

STRUCTURAL PROBLEMS IN ITALIAN SCHOOL BUILDINGS OF THE LATE NINETEENTH CENTURY: THE SCHOOL “REALDO COLOMBO” IN CREMONA

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Abstract. *Camillo Boito is depicted in the history of the Modernist Movement, primarily as a critic although he designed a small number of buildings and restorations. In fact Boito chose his occasions carefully, and his works were highly successful. Details of the schools - in Padua, the Reggia Carrarese (1877-80) or via Galvani in Milan (1886-1890) - were published in magazines and manuals and were models for hundreds of buildings. They were designed for the large student population generated by the extension of compulsory education, and reflected the new and improved educational standards of the “Coppino” Law (1877). Even the typological-structural conception was replicated. He foresaw three floors, with pavilions for stairs and services providing an interruption or end point with thicker division walls to the long buildings housing the classrooms. These were formed by the perimeter walls and a spine wall, which divided a wide corridor from the classroom, with large windows. The perpendicular walls between classrooms, were also load bearing, and ensured a “box-like” behavior. Imitators often simplified the structural system, while copying the distribution and decoration. A significant example is the Realdo Colombo school in Cremona, where the structure is reduced to long parallel walls of the façades and corridors. With little but carefully studied reinforcing and additional transversal frames, seismic safety can be completely assured, leaving virtually intact the bright and dignified façades and interiors. The text illustrates some of the results of research on schools in Northern Italy built between the Nineteenth and Twentieth century and their structural problems, the research was made possible by funding granted in the framework of Art and Culture by the Cariplo Foundation. Research on schools in Milan and Cremona was conducted by Angelo Giuseppe Landi, while Alberto Grimoldi mostly concentrated on the case of Padua.*

1 INTRODUCTION

Camillo Boito the «happy patriarch of Italian architects» as he was called by one of his young opponents, Mario Ceradini [1], appeared in the historiography of the fifties essentially as a critic [2]. He designed a limited number of buildings and restorations which went unfollowed in the intense building activity of the late Nineteenth century. His architecture was considered only with regard to its neomedieval references, and reduced to one of the many expressions of eclecticism. Not even the new perspective (the work of Henry Russell Hitchcock being emblematic) which from the mid - Twentieth century gave a new reading to the architecture of the Nineteenth century [3], highlighting both its technical as well as its formal innovation, has led to a greater attention to the works of Boito. The architect himself had carefully delineated his public image, assigning a role to its multiple activities, and choosing not to leave his own archive; indeed even his letters to his many correspondents have only been published in part [4]. This “self-portrait” peremptorily discouraged any review and hindered those who might have been interested in reconstructing his busy public life and it would help to understand him, and through him understand many aspects of late Nineteenth century Italian society. Depicting himself as an architect, Boito has escaped historians, and even his literary works have remained the preserve of specialists and more sophisticated readers such as Luchino Visconti. The copious literature [5] dedicated to him has continued to focus attention [6] on his continuous and lively participation through numerous articles [7] in the debate on architecture and restoration, thus overshadowing his buildings especially in terms of their constructive aspects. In fact Boito chose his commissions carefully and his works were widely followed, thanks to the cultural/political role that he had carefully constructed. His schools are part of this strategy. The bill by the Minister Michele Coppino [8] published the 15th July 1877, extended compulsory schooling to the entire Italian state and required municipalities to implement this.

2 SCHOOL BUILDINGS DESIGNED BY CAMILLO BOITO

In May 1877 Boito received from the City of Padua a commission to design a new elementary school in the heart of the city center, as part of the Fourteenth-century Reggia Carrarese [9], realizing a program under discussion since 1872 [10].

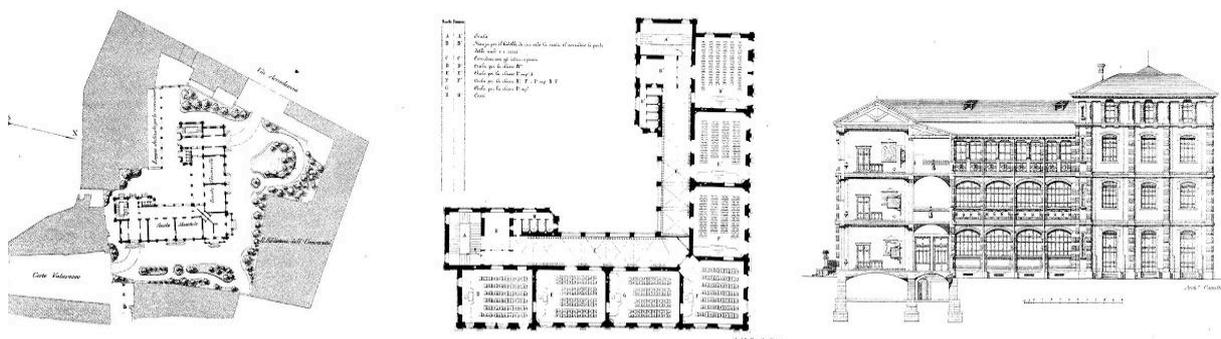


Figure 1: Project of the Reggia Carrarese school in Padua by architect Camillo Boito.

This initiative would seem to offer tangible political support to a man of culture who was also interested in issues of building preservation; in 1888 [11] a proposed law on the subject, supported by Boito [12], failed to be approved. Furthermore, in his report of August 29, 1877 Boito himself refers to the directions of a ministerial committee on schools. A more thorough investigation might discover, in this reference, a play of roles: the influence of Boito on Ministries of Education and Public Works was constant. Boito conceived his school as a

generalizable model and promoted its spread. The solution appears rational and systematic in the type and construction, and was illustrated by a booklet [13] prepared by the Inspector of the City Schools, Pietro Vittanovich, republished as a timely article for the *Politecnico* [14]. Even earlier, in 1881, a series of eight photographs of the building was addressed to the most important Italian municipalities as well as the Pedagogical Museum of Palermo [15] and the Museum of Training and Education of Rome [16]. In the same year, Boito presented his drawings in the section dedicated to architecture at the exhibition of Milan [17]. Compulsory education was introduced in the State of Milan by the enlightened monarchy of the Hapsburgs [18], it had rarely translated into a building typology: in the cities, where the rapid increase of the population was concentrated the monasteries abandoned had mainly been used, or alternatively, large aristocratic palazzi whose rooms, exaggerated by of Nineteenth century life, provided the space prescribed by the “hygienists” [19]. The Padua school has three floors of classrooms, spread over two wings almost identical, one for male and one for female students, as well documented in a recent study [20]. The whole construction was carried out in regular brick masonry with a constant depth of 60 cm. The façades were reinforced by buttresses, corresponding to the spine walls and to the main beams between the windows of the classrooms. On the third floor they were connected by segmental arches which increased the thickness of the wall in order to better support the eaves. The wings of the classrooms joined at right angles in a square bordered on two sides by the two contiguous transverse walls of the classrooms. At the end of the two wings were formed two four-storey pavilions where, the last floor was intended for housing for the staff. These pavilions contained the stairs, in a compartment perpendicular to the corridor, and joined to this towards the courtyard a thinner construction, intended for services. The ground and first floors were 5 meters high while the second was 4.5 meters, this to meet the standard generally accepted by the hygienists of 6 mc per pupil [21] numbering 40-45 per classroom. The longitudinal central spine wall was pierced by large windows towards the corridor corresponding to those on the façade, thereby reduced to a series of masonry pillars. The access corridor leans against the body of the classroom building, the outer wall forming a series of arches which were glazed. The building company, despite being Milanese and apparently trusted by Boito, was not able to achieve either the barrel vaults lowered to the iron beams [22] foreseen in the corridors, nor the iron girders which were to bear the larch joists of classrooms. These were replaced by composite wood beams, an ancient solution, applied by G. Jappelli in the *Caffè Pedrocchi*. They ensured the rigidity of the floor and together with the lath ceiling reduced noise transmission downwards. In addition to the barrel-vaulted ceilings of the cellars, also the corridors on the ground and first floor were constructed with single head barrel vaults, while the top floor was lowered with double arches. Even the channels - the hot air heating, the gutters - had been studied in advance so as not to weaken the wall sections. However, the rationalist tendencies of the Nineteenth century resulted in great consistency: a distribution adequate to the use of the building corresponded to a regular and accurate geometry without sacrificing comfort to symmetry. The quality of the building was entrusted to a subtle interplay of proportions and variations that corresponded to various solutions that strengthened a still traditional, but refined, construction, characterized by the correct use of different durable materials.

The same character can be seen in the elementary school in Milan, via Galvani (1887-1890): the building lot suggested a linear layout, oriented to the North West (with classrooms along via Galvani) and South East (with the corridor facing the courtyard garden). The length was remarkable, 120 meters and to provide balance, both from the formal and static point of view, Boito designed a pavilion at either end and a central projection.

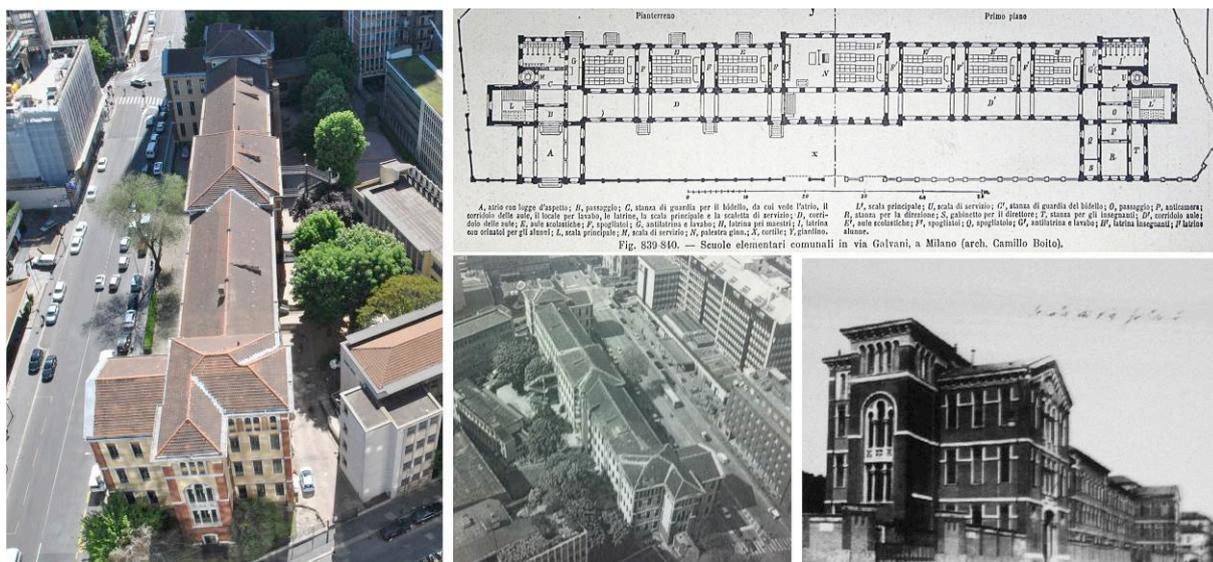


Figure 2: School placed in via Galvani (Milan), designed by Camillo Boito between 1887 and 1890.

Smaller rooms of the same depth as the classrooms were attached to them perpendicularly and they were used as access. In this way, the transverse walls were doubled by the vast portals through the corridor, joining the façade. The second volume of Daniele Donghi's *Manuale dell'architetto* published in full in 1925 [23], but available in installments in the 1890s [24], illustrated the school and also on August von Voit's school in Blumenstrasse in Munich [25], completed it in 1876-77, with access rooms. The size of the openings, both on the façade and spine wall, was similar to Padua, but lacking the pillars protruding from the front. The niches in the center of the transversal walls – for hangers and, near the windows, for closets – corresponded to a construction for masonry pillars of various widths. The central projection - bordered by two compartments entrance to the classrooms - effectively formed a separated construction and on the internal façade, along the corridor, the greatest depth of masonry pillars between the windows. The pavilions at either end, in addition to the entrance hall, are formed by rectangular rooms smaller than the classrooms, perpendicular to each other, and the side walls closed by the stairs, which protrude over the roof of the wings, act as a buttress along the long corridor. Despite having to reduce spending, Boito nonetheless succeeded in obtaining the construction of girdle floors and *volterrane* (vaults laid with large perforated brick blocks), while the corridors were characterized by low vaults, as if to indicate the different function of the rooms through their different configuration. Luigi Broggi, pupil of Boito [26], pointed out the difficulty of Milanese public opinion to understand this architecture [27].

Both schools, Padua and Milan, show a structural system based on the close connection between the longitudinal and transverse dividing walls. In via Galvani Boito knew how to choose and simplify reaching a synthesis in which the constructive consistency translates into an equal consistency and strength of image. Thanks to the careful study of the plans, the interiors, too vast, uniform and repetitive, split into a sequence of distinct and recognizable spaces. The thick and well-connected dividing walls increase the buildings stability and rigidity, but also define a sequence of interconnected rooms which penetrate each other, but never quite close, and offer the visitor a journey animated by varying the proportions and light. Subsequent changes, in particular those of the last decade, have in numerous points irrationally disrupted the continuity of the load-bearing walls, a continuity which greatly helps stability [28]. The quality of the architecture of Camillo Boito and its structural coherence are

more visible if compared to the numerous buildings that began to use them as a model, albeit not literally. Angelo Savoldi [29], a former pupil and assistant for the management of the construction yard of the school in via Galvani [30], built the elementary school situated in via Casati [31], in the Lazzaretto district, saturated with a very high density of buildings. Only the central church and six bays spans of the perimeter porch remained, as a backdrop to the school garden, which occupied a rectangular lot, half of a block. The building is laid out around a square courtyard, the north side of which (demolished in the 1960s) housed the stairs, gym and classroom dedicated to sewing, standing higher than the other classrooms. The façades and walls of the longitudinal spine are connected and stiffened by transverse walls, which separate the classrooms and span the corridors through large arches. The floors are steel beam and ceilings are flat. The stairs are in the corner, in the body of the building at the same depth as the classrooms. In this case, stability is guaranteed by an extreme simplification of the distribution and the uniformity of the compartments, by the reduction of the building to a mere simplified type. On the façades, visible references to the past served to recall its destination as public buildings. The rich evidence in the decor allows an immediate grasp of the careful system of air exchange, guaranteed by small circular rosettes in the parapets, carefully designed window frames with venetian blinds and from the hot air conduits. These aspects are presented in detail by Donghi, both in the exhibition catalog of 1890 and in the *Manuale dell'Architetto*. The school in via Casati will also be published in the magazine *Edilizia Moderna* [32], with more details than other schools in Milan illustrated by Donghi. The schools of Boito, in particular the Milanese one, showed no specific anti-seismic devices, except but a regular construction in form and transversal links: they lack the chain systems introduced by Donghi in the schools he constructed in Turin, after the earthquakes of Ischia (1883) and of Western Liguria (1887).

3 THE SCHOOL «REALDO COLOMBO» IN CREMONA

The Realdo Colombo school was constructed in two separate lots, between 1895 and 1915, based on a design by the municipal engineer Pietro Ghisotti. The sudden increase in the school population, a consequence of laws that raised school leaving age [33], forced local governments to create school buildings, either housed within existing buildings or in buildings built from scratch. The construction of the longilinear building was simultaneous with an urbanistic operation which involved planning a new road linking contrada Gonzaga and via F. Aperti: the long front of the school building was therefore necessary to give a continuous and uniform façade to the northern front of the new road. Ghisotti was commissioned by the City Council to design the school building, to be built according to the most recent indications regarding the health and comfort of classrooms. The meager finances of the City and the need to hastily erect the building formed the basis of the design which Ghisotti prepared in a very short time. In November 1893, the Municipality of Cremona authorized Ghisotti to visit the «new school premises heated with low-pressure system in Milan» [34] in order to evaluate the efficiency of their heating systems: the building in Milan referred to in the document is probably the school designed by Camillo Boito in via Galvani, a model for school building during the late Nineteenth and early Twentieth century.

The construction of the school, though conceived in its entirety by 1893, was made in two separate phases, completed at a distance of about twenty years from each other using different construction techniques and finishes: the central body and the whole of the eastern part were built between 1895 and 1896, while the gym on the ground floor and the entire west wing starting from 1915. The building plan, of linear form, reflects the proportions and

measurements of the school in via Galvani, from which it inherits also interior layout: the main front of the Realdo Colombo school is over 122 m with a depth varying between 14 (classrooms) and 18 metres at the projections (at each end and centre of the building), also made to stiffen the whole building. The building is very tall and narrow, being 18 meters high at the eaves, with storeys averaging about 5 meters, designed on an almost symmetrical floor plan, is built around a central block, on which are grafted two wings designed to accommodate male and female elementary schools, according to the Nineteenth century pedagogical indications, each with its own entrance: the buildings' header, initially designed to be smaller, englobing some classrooms, toilets, access to the ground floor and the two staircases at full height.

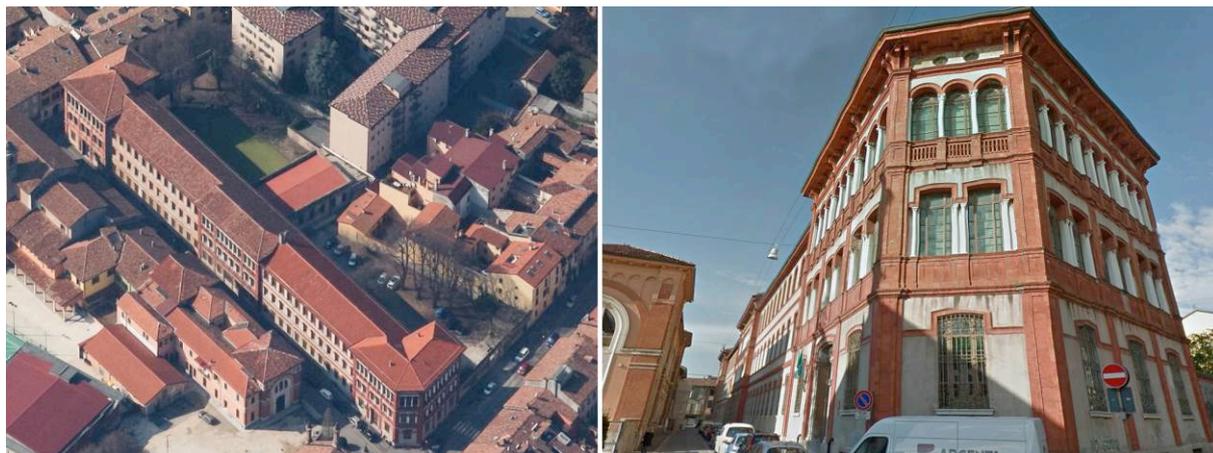


Figure 3: Aerial view of the «Realdo Colombo» school in Cremona, built between 1895 and 1915.

The different conformation of the eastern end, built on an irregular polygon with five sides, originated from the direction of the streets onto which it faced and the existence of the Fifteenth century church of S. Maria Maddalena. The small variations in the plan and in the moldings of the façades are also found in vertical structures, made of new bricks starting from the ground floor, while the cellars were built using recovered bricks. The walls, though of varying thickness, are well made, with bricks and a strong lime mortar, following well-established local building traditions. The internal load-bearing walls are largely made with the same construction technique, starting from the walls which are knitted into the steps of the staircase, the longitudinal wall separating the classrooms from the corridor and some walls that separate the classrooms from one another. The cellars are built with mixed masonry, consisting of both new and recovered brick, with a thickness of 0.80 metres; these walls rest on a concrete floor leveling the ground, characterized by loose soils and marsh. From the skewback the wall maintains the same thickness of eighty centimetres but the specification of the work indicates the use of only new bricks. Also for the vaults the use of new bricks was specified, and stiffening brick ribs were foreseen at walls and discontinuities to the upper floors. An initial tapering of the walls, of about 20 centimeters, can be noted starting from the ornamental exterior skirting board, on the ground floor, again following the dictates of the "rule of the art" for the construction of buildings in masonry. A further offsetting of the wall was foreseen, at the level of the first floor reducing the walls thickness from 60 to 45 centimeters, however this was instead made at the second level, «considering the irregularity of the said wall, the result of the window spaces and the insertion of the terra cotta decoration» [35], confirming that Ghisotti already had in mind the instability and structural problems of the building. Ghisotti's awareness is reflected in a survey of the current state of the building where the profile of the bearing walls, both external and internal, are affected by

discontinuities in the vertical section (with offsets, thickening, openwork decoration etc.) as well as the horizontal one, due to the considerable number of openings.

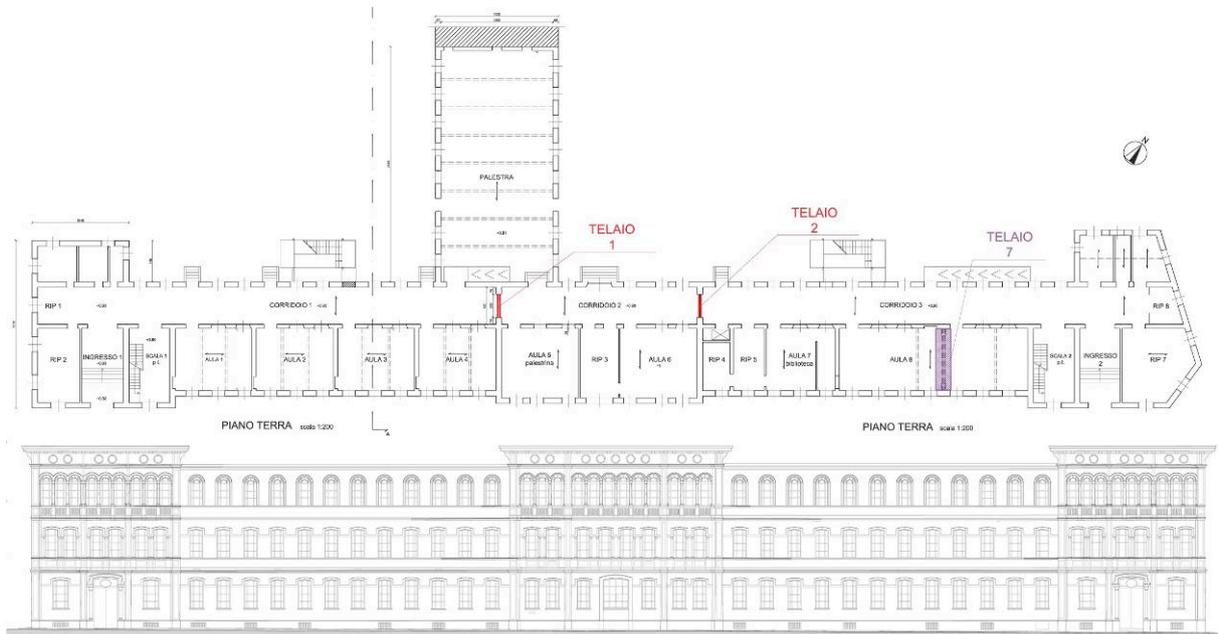


Figure 4: Plan of the ground floor and main façade of the «Realdo Colombo» school in Cremona.

The two access stairs are built of shaped stone blocks cantilevered into the perimeter walls, while the ramps rest on metal beam and brick tile balconies. This construction system, with cantilevered steps, does not present any signs of instability, although the overall width of the overhang, of 1.40 metres for the ramps of the first two levels, requires a thorough examination with respect to structural failure of individual steps. At the end of the ramps an iron railing with wooden handrail further aggravates the load. The main differences between the two building phases are more clearly discernible with regard to the structural characteristics of horizontal elements (the floors and roofs). In the first lot, the floors (with the exception of the cellars sometimes surmounted by brick vaults) were made of metal beams and hollow flat tiles, while the second lot, built in 1915, used reinforced concrete [36]. Technological progress and economy, especially in a period of exponential price rises of iron due to the war (in the decade 1911-1920, owing to a general rise in the prices of metallurgical products, the price of the iron rose from 26 to 103£/ql, that of cast iron from 10 to 50 £/ql) [37], were the basis of the structural choices that today result in differences in proposed maintenance and repairs. The east wing has various types of iron and brick mixed floors, one for the classrooms and a second for the corridor, to reduce the cost associated with the purchase and installation of iron beams: in the corridor, having a span of just 4.15 metres, were used IPN160 joists (at 80 cm centres) connected by hollow brick tiles embedded in a conglomerate concrete substrate, as a base for paving. For the classrooms, with clear span of 6.60 metres, IPN200 joists were used (at 80 cm centres), while maintaining the same construction technique. These differences are also discernible in the floors of the attic, although the metal beams are smaller and the concrete screed and flooring are lacking. The laying of the floors is always perpendicular to the spine walls and façade (north-south), except in the body of the head where the beams lie east to west. The roofs of the east wing are mixed structures made of wood and iron, using *Polonceau* trusses [38], composed of struts in larch and include an underlying metal lattice structure. In the main body of the building, where the opening reaches 13.40 meters, the *Polonceau* trusses are replaced by traditional wooden trusses (with

iron chains, positioned above the classrooms and facing the road) and by impressive false struts towards the inner courtyard. At the floor four diagonal chains, at the four corners, were nailed to some of the metal beams of the floor to strengthen the connection between horizontal elements and walls and to prevent any structural deformation in walls at the temporary end of the building (which would not then have been terminated). The west wing, built twenty years later, was constructed with concrete girder-slabs and ceramic interjoists, from the cellars to the roof, with floors made from reinforced cast concrete between perforated blocks (composed of hollow flat tiles joined together) which acted as disposable formwork. The tests conducted on the whole confirm the lack of metal rebars in the rafters between the perforated blocks while the main beams are reinforced at the base with two iron rods with a diameter of 14 mm. It is likely that further rebars have been adopted also in the upper part, but it was decided to limit the tests to preserve the structure. These beams, unlike the joists, lie perpendicular to the external walls and have rounded edges. The thickness of the concrete slab with ceramic interjoists is 16+4 cm plus an additional 5 cm screed and the floor (the distance between joists is 65 cm, with a base of alternating between 10 and 20 cm, and a height of 14 cm): the thickness of the slab, if compared to spans and to permanent loads, and the limited use of rebars, confirm the scanty finances available for the construction of the building. The technique of the main structures in reinforced concrete was also adopted for the roof of the second phase: the large reinforced concrete beams (40x50 cm) that run parallel to the walls of the façade to the ridge of the hipped roof, support the secondary structure of wooden purlins and hollow tile covering. The weight is transferred to the partition walls of the classrooms on the lower floor: unlike the first phase, the distribution of loads no longer rests on the external walls. On all three accessible levels of the building (from the ground to second floor) the external walls and the long inner wall, are characterized by a close sequence of window openings, designed to give light and ventilation to the classrooms. This solution is intensified on the second floor of the protruding buildings, where the sequence of windows is replaced by a loggia resting on slender columns of Botticino marble, enclosed by large wood window frames; hence the vertical continuity of the walls, is interrupted on this floor by a series of punctual and unstable architectural elements.

The Municipality of Cremona, also thanks to funding from the Ministry for Infrastructure to improve the safety of school buildings in areas subject to earthquakes [39], considered it necessary to deepen their knowledge of the seismic risk associated with the Realdo Colombo school, home to both a nursery and a primary school (the commission for the assessment of the seismic risk of the school was entrusted to engineer Gian Ermes Massetti, Cremona, which I thank for the data and the image of the structural model). Within the vast and diverse architectural heritage of the city the choice fell on the school because of its use as well as its historical and artistic value, as evidenced by the protection placed on it by the Ministry of Cultural Heritage. While respecting the standards [40], the work on protected historic buildings can enhance the safety of the building with respect to seismic shocks, without necessarily adapting existing structures to the strict parameters imposed by previous regulations on new buildings.

The starting point has been understanding the phases of construction, transformation or maintenance that the building has undergone since 1895, the year of construction of the first phase. Knowledge of the history of the building maintenance was also of great importance for detecting discontinuities in the walls, repairs and modifications to individual structural elements and the dating of crack patterns. The apparent uniformity of the building 's exterior conceals important structural differences between the two construction phases, but also numerous tampering with the walls and horizontal elements: a comparison with the school

building made by Boito in Milan in via Galvani has allowed us to rapidly detect the simplifications implemented by engineer Ghisotti, made necessary by the limited budget available. The structural investigations have also provided useful data for the evaluation of consistency of the walls of the building, which is very well woven (with many bond stones), regular joints and well-fixed with good quality lime mortar. Sonic tests have produced good results with mean values of the transmission speed between 1,000 m/s 2,000 m/s while the results of the local states of stress, obtained with individual jack plates, have given values, depending on the survey point, of between 0.73 and 1.02 N/mm². The double jack plates have identified the mechanical properties of the masonry with an average transverse expansion coefficient of 0.22 and an average elastic modulus E equal to 2.475 N/mm², these parameters were adopted in the structural 3D modeling.

To assess the overall state of the building, which in a first visual analysis appeared intact, investigations to detect discontinuities in the walls (due to maintenance work) were proposed. Thermographic imaging showed substantial changes, especially in the body of the east head where the original large wooden portals, located in the partitions that run lengthwise to the building, were reduced to doors. This thermographic imaging allowed us to identify the rain water channels built inside the wall from the attic to the cellar floor: the gutters discharge rain water into these channels positioned between the external walls and spine walls. This resulted in a weakening of the walls especially at the toothings in the corners. Thermal imaging has also allowed us to understand that, at the second floor, the walls that run longitudinally are not connected with the external structures, formed by slender marble columns: the walls are interrupted close to the loggia of the façade, and are connected to it with thin hollow brick walls. Moreover, the introduction of a hot air ventilation system during the construction of the building involved the insertion of the ventilation ducts in the transverse partitions, in order to distribute the air in classrooms and corridors: also these elements of discontinuity were detected and allowed a more precise definition of the structural model.

The structure was analyzed as a block, using a three-dimensional modeling equivalent frame, in order to determine the capacity curve of the structure V/d and compare it with the displacement provoked by an earthquake. Historical research and numerical data obtained from diagnostic tests have allowed us to characterize the individual structures composing the three-dimensional model. The purpose of structural modeling is to identify the critical issues in the event of an earthquake, excluding some variables from the model regarding small discontinuities to the walls which would have unduly overloaded the computational model without adding new information. Despite the good quality of materials and their correct application critical issues emerged regarding the resistance of the building to earthquakes, even when not very intense: the length of the building results in issues regarding the central body and the protruding end blocks, where damage would occur resulting in a partial collapses. The pattern of cracks in the building is limited, especially on the lower floors, the buildings to the sides and the gym: the first show a twisting under the effect of wind and of past earthquakes with lesions to the floor and ceiling, while the gym has (at the top of the perimeter walls) an almost horizontal cracking, evidence of shearing stress caused by the horizontal thrust of the main building. The instability increases on the second level where the cracks in the ceiling and floor are widespread and regular: ceiling damage follows the sequence of metal beams along all the corridor and, in part, also in the classrooms, while in the west wing a continuous gap is evident at the corner between the floor and the external wall of the corridor; it is immediately obvious the way that the iron and brick floor has absorbed the thrusts in a more widely distributed manner compared to the reinforced concrete pavement that is clearly cracked at the connection with brick walls. Cracking phenomena, apart from those attributable to local failures, are entirely absent on the side walls.



Figure 5: Structural 3D model of the «Realdo Colombo» school in Cremona. In case of earthquake, the head of the east wing could collapse. In detail the third level, characterized by a loggia, appears more vulnerable.

In light of the problems described, the project was divided into proposals for action limited to those parts of the complex necessary to achieve a degree of safety consistent with the regulations and to ensure, in the event of an earthquake, only localized subsidence of the structures. The demolished transverse partition walls between the classrooms are to be replaced with metal beam lintels connected to the surrounding walls with metal frames; in the long corridors the partitions with wooden portals that separated spaces and stiffen the building will be rebuilt. In the existing partitions wooden portals will be encircled with a metal frame that ensures greater resistance to torsional stress. Additional walls with portals will be placed along the corridor to improve the stiffness in the Y direction, i.e. transversally to the hall: as an example a frame will be added to the landing of the staircases to connect the east perimeter wall with the external wall of the buildings which project outwards towards the courtyards. A second project concerns the metal frames of the windows on the first and second floor of the protruding buildings, namely those at the middle and end: on the first floor the frames will be included in the splays inside the window openings, recomposing the structural continuity of the masonry, stiffened at points of discontinuity. Upstairs, where the front loggia is the site of a serious example of instability, it is necessary to insert external metal frames between the columns, connecting them to each other. This consolidation reestablishes the structural continuity in the event of an earthquake, limiting outward rotation or rotation of the columns that work as genuine connecting rods. Finally sixteen metal chains will be installed at the floor of the attic along the central building and the two wings, with the aim of preventing a tipping of the façades.

The planned interventions significantly reduce some breaking mechanisms, but there remains a significant risk of breakage due to shear and bending (combined compressive and bending stress) of the walls and what's more the structure is deficient in the Y direction, that is transversally to the body of the building. Such breaks, however, would not affect the overall stability of the building, damaging only some portions.

In conclusion, also in this example it is possible to establish the aspects in which an understanding of the case study has made it possible to achieve excellent results, minimizing the impact of the consolidation and restoration. The knowledge of the building, contemplated and encouraged by the relevant national laws, has been extended to a wider context which was used to direct the project: historical and archival research, diagnostic investigations, surveys and measurements were complemented by research on the debate on the construction of school buildings of the late Nineteenth century, which allowed us to reconstruct the context of contemporary cultural debate and thereby to trace the typological models and reference buildings for the construction of the school Realdo Colombo. This more general knowledge – based on the comparison between models – has allowed us to identify the changes made to the school Realdo Colombo and hence to resolve structural defects more precisely. The evaluation of higher risks of damage is the result of an overall assessment on the building and its intended use, considering the conservation of a protected building, the costs of intervention and the complexity of such an intervention in a building in use.

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