Ildebrando Tabarroni *Ingegnere*: Construction in Bologna between the Two World Wars

Luca Guardigli

INTRODUCTION

The archives of the Italian engineer Ildebrando Tabarroni, which depict his professional life from 1905 to the late 1950s, were recently given to the Department of Architecture and Planning (DAPT) of the University of Bologna. The archives have been donated to Prof. Anna Barozzi, friend of the Tabarroni family.

Tabarroni was very active in Bologna from the 1910s to the 1940s. However, he is not often mentioned in the – rare – books on Bolognese architecture and construction between the two world wars. This is only partly explained by the fact that in the recent past construction during the fascist period – especially regime architecture – has not been studied, obviously for political reasons. The reason is mostly that his architecture is not very significant in relation to the development of the Modern Movement. Tabarroni was a traditionalist designer, like most of the engineers educated at the School of Engineering in Bologna in the same period.

As Hitchcock points out in his famous book, history of architecture focused on modernism because it represented a dramatic and adventurous tension – of a revolutionary kind – tending towards innovation and progress (Hitchcock, 1958). If history was quantitative, it should have concentrated its efforts on the countless thousands of built traditional architectures that, at least in the first half of the century, characterized European cities. The fact is that, during the twentieth century, written history of architecture is mostly, and understandably, the history of the Modern Movement. By the same token history of construction has been guided by the knowledge of new materials like steel and reinforced concrete. Many traditional and/or conventional buildings still remain un-studied as they did not appear to represent a significant path to the future.

In this paper our assumption is that some kind of *innovation* is present under the mask of *traditional construction* and deserves some attention. "Soft" innovation has been introduced in Tabarroni's projects – like in other traditional projects –, but it has remained hidden under his "banal architecture". Nevertheless, the study of his work is relevant not only for the contribution to the development of the city of Bologna during the first half of the twentieth century, but also because it depicts a very strong and distinctive career where the roles of the designer and the builder were strongly linked. The fact that his family owned a construction company and that he was directly involved, as director of construction, in numerous interventions, collaborating with a many contractors, produced a lot of interesting documentation which opens new and different points of view to construction history in Italy. Much information on building materials, costs, construction processes, building techniques etc. are going to emerge.

The work on Tabarroni's archive is still in its early stages, but some consideration of his output, and the light it throws on the construction state-of-the-art of construction in the inter-war years, seems feasible.

CULTURAL BACKGROUND AND PROFESSIONAL INTERESTS

Born in 1881, Ildebrando Tabarroni graduated in 1905 at the *Regia Scuola di Applicazione per Ingegneri* in Bologna. At that time both engineers and architects were designing buildings. However, while architects were educated in *Accademie di Belle Arti* (Fine Arts Academies) – Schools of Architecture and a professional degree were established in Italy only in the 1920s – the engineering degree was the only professional degree in architecture prior to that. The "scientific method" and the traditional approach to architecture that were taught in engineering schools were really influential among designers and had a very strong impact on the cultural formation of designers.

In the Bolognese School of Engineering, architecture was taught by the well-known professor, Attilio Muggia. Following a Vitruvian approach, the formal and aesthetic characteristics of buildings were organically linked with structural and functional ones: architectural principles were found in history. At the turn of the century engineers could also easily switch from one technical subject to the other, solving design problems, from hydraulics to architecture, from bridge construction to railways, or machines.

Only later, when schools of architecture gained power, and architects first switched from the traditional and classical Beaux Arts approach to the avant-garde, embracing the principles of Modernism, schools of engineering lost their cultural influence. Despite the changes in the architectural scene, engineers like Tabarroni, Graziani, Rizzoli, Veronesi kept following their cultural path for a long time and in their way contributed to the actual image of the city. Only some of them, like Vaccaro, became modernists or, more precisely, rationalists.

Although Tabarroni spent his life on architectural projects, right after his degree he was teaching assistant for the hydraulics course. At the same time he was involved in consultation activity on architectural, but also structural issues. In 1911, he was elected member of a technical commission by the *Società degli Ingegneri* (Society of Engineers), in order to establish the "characteristics" of the buildings that were going to be built in via Rizzoli, one of the most important streets in the historic centre of Bologna. In 1912 he was elected member of a technical commission "to study the causes of the worsening of quality in materials, totally antithetical to price increase". Again, in June

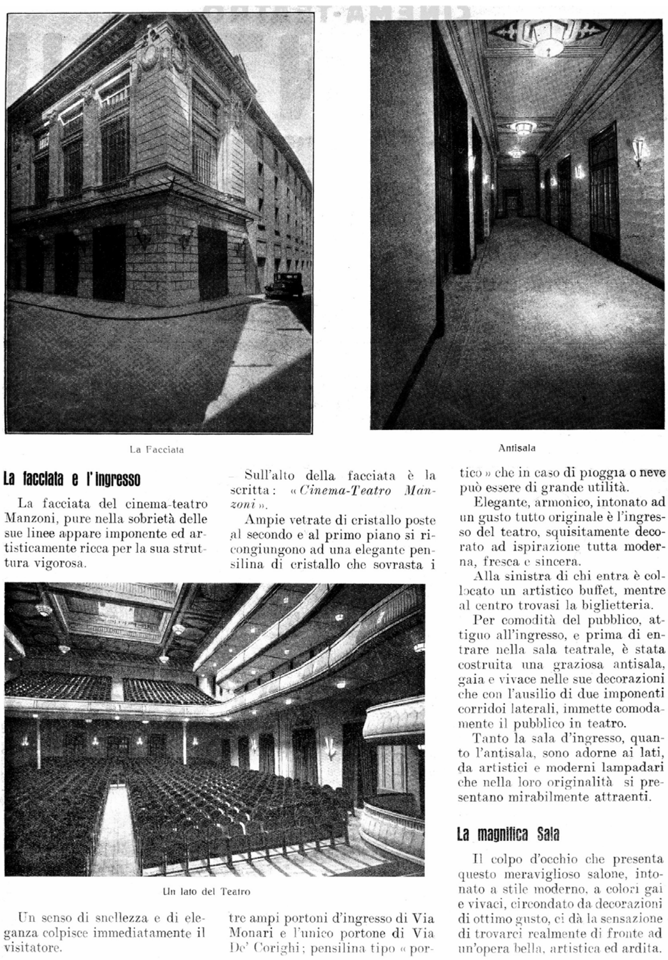
1912, the *Giunta municipale* (Town Hall) of Bologna called him to a technical committee in charge of studying the possible static loads on one of the two famous medieval towers that was dangerously leaning on one side.

This flexibility and positive attitude to problem solving helped Tabarroni in his daily obligations, although they kept him off the big architectural scene. All his professional life was filled with legal estimates and surveys for the Court of Bologna. The relationship between the design office and the construction company that he owned with his brother is also very significant. During the twenty years of activity the Tabarroni Construction Company built many buildings in Bologna: industrial buildings (Cartiera Giovannini, Fabbricato Magli, fabbricato Colombini); private houses (villa Malaguzzi, villa Barbieri), a small housing settlement with eight small villas, many private apartments and commercial buildings - some of which of major importance - in the centre (Fabbricato Faccioli in via Rizzoli, Fabbricato Mazzanti in via S. Felice, Fabbricato Monari in via Belle Arti, Fabbricato Zangheri in via Ugo Bassi, Fabbricato Dal Vecchio in via Livraghi), eight buildings owned by the Company. A lot of work was done on agricultural buildings. The analysis of the production of Tabarroni's company indicates a great deal of activity, where public and private interests coexisted regardless of his involvement with the political power. This actually shows how the fascist power permeated the whole community without destroying private interests and enterprises. Of course, after a period of private projects, at the early stages of his career, his public position forced him to focus on public interests. He was, in fact, appointed president of the *Istituto Autonomo Case Popolari* (Institute for Social Housing), or IACP, from 1927 to 1933 and *Delegato podestarile all'Edilità* (delegate to public works) in Bologna from 1926 to 1934; dozens of buildings were built by the IACP and other Housing Cooperatives under his supervision.

The architectural production of Tabarroni is wide-ranging in building typology. In the first part of his career (1905-1925) he worked for the rich Bonora and Benni families, real estate owners and entrepeneurs in the rural sector.

Apart from minor competitions (Competition for Touring Club hotels (1908); Competition for social housing in Venice (1911); Competition for a Garden City in Venice (1912)), very important is the competition for the hospital of Parma, that he won with another engineer, Giulio Marcovigi. This area of interest – hospital design – will continue throughout his life. It is a kind of typology compatible with the functionalist attitude of engineers: cost control, functional plans, sober architecture. In the period, 1926-1934, Tabarroni started his public career being responsible for public works in Bologna, having been appointed by the *Podestà*, and the beginning of the thirties was his most profitable period. He was the designer and the director of construction for the *Colonia Marina Fascista* in Rimini (a vacation house for children), the biggest of its kind in Italy. He focused on the construction of many social housing buildings. He made profits with his construction company, building a big theatre in Bologna on his own, probably his most complicated project of the period in the city **(fig.1)**. For this purpose he called upon the Calzoni Company – a well-known steel manufactory – for the construction of the movable roof with sliding roof panels. Unfortunately, after this period, just before World War II, there was no more time left for other important projects.

From a preliminary search of Tabarroni's archive no documents have emerged regarding his relationship with the fascist power. He is described as a very shy and reserved person. Arpinati, one of the fascist leaders in Bologna is surprised that in 1934 he had not already taken up the "tessera" (member card) of the Fascist Party. Documents show, for instance, that during the opening of the *Colonia Marina Fascista* in Rimini, a very important commission, he was not present, but he came the day before just to make sure that everything was in order. Of course, this should not sound as an excuse for his responsibilities.


La Facciata

Antisala

La facciata e l'ingresso

La facciata del cinema-teatro Manzoni, pure nella sobrietà delle sue linee appare imponente ed artisticamente ricca per la sua struttura vigorosa.

Un senso di snellezza e di eleganza colpisce immediatamente il visitatore.

Sull'alto della facciata è la scritta: «*Cinema-Teatro Manzoni*».

Ampie vetrate di cristallo poste al secondo e al primo piano si ricongiungono ad una elegante pensilina di cristallo che sovrasta i tre ampi portoni d'ingresso di Via Monari e l'unico portone di Via De' Corighi; pensilina tipo «portico» che in caso di pioggia o neve può essere di grande utilità.

Elegante, armonico, intonato ad un gusto tutto originale è l'ingresso del teatro, squisitamente decorato ad ispirazione tutta moderna, fresca e sincera.

Alla sinistra di chi entra è collocato un artistico buffet, mentre al centro trovasi la biglietteria.

Per comodità del pubblico, attiguo all'ingresso, e prima di entrare nella sala teatrale, è stata costruita una graziosa antisala, gaia e vivace nelle sue decorazioni che con l'ausilio di due imponenti corridoi laterali, immette comodamente il pubblico in teatro.

Tanto la sala d'ingresso, quanto l'antisala, sono adorne ai lati, da artistici e moderni lampadari che nella loro originalità si presentano mirabilmente attraenti.

Un lato del Teatro

La magnifica Sala

Il colpo d'occhio che presenta questo meraviglioso salone, intonato a stile moderno, a colori gai e vivaci, circondato da decorazioni di ottimo gusto, ci dà la sensazione di trovarci realmente di fronte ad un'opera bella, artistica ed ardita.

Figure 1. The Manzoni theatre as presented in "Il comune di Bologna", 1932.

CONSTRUCTION BETWEEN TRADITION AND INNOVATION

In Tabarroni's busy professional life, among plenty of minor duties, there was time for some innovative projects and original solutions. All of these innovations were taken into consideration only if economically feasible. One of the major concerns in all his projects was cost control. It is very well known that innovation in construction technology – steel and/or concrete construction – was introduced into Italy, with some time delay, by French and German engineers as well as construction companies. In fact, this happened very slowly, and old technologies continued to be used in Italy for many years. For instance, load-bearing walls were widely used in residential buildings with continuity until the end of World War II.

This is why concrete skeletal frames and relative calculation methods were adopted very cautiously. It is probably banal to say that more often only single elements – floor systems, beams, panels, etc. – were tested and embedded in buildings that remained structurally essentially traditional. The small size of construction companies played an important role in this selection of elements as the focus of attention, as it still does. Italy's financial situation after World War I was another important factor in technology development.

As innovation proceeded very slowly, the design approach continued to be very traditional. Even when new technologies were brought into construction systems this happened without serious conflict with architectural practice. In other words, innovation was introduced only if compatible with the overall construction system and the architectural concepts. As historians have already demonstrated, at first experimentation with reinforced concrete did not change architectural approaches. The promotion of new architectural forms through the use of technological innovation was, in fact, not the goal of most of the projects. Traditional typologies resisted for a while, forms and architectural language too. Some new elements were introduced very cautiously, hiding behind stucco and decoration. It is important to mention that this was not only an Italian phenomenon. Reinforced concrete techniques generally changed architectural concept everywhere in Europe over many years. It should also be noted that this situation was the same for both for private and public building.

One clear example is given by Tabarroni's production in the project for a seismic church. Technology was introduced through the extensive use of steel framing and a different approach in structural calculations. Nevertheless the impact on the aesthetics of the building was practically non-existent **(fig.2)**. He definitely followed the "Italian way" in architecture, which was primarily rationalist and attached to history and tradition. Steps forward were very timid. To demonstrate all the above assumptions we will focus on a few projects.

The "Rigid" System

In the early stages of his career Tabarroni was research assistant to Prof. Canevazzi, who was teaching hydraulics and was also director of the "Gabinetto di Costruzioni" (construction laboratory) at the University of Bologna. In 1908, with Ing. Armando Landini, Tabarroni developed a new construction system, called "Rigid". It was a new patented floor system. The structure was essentially formed by prefabricated "tavoloni pieni" (reinforced concrete solid slabs), which were placed on concrete beams and fixed to them with concrete grout **(fig.3)**. Another continuous surface can be placed at the bottom of the beams, obtaining an air cavity roof system ("solaio a camera d'aria"). The lower surface can be flat or "cassettonata" (coffer ceiling). In this project Tabarroni focused on technological problems derived from concrete pouring and quality of materials rather than on new calculation methods. He was especially concerned about concrete mix design. The laboratory of the School of Engineering in Bologna tested the "Rigid" system observing the improvement of resistance in relation to the variation of the quantity of sand and water and the quality of "pressing".

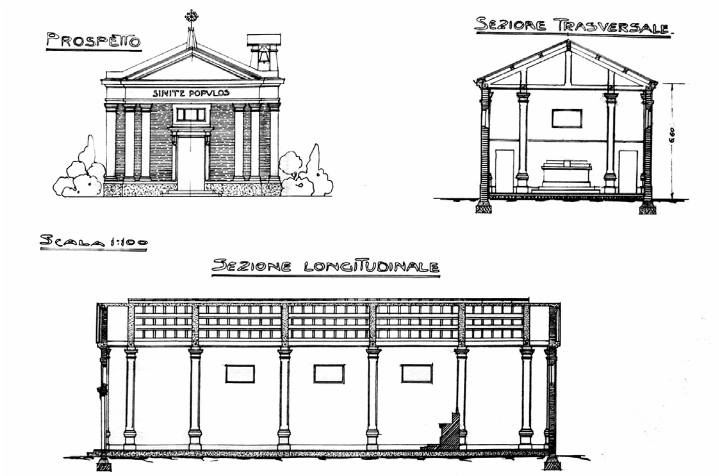


Figure 2. Project for an anti-seismic church (Tabarroni 1915)

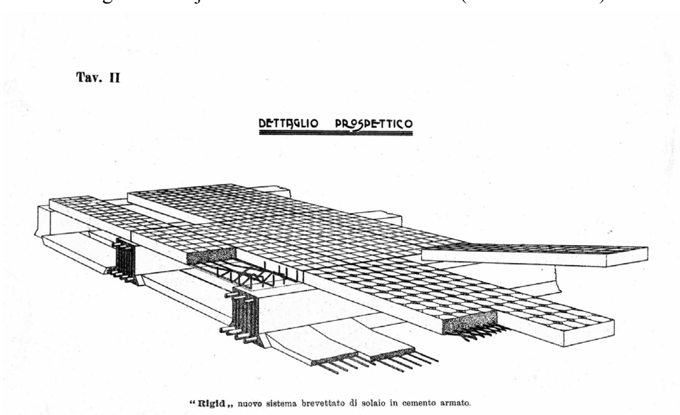


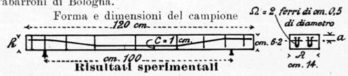
Figure 3. "Rigid", new patented system for a reinforced concrete floor (Tabarroni 1908)

R. SCUOLA DI APPLICAZIONE PER GLI INGEGNERI
IN BOLOGNA

LABORATORIO SPERIMENTALE DI RESISTENZA DEI MATERIALI

Risultato di esperienze alla flessione eseguite su tavoloni in cemento armato « *sistema Rigid* » presentati dagli Ingegneri Armando Landini e Ildebrando Tabarroni di Bologna.

Forma e dimensioni del campione



Risultati sperimentali

Numero d'ordine	Distanza fra gli appoggi cm.	Carico di rottura applicato nel punto medio fra gli appoggi espresso in Kg. (*)	Momento di rottura espresso in Kgcm. M	Coefficiente di rottura riferito al cm.² (*) pel calcestruzzo in Kg. R_c (**)	pel ferro in Kg. R_f (***)	OSSERVAZIONI
1	100	450	11250	253	6323	(*) Escluso il peso proprio.
2	100	475	11875	267	6675	$a = \frac{-m\Omega + \sqrt{m^2\Omega^2 + 2m\lambda\Omega(h-c)}}{}$
3	100	460	11500	259	6458	$R_c = \frac{2M}{\lambda a H}$ (**); $H = h - \frac{a}{3} - c$
4	100	450	11250	253	6323	$R_f = \frac{M}{H\Omega}$ (***)
Media				258	6445	Stagionatura dei campioni, giorni 28.

Deformazioni verificate durante l'esperienza

Freccie di deformazione	Carichi concentrati in Kg. nel punto di mezzo nei campioni 1	2	3	4
$\frac{1}{2}$ mm.	220	260	210	230
1 mm.	250	350	240	260
2 mm.	350	430	340	350
3 mm.	400	460	400	400
4 mm.	440	475	435	450
5 mm.	450	—	460	—

Bologna, 15 Marzo 1908.

Il Direttore del Gabinetto di Costruzione
SILVIO CANEVAZZI

Figure 4. The results of the tests on the "Rigid" system by the School of Engineering in Bologna

The results of the experiments are as follows: the ultimate bending moment of the 100 cm long slabs is about 11250 kg/cm for a concentrated load of 450 kg in the middle. The utlimate tensile strength is about 260 kg/cm^2 for concrete (R_c) and 6500 kg/cm^2 for iron (R_f).

The results from the simple equations come to:

$R_c = 2M/□·a·H$
$H = h - a/3 - c$
$R_f = M/H·\Omega$

where *M* is the ultimate bending moment (kgcm), □ is the width of the slab, *a* is the distance of the neutral axis from the top edge, *h* is the height of the slab, *Ω* is the area of the iron bars (0.5 cm in diameter), c is the distance of the bar from the bottom edge of the beam. The position of the neutral axis is given by the formula of Mörsche **(fig. 4)**.

The analysis of the patent is very interesting if compared with the calculation methods suggested in manuals of the same period, where it is declared that “a lot of uncertainty reigns in the subject of reinforced concrete” (Vacchelli 1903). For instance, the ratio between the modulus of elasticity of steel and concrete varies between 10 and 30, depending on the state of compression or tensile stress. Among the books that Tabarroni kept in his library, new formulas appear only in the 47th edition of the *Manuale dell’Ingegnere* by G. Colombo, in 1923. We have not found any evidence that Tabarroni used the “Rigid” system in any of his buildings.

Housing Projects

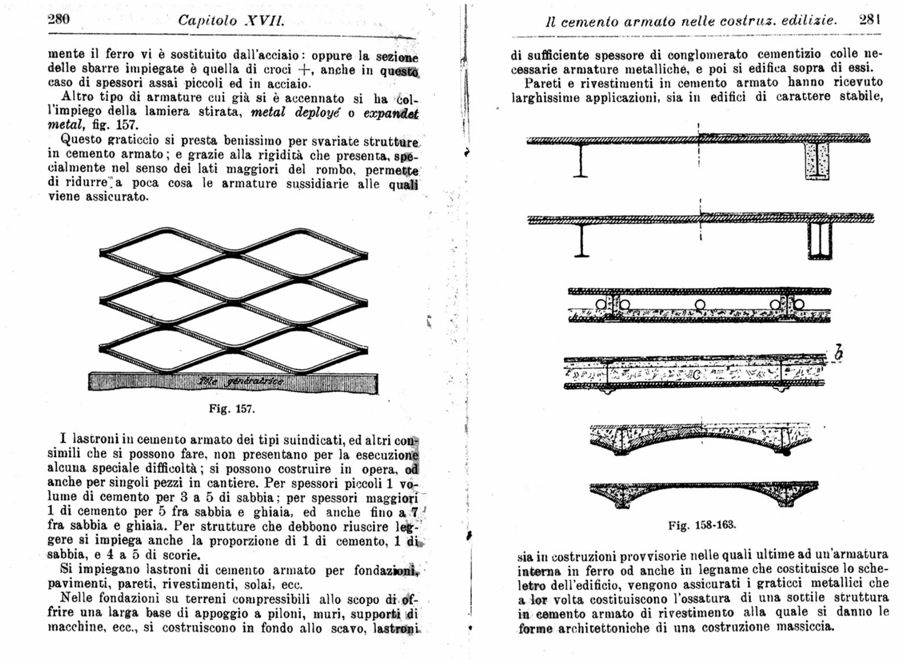
The floor system “in lamiera stirata” (with expanded metal or “metal deployé”) that we see in Vacchelli’s book **(fig. 5)** is presented a few years later in the section of architectural details for a competition in Turin **(figs. 6 and 7)**.

The floor system is an example of “soft” innovation introduced through the accurate observation of manuals. In this project we have a careful description of masonry walls that, according to Tabarroni, should not be selected only according to structural strength, but also depending on environmental requirements:

> Our goal was to follow all the regulations in order to realize maximum saving and obtain the most useful effect, which can be accomplished through the comprehensive study of building materials and space allocation. Saving should be intended as reducing everything to the necessary, leave each unnecessary ornament out, each waste of space, but satisfy the principles of solidity and commodity. [...] Two elements should be studied in walls: thickness and the materials they are made of. The thickness of the wall should not be established according to statical reasons, walls being regarded not only as a part of construction, but also as a factor of comfort and internal healthfulness.
>
> (Tabarroni 1910)

In fact, wall insulation, thermal inertia, as well as natural ventilation of spaces were seen as priorities in that project. The thickness of the wall was 40 centimetres at the ground level; air cavities were left in some walls.

At this stage of our analysis of Tabarroni’s work there is no evidence of calculations for masonry building walls – where horizontal forces are taken into consideration – except for some seismic houses. Wall designs were empirically done. The designer or builder would select the bearing wall thickness from wall thickness tables that had been incorporated into the Italian building laws. The wall thickness depended upon the height of the building. There were no interpretative methods to enable designers to modify a wall thickness, either by increasing or decreasing it, to meet a specific situation. There was no provision for wind or other lateral loads.



280 *Capitolo XVII.*

mente il ferro vi è sostituito dall'acciaio: oppure la sezione delle sbarre impiegate è quella di croci +, anche in questo caso di spessori assai piccoli ed in acciaio.

Altro tipo di armature cui già si è accennato si ha col l'impiego della lamiera stirata, *metal deployé* o *expandet metal*, fig. 157.

Questo graticcio si presta benissimo per svariate strutture in cemento armato; e grazie alla rigidità che presenta, specialmente nel senso dei lati maggiori del rombo, permette di ridurre a poca cosa le armature sussidiarie alle quali viene assicurato.

Tôle génératrice

Fig. 157.

I lastroni in cemento armato dei tipi suindicati, ed altri consimili che si possono fare, non presentano per la esecuzione alcuna speciale difficoltà; si possono costruire in opera, od anche per singoli pezzi in cantiere. Per spessori piccoli 1 volume di cemento per 3 a 5 di sabbia; per spessori maggiori 1 di cemento per 5 fra sabbia e ghiaia, ed anche fino a 7 fra sabbia e ghiaia. Per strutture che debbono riuscire leggere si impiega anche la proporzione di 1 di cemento, 1 di sabbia, e 4 a 5 di scorie.

Si impiegano lastroni di cemento armato per fondazioni, pavimenti, pareti, rivestimenti, solai, ecc.

Nelle fondazioni su terreni compressibili allo scopo di offrire una larga base di appoggio a piloni, muri, supporti di macchine, ecc., si costruiscono in fondo allo scavo, lastroni

Il cemento armato nelle costruz. edilizie. 281

di sufficiente spessore di conglomerato cementizio colle necessarie armature metalliche, e poi si edifica sopra di essi.

Pareti e rivestimenti in cemento armato hanno ricevuto larghissime applicazioni, sia in edifici di carattere stabile,

Fig. 158-163.

sia in costruzioni provvisorie nelle quali ultime ad un'armatura interna in ferro od anche in legname che costituisce lo scheletro dell'edificio, vengono assicurati i graticci metallici che a lor volta costituiscono l'ossatura di una sottile struttura in cemento armato di rivestimento alla quale si danno le forme architettoniche di una costruzione massiccia.

Figure 5. Floor system with expanded metal (Vacchelli 1903, p. 280)

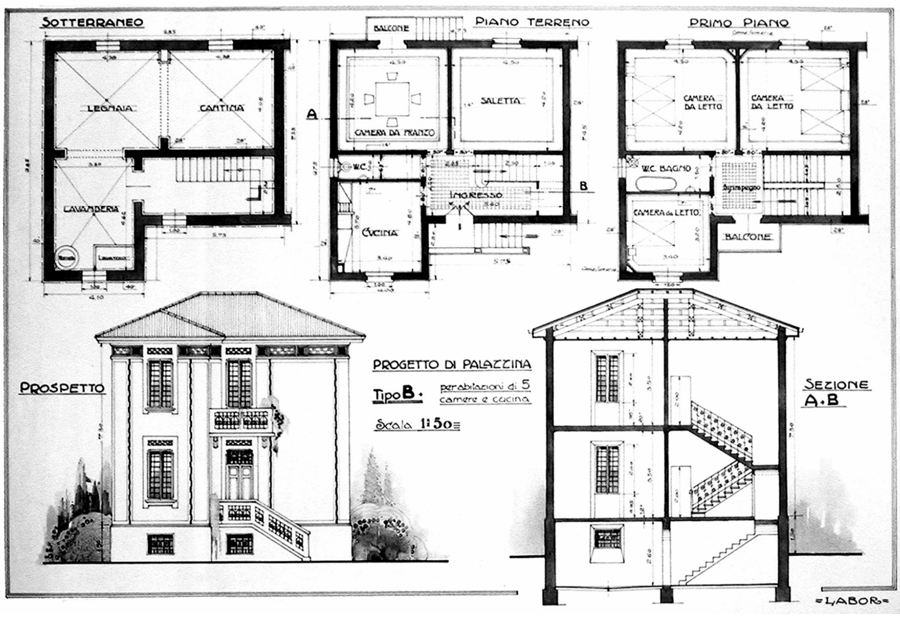


Figure 6. Competition for houses in Turin

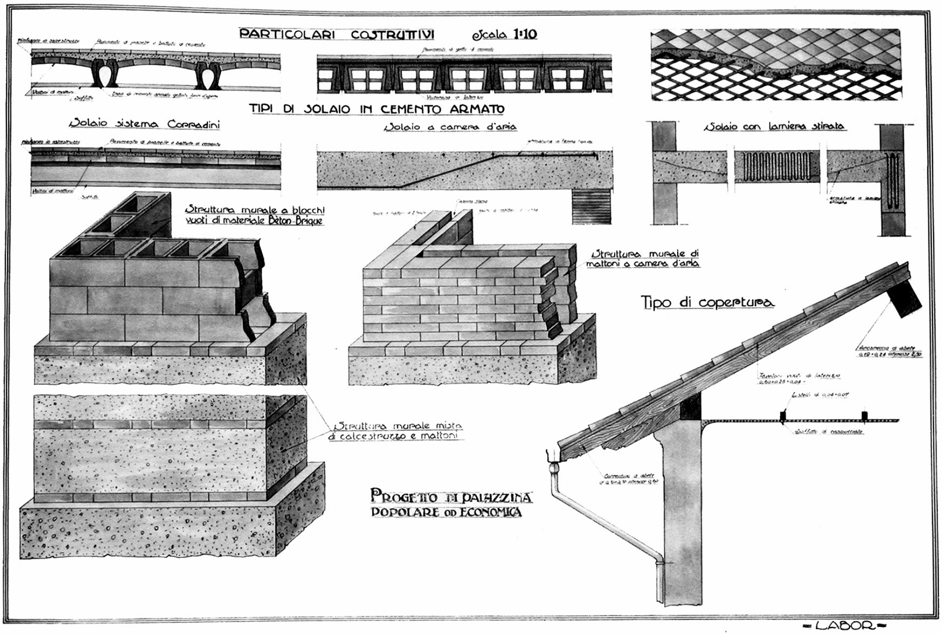


Figure 7. Details for the competition in Turin

Anti-seismic Houses

Technological innovation and use of new methods of calculation were brought into Tabarroni's profession by the competition for some "case asismiche" (anti-seismic houses) in the Abruzzo region, funded by the Italian government for the reconstruction of the towns destroyed by the earthquake of 13 January 1915. It is a set of building prototypes: some houses, one school and a church. Tabarroni followed some structural indications proposed by Canevazzi, who took part to the national committee charged to review the mandatory building codes for the towns hit by the earthquake of 1908 in Messina. The project comes right after a period of major earthquakes, when strong efforts were made to increase safety. Research on earthquakes and calculation methods were not enough developed yet and safety coefficients were certainly overestimated. Performance-based calculation methods in the elastic field which, as we know now, are not very effective were counterbalanced by strong technological solutions.

In the description of the construction system for the anti-seismic church **(fig.8)** we read:

> We tried to make the system as simple as possible, responding to static and economic needs. [...] Walls were designed in bricks (this material, when well baked, is the most convenient from the hygienic and economic point of view) connected by good eminently hydraulic mortar and stucco. In order to protect each wall from dislocations due to its weakness in tensile and shear

strenght, walls were configured with connections, or chains, placed at the intersections. We disposed internal frames constituted by two rows of reinforced concrete columns connected transversally and longitudinally by reinforced concrete beams. Vertical reinforcing bars are placed into concrete at each corner and connected by horizontal chains, one at the foundation level and the other at the roof level. In order to insert reinforcing bars at the intersections of walls, we designed two types of special bricks with a circular hole of 9 cm in diameter and a cut of 2 cm for the passage of the bars, filled with concrete.

(Tabarroni, 1915)

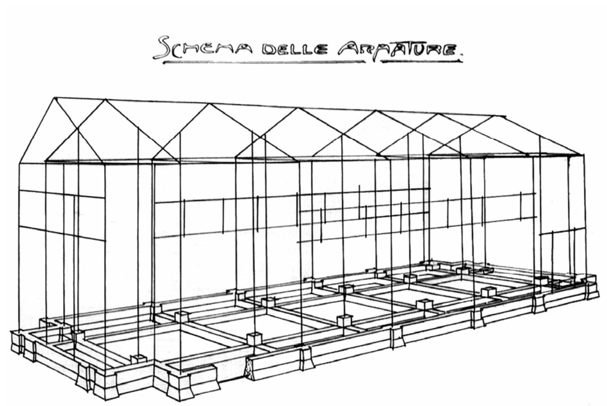


Figure 8. Construction system for an anti-seismic church

Calculations were done following a "metodo abbreviato" (shortened method) by Prof. Canevazzi, which Tabarroni accurately reported in the text (Canevazzi 1913). In this case innovation passes through the experimentation of a new restrictive normative.

The study for the stability of a building should be done in respect to *"subsultory"* or *"undulatory"* movements. For the first ones, having been admitted that their effect is comparable to the one produced by the increase of 50% of the real weight, a special analysis is not required. However, for the second ones the whole building is divided into *zones* with two sets of parallel vertical planes. In such a way the planes of one set are perpendicular to the ones of the other. The equilibrium of the construction related to the "undulatory" movement will be assured when the conditions that guarantee the equilibrium of any of the zones are determined.

[...] As long as perimeter walls and framing walls are ordinarily perpendicular to each other, it is convenient to consider the directions of the seismic actions that are assumed for the calculation of stability parallel and normal to the walls of the building.

[...] It seems that the stability of the building is guaranteed when is considered as such under the static action of real loads and horizontal forces proportioned to the weight of the various elements that make it and load it. This coefficient of proportionality □ is established by Canevazzi equal to 1/10 (□*=0.1*).

[...] If we take into consideration one zone or elementary part of the building it is formed by two or more sectors of longitudinal walls, depending on the fact that it is a simple or a multiple body. The walls are connected because the reaction to a seismic action must be provided with the solidity of the parts. This connections could be good walls, capable of avoiding inward movements or chains and bracing, capable of avoiding outward movements.

If, like in our case, the good wall is missing, like we said above, the connecting part will be constituted by a portal frame (reticulated or quadrangular).

(Tabarroni 1915)

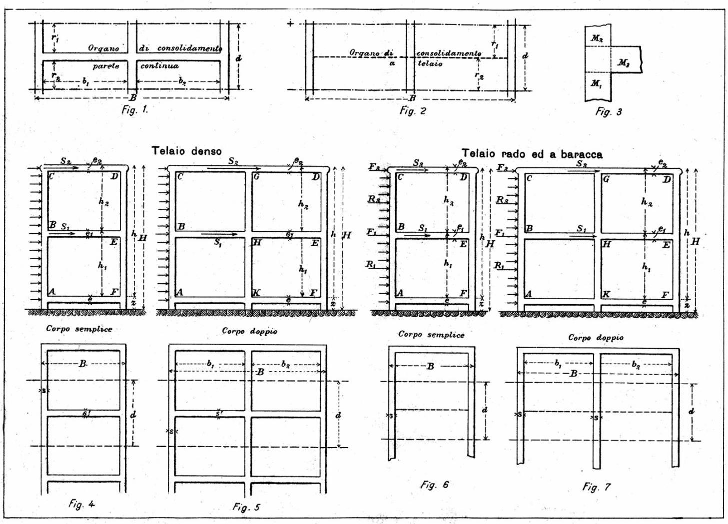


Figure 9. Building zones and frameworks according to regulations for seismic areas in 1913

Frameworks are divided into *dense* ones and *sparse* ones **(fig.9)**. As in Tabarroni project there are non-transverse walls every five metres, the frame designed for the church is considered *sparse*. Therefore,

the strenghtening of the system and solidarity between longitudinal walls are given by vertical quadrangular framework ("telaio verticale quadrangolato") and inner portal frame ("portale intramezzato") with columns fixed in solid ground or foundations, with a top at the roof level stiffened by a connecting beam jointed with the columns in order to avoid deformation of elementar quadrangles equipped with resistent diagonals.

(Tabarroni 1915)

Here we see a very simple project of one floor only. The conception is a masonry wall reinforced with steel bars (vertical and horizontal) that penetrate in special holes carved in full bricks. The strength of the system is overestimated.

In order to guarantee the stability against horizontal seismic action two different calculations are required, according to Canevazzi and Tabarroni: one related to the whole zone, as a cantilever beam fixed to the foundations, the other aimed at guaranteeing the un-deformability of the portal frame considered as a quadrangular system without any bracing. The beams offer resistance to deformation. The relationship between the seismic action on the two structures (vertical frames and beams) and the total action, is obtained balancing the expressions of deformation in common points. This relationship is function of the length of the elements and the moment of inertia of the sections. If we consider that the lengths of columns and beam are similar, we can accept the hypothesis that half of the seismic load is on the columns. A further simplification is to consider the loads on the joints and the beam perfectly rigid. Following this hypothesis, bending moments are null in the middle and at the joints they are given by the shear stress multiplied by h/4.

The bending moment at the level of the fixed joint is:

$$M = p \cdot d/10 \cdot [n \cdot s \cdot H^2/2 + 3 \cdot B \cdot e \cdot (h/2 + z)]$$

where:

p = weight of the considered material,
b = width of the zone (the distance between the consolidation elements)
h = sum of the heights of 1° and 2° floor
H = height from the ground level
n = number of longitudinal walls existing in one zone
s = uniformed thickness of longitudinal walls
B = total width of the structure
e = uniformed thickness of floor and roof; $e \cdot p$ is the total weight of these elements.

In longitudinal walls tension and compression are given by:

T = M/B

Not considering the tensile strength of masonry walls, it is necessary to introduce a complete framing made of tensile resistant material (iron or wood) with a section given by the formula:

a = M/B·□□T/□

Shear is:

$$V = p/10\ (n \cdot s \cdot H \cdot d + B \cdot s \cdot H + 3B \cdot e \cdot d)$$

The average volumetric percentage of framing compared to masonry is given by the formula:

$$\square = a/s \cdot d.$$

The Fascist Colony in Rimini

A new set of seismic regulations (*Nuove Norme tecniche ed igieniche di edilizia per le località sismiche. Approvate con Regio decreto-legge* 3 aprile 1930, n. 682.), which we found in Tabarroni's archives, accompanied the project for the *Colonia* in Rimini, in 1933 **(fig. 10)**. This city was classified as second category by the new regulations.

The proposed construction system for the Colonia was mixed concrete and load bearing masonry walls. Unfortunately, we could not study the calculations because they were done by another engineer. Tabarroni was too busy in Bologna with his political position. In fact, as director of construction, he visited the site, 100 kilometres away on the seashore, no more than ten times in over twelve months.

In the regulations we read:

> Art. 31. Calculations for stability. In calculations for the stability of buildings with reinforced concrete skeletal frames, or steel frames, or reinforced masonry walls ("muratura animata") the following actions on the resistant structures should be considered:
>
> a) the dead load of various parts and maximum live load for each of them. The loads should be increased by 1/3 to take into consideration possible actions due to "subsultory" movements;
> b) the horizontal forces applied to the masses of the various parts of the building, depending on the seismic accelerations transmitted by the "undulatory" movement. These forces should be considered acting in both directions, transversal and longitudinal. In buildings that are not higher than 10 m the ratio between horizontal forces and loads of the correspondent masses should be 1/10 for the basement and the ground floor, 1/6 for the floors above. In higher buildings this ratio should be always 1/6 for each floor.
>
> The frame should be calculated starting from the base, which should be anchored or jointed to the natural ground. If the frame is fixed in foundations, these should be 15 cm wider in each part and built with concrete mortar. In calculations "subsultory" and "undulatory" movements should not be considered contemporarily.

After almost twenty years these regulations do not seem to be very different from the document of 1915. As we have said before, we could not analyse the calculations for the *Colonia*, but calculations that were apparently done for the concrete elements did not arise come from the interaction with the masonry walls, distributing forces and torsion according to stiffness.

The pavilions that constitute the building are regular in shape, but the big rooms towards the sea are characterized by slender concrete columns in the middle, interaction of which with the perimeter walls has not been investigated yet **(fig. 11)**.

Figure 10. *Colonia Marina Fascista* in Rimini: view from the beach

Figure 11. Colonia Marina Fascista in Rimini: concrete columns in the big rooms facing the sea

Building at Porta Castiglione

Twenty years before, another interesting project shows the interaction between skeletal concrete frame and masonry wall. In 1911-1912 Tabarroni designed and built a L-shaped four-storied private building at Porta Castiglione in Bologna **(fig.12)**, with two long facades (45.80 metres x 49 metres).

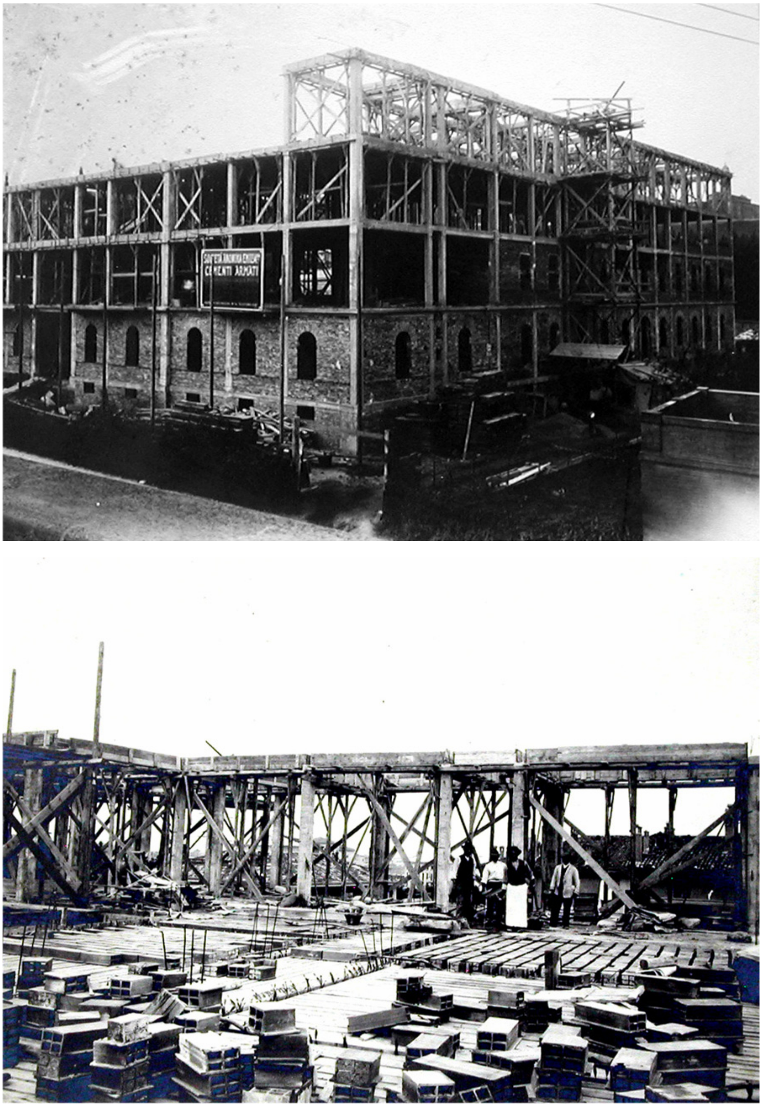
Figure 12. Building at Porta Castiglione as it looks today

From the specifications in the contract we read that he firstly designed brick vaults between basement and ground floor, and load bearing walls for the upper floors.
At some point the office of Ing. Cannovale & Delle piane, Bologna, part of the *Società anonima bolognese cementi armati*, whose calculations encouraged Tabarroni to use "un'ossatura" (a concrete skeleton), with the purpose of saving some money **(figs.13 to 14)**.

In the technical proposal by Cannovale & Delle piane we read:

- on-site poured concrete and beams at sight for the roof system,
- air cavity concrete system for ground floor and upper floors (Cannovale system). In these floors any sight of the beam is excluded because all beams are right above the walls and therefore they will be covered,
- perimeter and internal columns supporting floors, walls and roof,
- connecting flat arches on the top of the columns,
- slab foundations sitting 50 cm below basement level in order to keep stress in soil under $2kg/cm^2$.

Calculations for floors strength are based on 200 kilogram of load per square metre. We guarantee the resistance of floors to the test of 300 kilogram. Between the 50th and the 60th day after the end of concrete pouring you can test floors with the load of 300 kilogram. Under that load the inflection of the tested slabs or beams should not exceed 1/1000 of the total load. In case of unfavourable results we will guarantee the repair of the work, if possible, until obtaining the guaranteed resistance or the complete reconstruction.



Figures 13 and 14. Building at Porta Castiglione during construction

Construction started over the summer of 1911. A letter dated August 16, 1911, from Bonora says:

> [...] on the progress of work I had a disastrous impression. You won't be able to maintain what formally promised. I think it will be opportune to pay the cementists anyhow and continue with stone or with whatever you think is better. As I said another time, it doesn't matter if we throw money away, but I want it done for the deadline that you know»

In fact, the concrete work has caused some delays to the construction process, which leads to resentment from the owner and unpleasant letters to Tabarroni. According to the client, the solution of the concrete frame slowed up the construction process. This is a very interesting factor to consider. For conventional buildings load bearing walls are seen as a faster method than the skeleton, with the same structural performances and almost the same costs. Lower costs for concrete frameworks will occur only forty years later, during the post-war reconstruction period when, on the other hand, the quality of enclosure materials decreased, construction "fastened" and the relative cost of labour rose. Tabarroni experimented with the concrete frame but face some difficulties. In none of the documents that we have examined is there a single piece of evidence of recognisable technical advantages for reinforced concrete over traditional systems. Masonry bearing walls appear even cheaper. In fact, one can easily see that the section of the wall has not been reduced enough to balance the new expenses of the frame. Other interesting aspects of the Castiglione building regard decorations and other works, which are only partially traditional: new technologies were introduced for windows, floors, facades, especially concrete pre-cast elements. Tabarroni is very careful in checking all these details of the building, from door and window handles to concrete work. At this early stage, experimentation with concrete frame seems to happen in Bologna only in private buildings, not in public ones, and without success.

Social housing

Fifteen years later, Tabarroni is appointed president of the *Istituto Case Popolari*. He kept this position from 1926 to 1935. In this period he helped design many social housing schemes for another Cooperative, the *Società Anonima Cooperativa per la Costruzione e il Risanamento di Case per gli Operai* (Anonymous Cooperative Society for the construction and rehabilitation of Houses for Workers).

Looking at construction documents from twenty years after the building at Porta Castiglione, Tabarroni had definitively – and not surprisingly – moved back to tradition; not only for the use of load bearing walls, but also for the use of decoration. The plans of the new buildings are also very banal. Tabarroni does not free himself from manuals, like Barigazzi's, which were printed thirty years earlier, in 1903. Building typologies followed the examples of the turn of the century too. Tabarroni had adapted himself to this kind of construction. Many interventions regarded the rehabilitation of older buildings followed, but the philosophy of the work was still coherent with the past. The goal was not avant-garde, experimentation or surprise but rather quality in terms of cost saving, durability and maintenance. This type of engineer did not seek innovation regardless of the cost; innovation was mediated through fast process, available technology and costs.

The architectural results are not exciting: in elevations of buildings that were built twenty years earlier it is hard to distinguish between the old fabric and the new parts. In the case of Fabbricato C, in via Zambeccari, for instance, it is practically impossible to tell the difference between the old brick texture and the new one of the top floor **(fig.15)**. The small innovation by Tabarroni was simply the introduction of a new type of roof “alla fiorentina”, where rafters projected beyond the outline of the external facade. Despite his conservative solutions, these buildings are still in good condition and popular now as middle-class apartments.

Figure 15: Bologna*, Società Anonima Cooperativa per la Costruzione e il Risanamento di Case per gli Operai: Fabbricato C*, in via Zambeccari

CONCLUSION

Some work still needs to be done on Tabarroni, but we can reach some preliminary conclusions. History of architecture and construction is characterized by a great number of traditional projects that represent the major part of the total production in Italy and, more generally, in Europe during the first half of the twentieth century. A lot of work should be done to discover this huge quantity of buildings, which were considered not innovative, but contain some new reasonable technologies and hidden innovations behind their conventional surfaces. This is a good reason to focus more research on these buildings. Technological innovation, of the modernist kind, which was introduced into Italy with a delay of ten years compared to France or Germany, was mostly independent from the evolution of the architecture language. However, sometimes it is possible to find innovative elements in traditional fabrics, like in Tabarroni's and, on the contrary, see modernist buildings that are poorly constructed.

Innovation came in smaller components rather than in whole construction system (apart from the seismic houses, that were done in a sort of emergency situation). While many new elements were implemented into buildings, new technology translated into "new construction systems" was not always considered. From this point of view Tabarroni, like many other engineers of his period, was not capable of being an innovator. This position was probably determined also by his clients and the general economic system.

Despite the fact that he is not an innovator, many buildings built by Tabarroni, are still in good shape. These buildings are probably not architecturally significant, but of high *construction quality*. They keep a very high price in the real estate market, especially the ones that are sold into the private market. An interesting research field that we propose to assess in the near future through analytical approaches, is the structural safety of these buildings, due to the interaction between the skeletal frame and masonry walls.

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