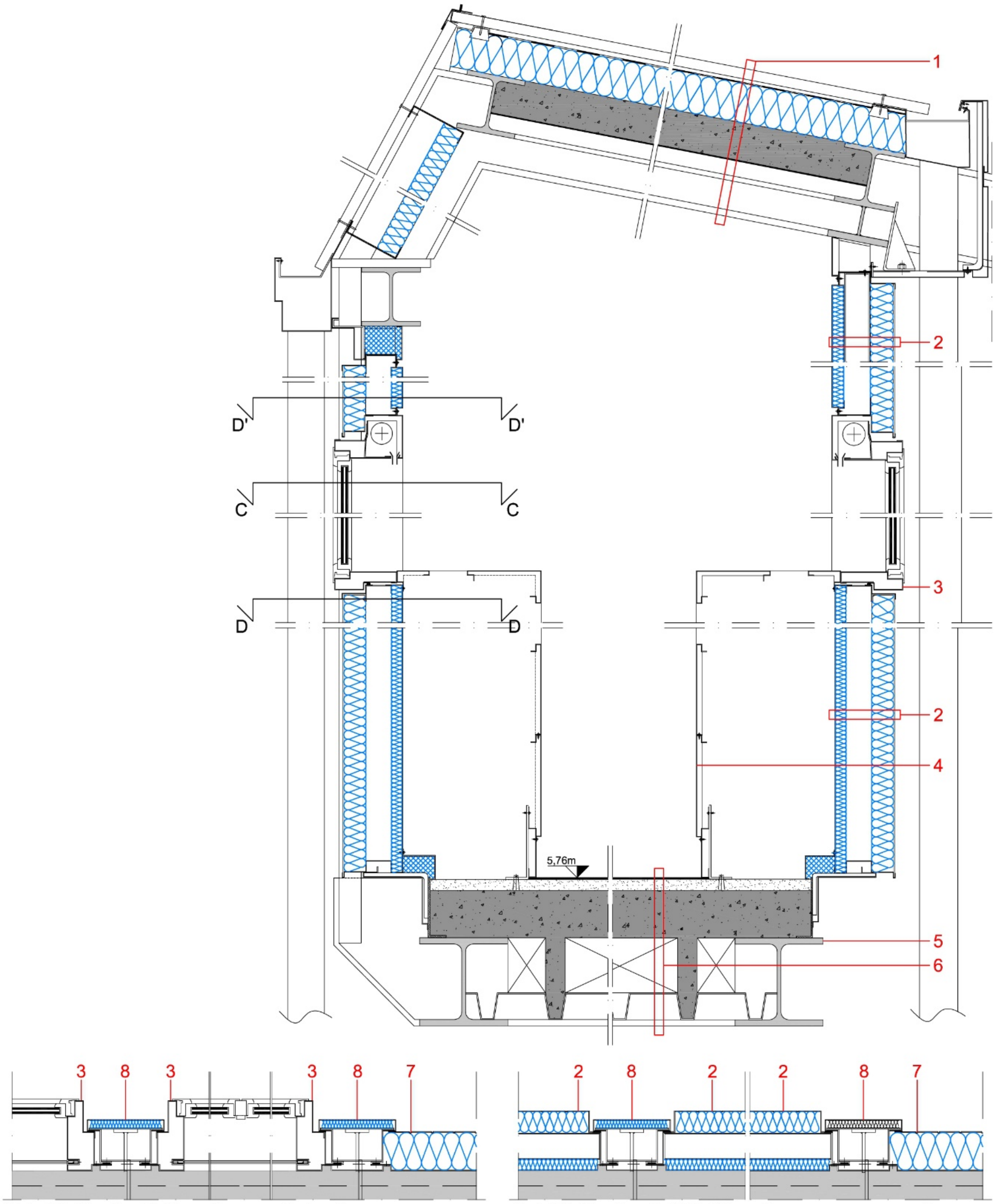
The external wall can be ascribed to the category of curtain walls, in the logic of an integrated wall solution served. The technology therefore provides for the presence of a substructure consisting of painted box-shaped steel uprights, connected by brackets to the steel structure of the building, completed by opaque and transparent panels. The vertical closing system was designed and built by SECCO S.p.A. of Treviso starting from Michelucci's technical drawings.

The façades are organized in the interfloor distance on three bands: one upper and one lower opaque (the latter also makes the parapet) and one of ribbon windows.

The opaque panels, with the exception of those at the steel portals, are made from the inside to the outside: steel sheet, 3 cm thick polyurethane foam panel, a 7 cm thick air gap, an additional 5 cm thick polyurethane foam panel and finally a bronze sheet as the outer covering. Between the two insulating panels there is a steel sheet to build an internal box, which acts as a supporting element of the panel. The panels are fixed laterally to the uprights by means of a system of rails attached to the steel upright (Fig. 6).

The ribbon windows are made using modules of the same width as the opaque panels, to share the fixing to the vertical steel upright.

In correspondence with the portals there is a panel composed of a steel sheet on the inside and a bronze one on the outside, with only one insulating layer 10 cm thick.



Detail 1 (Section C-C) section on window frame

Detail 2 (Section D-D/D'-D') section on opaque panel

Legenda

1-Roof THK. 40cm:
- Main steel beam HE240B
- Secondary steel beam HE160B
- Corrugate sheet not collaborating (H. 70 mm, W. 185 mm, THK. 3 mm)
- Reinforced concrete THK.10cm
- Polyurethane foam panel THK. 10 cm
- Bituminous sheath
- Bronze sheet

2-Prefabricated panel
- Steel sheet
- Polyurethane foam panel THK. 3 cm
- Air gap THK.7cm
- Polyurethane foam panel THK. 7 cm
- Bronze sheet

3-Bronze frame SECCO

4-Bronze sheet metal cabinet

5-Steel beam HE240B

6-Slab
- Main steel beam HE360B
- Secondary steel beam HE240B
- Corrugate sheet not collaborating (H. 70 mm, W. 185 mm, THK. 3 mm)
- Polystyrene blocks (lightening)
- Load distribution slab in reinforced concrete THK. 12 cm
- Screed
- Moquette

7-Prefabricated panel (special piece THK. 10 cm)

8-Upright (type element)

Fig. 6: Reconstruction of cross-section portion and details of the opaque portion of external wall and windows [6].

In order to guarantee the correction of the thermal bridge at the steel uprights there is a metal finishing casing with a thin layer of insulation in between.
The opaque panel guarantees a thermal transmittance value of about 0.3 W/m^2K. To estimate this, a thermal conductivity value for the insulation $\lambda = 0.03$ W/mK[1] and an air gap resistance of 0.16 m^2K/W were used. However, the panel is not verified with respect to the formation of interstitial condensation, as there is no element in the wall that effectively acts as a vapour barrier. Despite this, it can be said that the wall has a good insulating capacity.
In correspondence with the panels under the windows there are bronze sheet metal cabinets. These contain the air conditioning systems consisting of fan coil heaters.

3.2 The horizontal envelope

The horizontal envelope technologies are mainly divided into two solutions: the bottom closure and the roof.
The lower enclosures, as previously described, are made with floor slabs cast in place with steel sheet on the intrados with the function of formwork and lightened with blocks of polystyrene. The latter are the only insulating element present in the floor. From this it follows that all the portions of the floor in correspondence of the reinforced concrete beams constitute important thermal bridges (Fig. 7).
The pitched roofs of the building consist of corrugated sheet metal floors as well, in this case collaborating (height 7 cm, pitch 18.5 cm), warped in the opposite direction to the floor slabs. The thermal insulation layer of the roof is made of a 10 cm thick polyurethane foam panel and the waterproofing one, with a layer of bituminous sheath. As for the façade panels, the external finishing element is made up of a bronze corrugated metal sheet, punctually fixed to wooden strips underneath the bituminous sheath. The overall thickness of the roof is 40 cm (Fig. 6). The roofing slab also offers good thermal insulation. The transmittance can be estimated at 0.26 W/m^2K, which is therefore close to the limit imposed by current energy legislation for roofs. In this case the enclosure is verified with respect to the formation of interstitial condensation, in fact the vapour pressure, present between the individual layers, never exceeds the saturation pressure.

4. The energy criticalities

The problems of energy and interior comfort already became apparent in the years just after construction. In particular, there were critical issues in terms of very high indoor temperatures inside the premises during the summer season, despite the proper functioning of the cooling system. In fact in 1986 both Prof. Ing. Enzo Giusti (designer of the air conditioning systems) and Michelucci were involved again to solve the problem.
On 03.09.1985 Monte dei Paschi di Siena sent a letter to Michelucci informing him that it was necessary to find a solution to this problem. The letter reads: "In the spaces of our branch in question in the current summer season there have been considerable inconveniences due to the environmental situation with repercussions on the staff and consequent intervention by the trade unions."[2]
The plant designer was also informed of this problem, who replied to the Monte dei Paschi technical office: "Following the inspection carried out at the branch in question, it emerged that the discomfort encountered by the employees was essentially due to the radiant effect resulting from the heating of the dark coloured internal metal parts. In fact, the temperature of these metal parts invested by direct sunlight rises considerably and gives off heat by radiation with the fourth power of the temperature; it is well known that the radiation is not in contrast with a decrease in ambient temperature, but only by preventing their propagation through appropriate sunscreens"[3]. The solution adopted was to integrate the façade with a system of sunscreens. Indeed, in Eng. Giusti's technical report there is this indication: "Since the cause of the problem is well defined, we believe that the most centred and safe solution to overcome the above mentioned drawbacks is to prevent direct radiation on the façade of the building; this can be achieved by installing adjustable sunscreens outside the building". (Fig. 8)
Despite the sunscreens, the bank employees still complain about uncomfortable situations inside the building, due to excessive heat in the summer and cold in the winter, particularly when it is reopened after the days when work is closed. These problems are also due to the presence of numerous thermal bridges, many of which are caused by the fact that the structure of the building is exposed and permeates directly inside the various spaces (Fig. 8).

1 The conductivity values of the materials have been derived from the letter of 18.01.1980 (AABS) which contains the global transmission coefficients of the enclosure.
2 Cit. Registered letter sent by Monte dei Paschi di Siena to Prof. Dr. Arch. Michelucci on 03.09.1985.
3 Cit. Report on the internal environmental conditions of the building owned by Monte dei Paschi di Siena located in Colle Val d'Elsa, written by Enzo Giusti and dated 04.03.1987.

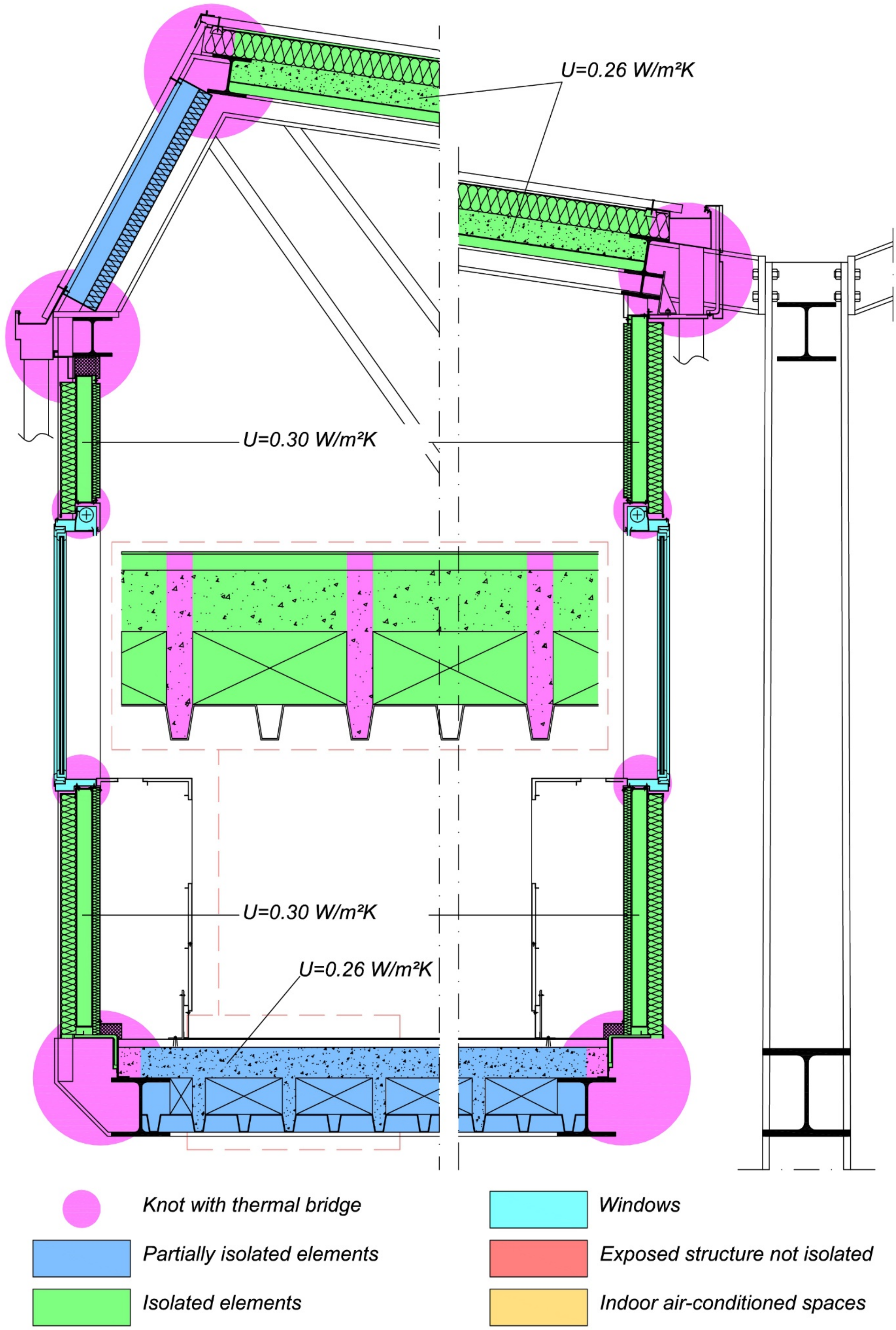


Fig. 7: Identification of the criticality in relation to thermal bridges in a typical portion of the cross-section [6].

Fig. 8: From left to right: a view of a façade in which it is evident the organization of the curtain wall and the structure that enters the building; the east façade with the insertion of the sunscreens; a view of the interior in which you can see the structure of the steel portals that crosses the volumes.

If we analyse some typical nodes of the building, the presence of many thermal bridges can be detected. For instance, if we consider the node between the external wall and the roof on the eastern façade, we can see that the fixed window frame is directly connected to the lower flange of the steel beam (HE240B) and that the eaves is insulated only at the top. Thus creating an important thermal bridge. The reinforced concrete slab, which is the structural part of the roof, apart from the exposed steel perimeter beams, does not allow the structure to be properly insulated (Fig. 9).
Always on the same façade, but in any case a common problem to other ones, it is possible to identify a criticality in the connection between the opaque panel of the vertical wall and the slab placed above the public square. The steel perimeter beam is exposed (Fig. 7, lower right node) and is therefore subject, , to considerable temperature changes both in winter and summer. Between the beam, the reinforced concrete slab and the vertical wall there is no thermal insulation and consequently the heat flow can easily pass from inside to outside (and vice versa), thus creating a thermal bridge. However, it must be considered that inside, next to the perimeter wall below the window frame, there are the metal cabinets that house the terminals of the air conditioning systems. Therefore, the section that the heat flow has to go through inside the reinforced concrete floor is about 30 cm, which helps the thermal insulation even if it does not eliminate the thermal bridge present there.
The critical points of the wall/roof knots are very common. In the office block on the second floor, the node between the external wall facing the covered square and the roof (Fig. 7 top right) shows a discontinuity of the thermal insulation near the eaves and the perimeter beam, generating an important thermal bridge for the entire extension of the façade.
In the facade facing della Ruota street (Fig. 7 top left), the knot of the wall with the roof was made with a special, slightly inclined element. This element is partially thermally insulated: although it contains a polyurethane foam panel, it is not thick enough to insulate sufficiently. Moreover, at the points of connection of this element with the vertical wall (below) and the roof (above) there is no thermal insulation, similarly to the node analysed above, but on the contrary, in both cases, the only element separating the outside from the steel perimeter beam, left visible inside, is the finishing metal casing.

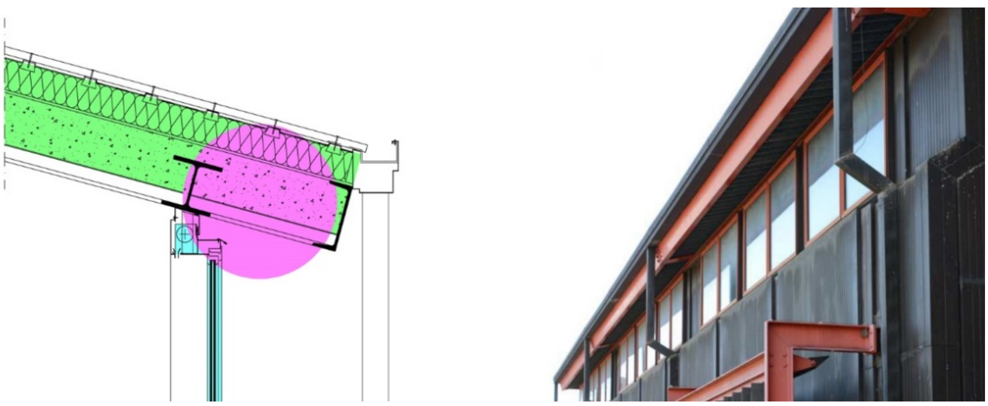


Fig. 9: Thermal bridge and photo of the node between the vertical wall and the roof on the eastern façade [6].

Other thermal bridges, although less important, are in the node between the frame and the opaque panel. There is no connection between the two elements: both are fixed only to the vertical uprights. In this way, between the window part and the opaque part, there is no thermal insulation of any kind, except for no airtight layer.
It is also necessary to stress again the problem represented by the steel structure that "enters" the building. In fact, the main beams of the roof and the structure of the portals are always left visible and therefore transport most of the heat transmitted by the solar radiation directly incident on them.

5. Conclusions

In conclusion, therefore it can be said that the internal discomfort conditions, both in summer and winter, are due almost exclusively to the presence of important and extensive thermal bridges. In fact, the individual technological packages of vertical and horizontal enclosures, except for the slab above the public square, have a good thermal insulation value, especially in relation to the year of construction of the building. On the other hand, the thermal bridges are mostly located in the nodes between the various envelope components envelope. The problems related to direct radiation on the eastern façade have already been solved by the insertion of vertical sunscreens.
Therefore the solutions are to be found in the correction of thermal bridges, which we can say are mainly of two types: the first, related to the interruption of the thermal insulation in the connections between the various technological packages; the second, related to the flow of heat that, through the steel structure, passes freely from outside to inside in summer and vice versa in winter. At the same the interventions must respect the design prerogatives that underlie the work, among which we can list: the use of construction materials in respect of their material " authenticity " and the structure shows outside and inside the building.
When the supporting structure outside is covered by a casing, it is certainly possible to intervene by inserting an insulating panel, without modifying the work in any way.
Any other intervention that could involve, for instance, the insulation of the structure inside the building and therefore the provision of its cladding, an operation that would certainly significantly improve the conditions of internal comfort, would completely change the essence of the work designed by the master. The proposed interventions, in compliance with the building concept, can therefore solve only a small part of the problems described above.

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