Two Architects and One Engineer: The Reconciliation of Disciplines

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Abstract. At the end of the 17th century, when the Académie royale d’architecture was created in France, architecture was studied for the first time from a theoretical and analytical point of view. 100 years later, the École royale des ponts et chaussées was found, also in France. This division of responsibilities within the building discipline varies from country to country and within the specific historical period but, the idea of two professional branches related to architecture, remains to the present day. Through the centuries, this division has been perceived as a problem or as an advantage depending on the specific event, project or construction. However, at the end of the 19th century, when reinforced concrete came into the world of construction, both branches started an interesting collaboration that produced not just marvelous buildings but also helped to evolve architecture. This collaboration started in France and then spread to Spain, Italy and the rest of Europe. As an example of the work that these professionals carried out together was the team formed in the late fifties of the last century by two architects, Bruno Morassutti and Angelo Mangiarotti and an engineer, Aldo Favini. They worked together in Italy projecting amazing and very significant works, such as the Church of Mater Misericordiae which was constructed in Milan between the years 1956 and 1958. One of the main conclusions is that an adequate approach in the collaborative work of architects and engineers, results in impressive and amazing works in which the combination of aesthetic qualities and structural efficiency result in a harmonious building with plenty of significance.

1. Introduction: A new concept in the world of construction

At the end of the 17th century, when the Académie royale d’architecture was created in France, architecture was studied from a theoretical and analytical point of view. 100 years later, the École royale des ponts et chaussées was found, also in France. This division of responsibilities within the building discipline varies from country to country and within the specific historical period but, the idea of two professional branches related to architecture, remain to the present day. Through the centuries this division has been perceived as a problem or as an advantage depending on the country, historical period, specific project or construction. However, there is no doubt that if the collaboration between these two figures is fluid and responsible, projects become more interesting. France was the country that leaded this division and, from the time of due to the experience during the construction of gothic cathedrals, structural aspect was something really important within the building. At the end of the 12th c., the wall could be opened with marvelous clerestories as the new structural system permitted loads to be transmitted to the foundation only to some defined points. But works were in charge of the Master builder who was the one that coordinated both worlds, that of the structure and that of the architectural

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wall. The result was that both branches, that had not yet been divided, worked together and the structural system was also part of the ornate, following the principles of the movement.

From the 19th century, new materials, beyond those that were traditionally used, were included in building construction. This fact led to different consideration: on the one hand, these new materials were, at the beginning, part of the engineering world and were used for the construction of bridges and building structures mainly, [1]. On the other hand this was one of the reasons that made possible that both professions started an interesting collaboration in the field of construction. When reinforced concrete was included in the repertory of construction materials, several systems invented by engineers were slowly defined through different projects and works made and set up by architects. This material was also very interesting for both professions because it allows larger spans to be covered and it has a plasticity that makes it possible to adapt the material to different shapes.

One of the first examples was the church of Saint Jean of Monmartre, built in Paris in 1893 under a project of Anatole Baudot that followed for the structural part, constructed with concrete, the instructions of Cottancin. This engineer had presented his discoveries in the field of reinforced concrete to the “Society of Civil Engineers of France” in 1889 [2]. This construction is allegedly the first building constructed with a primitive reinforced concrete system in France. Another engineer, Edmond Coignet, presented to the same society an interesting method to calculate the efforts in reinforced concrete structures in the year 1894, a couple of years after presenting his own patent to build with this material. A good example of this system was the construction of the Château d’eau for the Universal Exhibition that took place in Paris in the year 1900[2].

But in the case of concrete, two names are associated with this material: Joseph Monier, who patented his system in 1867, and Francois Hennebique whose patent name was “béton armé” and who expanded this material throughout the world due to a magnificent business organization. Even scholars consider that the first non-industrial building entirely constructed with reinforced concrete was the main building of Hennebique’s company which was erected in 1898.

During this period, a strong controversy went around reinforced concrete: while the Dutch architect Berlage said that reinforced concrete was probably going to be the cause of a revolution in architecture, Domingo Fort, an architect who gave lessons at the School of Architecture in Madrid, expressed his opinion during the 6th International Congress of Architecture[3]. According to him “the modern process of molding concrete could not express the artistic form which was appropriate to the architectural form”. As a consequence, he said that “this system should only be employed for useful or industrial constructions which don’t pretend having any kind of beauty”.

Many other different theories, inventions and patents appeared during the second half of the 19th century giving place to new models and ways for the use of reinforced concrete in building construction. Since that time, the interest of both professional, architects and engineers on this material was increasing and, there is no doubt that, as in the case of the architect Anatole Baudot and the engineer Cottancin, both professions needed to go hand in hand. As a result of this, as time goes by, many different typologies of buildings that were constructed with reinforced concrete such as dwellings, churches and markets extended its use to the whole world of construction.

Concrete required a scientific mind to fully exploit its properties. Therefore, experimentation and theorizing were carried out by engineers and architects who took out patents on their ideas. In Stephen Sennott’s opinion [4], many architects and engineers looked at concrete as an alternative to stone, perhaps because of the similarities between both materials. Concrete also was perceived as the thinking man’s building material and the possibility of creating a monolithic structure excited architects who understood that with concrete each element would resist loads as one integrated structure. According to the mentioned author, this was an important and tantalizing potential, because for many architects in the early 20th century, the key problem was finding a way to bring pragmatic considerations of the engineer
together with the architect’s taste for beauty and formal unity. Sennott also considers the French architect Auguste Perret as the first 20th-century architect to fuse the new medium of concrete with existing attempts to find a modern and modernized expression of architecture. Greatly influenced by the ideas of Viollet-le-Duc, Laugier and Guadet, who was his mentor, he saw concrete as an ideal medium for creating frame structures, articulating columns in a clear and rational expression of their structural use. Perret introduced a new architectural language using concrete in a different way in one of his most well-known buildings: Rue Franklin apartments in Paris. In this case, the building’s structure was constructed in reinforced concrete and the façade was wrapped with concrete panels casting with a flowered pattern. The structure can be clearly guessed from the outside of the building. In his opinion, “if the structure of the building is not worthy of being seen, the architect has not done a good job.”

In this building, the structure was not clearly articulated; however, he used a subtle technique of varying color and texture to distinguish the part of the façade that bears the loads. Thus, Perret deemphasized the mass-wall characteristics of concrete. The effort to read the façade like a frame-and-panel assemblage, a more truthful reading of the structure, was Perret’s way of maintaining continuity with the neorational ideas of the past [4]. It is also interesting for this paper that the engineer, builder and pioneer in concrete construction, mentioned a few lines above, François Hennebique, acted as consultant on Perret’s project. Hennebique, as previously discussed, had several patents for concrete members already and unlike the architect who strove for a homogeneous and uniform structural expression, Hennebique articulated joints between column and beam by thickening the columns and extending the beams in a cantilevered bracket as it can be appreciated in his own house built in Paris in 1904 [4]. Le Corbusier worked at Perret’s studio in 1909 and this was probably the place where he got in touch with reinforced concrete. In 1914 Le Corbusier’s ideas about this material were summarized in his Domino house which marked his works for several years and was a reference for modern architecture. During the following years, this collaboration between architects and engineers was started and carried out by different teams across Europe with the result of interesting constructions that are, in the most of cases, the best examples of the architecture developed at the first half of the 20th century.

In Spain, between 1910 and 1912 an architect, Francisco de Urcola, worked with Luis Sierra and Antonio de Líaño who were military engineers on the construction of one of the first urban building constructed with reinforced concrete [2]: the new theatre of Victoria Eugenia in San Sebastián in northern Spain. The structure of this building was calculated to avoid the existence of columns in the boxes for a better view. Also in Spain, another architect, Teodoro de Anasagasti attempted to renew architecture and fight against “the Ornamental abuse and excessive baroquisim of molded cement” and, for him, the only way was the realistic and sincere treatment of reinforced concrete structures in buildings. One of his most important works was the Monumental cinema that was inaugurated in the year 1923 and was the result of the collaboration between Anasagasti and the technician of the Company of Sestao that was also the company commissioned for the construction of the building [5].

A few years later, in Madrid, Casto Fernández-Shaw [6] was the responsible for the construction of one of the first modern architecture projects in Madrid, the Petrol station Porto Pi [7]. In the previous years he had been working with an engineer, Carlos Mendoza, in the construction of two dams in Cordoba and this experience, as he would later recognize, was in the origin of “his assessment of the structural problems of the architecture as a fundamental way for the renew of architecture”. The most important parts in the project for the Petrol station, from a structural point of view, are the shelter and the tower that were constructed with bare reinforced concrete. Most of the rationalist architects that were working in Spain around the thirties considered structure as essential part of the architectural project and this encourage closer collaboration between architects and engineers during the years before the Civil War in Spain.

By this time, the engineer Eduardo Torroja, one of the most important engineers in the field of reinforced concrete in Spain, was working closely with different architects in some interesting projects. One of them was the construction of the University campus in Madrid commissioned to a team that was led by an architect, Modesto Lopez Otero. Torroja was responsible for most of the building structures, roads and viaducts. He also worked with architects Carlos Arniches and Martin Dominguez for the
construction of some interesting projects as is the case of the Hippodrome of the Zarzuela at Madrid\textsuperscript{[8]}. They were commissioned to carry out this project after winning a competition in the year 1934 and the building was declared a Cultural Interest Site in 2009 and awarded with the National Architectural Prize in the year 2012. A few years after the inauguration of the Hippodrome, in 1962, Torroja wrote an article about this project and explained the close collaboration between himself and the architects: “The problem of the structures had different interesting modalities; but focusing on the main and general tribunes, we see that, in both cases, functional necessities forced to draw some sketching and rough estimates, looking for the highest rapport between structural and architectural elements reaching, thanks to an intimate collaboration between architects and engineer, to a new typology of structure that has a new resistant disposition totally original, \textsuperscript{[9]}”

In Italy, one of the most famous engineers during the first half of last century was Pier Luigi Nervi. He explored the world of reinforced concrete and worked with architect Annibale Vitellozzi for the construction of the Palazzetto dello sport at Rome. This was one of the most important building of the fifties of the last century in which both worlds, that of the structure and that of space worked together. It is also interesting that Nervi’s collection of contact prints included some images from Gothic and renaissance churches to typewriters, from opticians studios to aircraft fuselages and this served him as references and cues for studies, \textsuperscript{[10]}.

2. The case of Italy: Aldo Favini, Bruno Morassutti and Angelo Mangiarotti

Also in Italy, a team formed by two architects, Angelo Mangiarotti and Bruno Morassutti and one engineer, Aldo Favini, worked together since they met at BBPR Studium in Milano. Aldo Favini, the engineer, was slightly older than the architects and he had been working in several projects before the church, giving the importance to the structural part of the project. It is the case of the Petrol Station at the highway in Sesto San Giovanni. Bruno Morassutti and Angelo Mangiarotti had been in the USA working with avant-garde architects that provided them with a different language. They were involved in several interesting projects that are the result of a close collaboration between the three professionals.

2.1 The Church of Mater Misericordiae in Baranzate (Milano)

Between 1956 and 1958, they worked on one of their masterpieces, the church of Mater Misericordiae at Baranzate, a commune near Milano. This work was a surprising building that, even today, remains an icon of modernity that became possible thanks to the close collaboration of this team. They worked together obtaining a building in which architectural and structural solutions produced a space undoubtedly modern. Beyond the importance of this building in relation with modern aesthetics, this model also means the rupture with the typology used so far in this field.

On the other hand it is an important construction as it represents the peak of a number of attempts to renew liturgy and therefore sacred architecture. The construction of this masterpiece was framed into a plan led by the Archiepiscopate of the city and represented a breakthrough in several fields connected to architecture: modernity of sacred architecture, construction and new technologies. The church was inaugurated in the year 1958, creating some controversy at time, by Giovanni Montini, archbishop of Milano, who would become pope Paulus VI a few years later.

Regarding new materials, as discussed above, some major changes took place at the beginning of the 20th century when such materials began to be used with greater profusion and rigor. In the case of Mater Misericordiae, concrete was employed in the construction of a basement - which accommodates the baptistery, the sacristy, a chapel and some secondary rooms - which serve as a platform from which the main structure arise. Concrete is also the material which was employed for the construction of the main structure that defines the upper sacred space. It consists of two porticos built on site that support six beams constructed with precast concrete pieces with “x” shaped section which were assembled also on site. Over these beams, once post-stressed, precast concrete panel slabs were placed.
The church is also interesting due to the novelties appearing in the envelope constructive system which consists of lightweight panels assembled on a secondary steel structure. The uprights of this structure go up from the basement until the post-stressed six beams and, in between them, there are crossbars that form a rectangular structure where the panels are mounted. The original panels were 35 mm thick and were made up with two 5 mm thick glasses. In between both glasses there were 25 mm of low-density polystyrene to improve the system insulating properties. This material creates an interesting dialogue between sunlight and interior space during day and artificial light and the outside of the building during night. (Figures 1 and 2)

As an evidence of the collaboration between the architects and the engineer remain the documents that are at the library of the Polytechnic University at Bovisa (Milano) where the archive that keep Favini’s work is. There are several documents in the archive about the church including structures analysis and calculation, images and plans of the building. In the cross section, where the main structure is defined, by the time (according to the date written on the plan) in which Aldo Favini had already defined the structure, the architects did not know how to draw some parts of it as the cross section send by them to Favini has some parts unfinished, for example the joint between the pillar and the main beam. This was a difficult thing to draw because Favini’s solution for this part was a roller in one of the two joints\textsuperscript{11}. Favini explained in his article “Copertura in C.A.P. di una Chiesa”\textsuperscript{11}, that only a solution in precast concrete permitted to obtain a lighter structure in order to become part of the architectural space and therefore a visible structure. If we observe the interior space of the building, structure is not only part of the image but a very important element that defines it. Beyond this the proportions of each element are according to the rest of them and the panels that formed the glass wall are in relation with the pieces that are part of the precast beams. The precast panels that are over this beams are also in correspondence with the pieces that formed them. Figure 3.

In the year 1979, the church suffered an attack that caused a fire. Part of the envelope system was damaged so one year later the panels were replaced by new ones made up of reinforced glass and high-density polyurethane. In the year 2006, a new rehabilitation in the envelope system was necessary because the layers of polyurethane were highly deteriorated. After many proposals, a plan supervised by the original drafting team of the project was drew up. The rehabilitation works started in 2012 and were carried out between this year and the year 2014.

Figure 1 and 2: Interior of the church by day and the church by night.
3. Conclusions

From the 19th century, when new materials were used in building construction, both professions, architects and engineers, started an interesting collaboration in the field of construction. When reinforced concrete was included in the repertory of construction materials, several systems invented by engineers were slowly defined through different projects and works made and set up by architects. This collaboration can be appreciated in many interesting buildings that have been constructed throughout history. In the case of Mater Misericordiae, both professional worlds worked together for a building that, seventy years later, continue being an icon of modernity.

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