BUILDING FOR HOUSING: STEEL TECHNOLOGIES

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ABSTRACT

In house architecture, the steel technologies use has constituted, especially in Italy, a research and experimentation field rather delimited. Although the house topic has been most important in the modernist discussion, becoming, after the war, a social problem, its declension as to steel technology remains conditioned by the historical events, cultural background does not accept the temporary idea of housing, suggested by use of steel. In the outlook of vicissitude with fragmentary border reconstruction, the goal is to research technical modes and building system and to assess techniques and shape implications. These technical-project vicissitudes were analyzed as to different topic trends: “experimental house”, “anti-seismic house”, “temporary house” and “steel house”. The building experiences of steel house have implied innovation processes, marginal and partial, and large and general tendency to technique hybridization, researching more the factors of constructive and functional rationalization, than the linguistic potentialities.

Key words: Temporary house, Anti-seismic house, Experimental house, Steel house.
Introduction

Since before the unification of the country, the productive Italian area was characterized by ten years of delay compared to the Industrial Revolution and it seems very heterogeneous from territorial point of view and regarding some predominant sectors, as the textile. The national situation, in the iron and steel sector, was characterized by the presence of poor settlements situated in areas with iron mining resources, and by a production that didn't exceed 13.00 tons of cast iron.

After the unification of Italy, the situation did not change, but became worse due to competition of foreign market. The first signs of change were determined by the creation of infrastructural lines and junctions. That is the extension of Genoa harbor and the realization of railway line between Genoa and Turin. At this stage there is a progressive extension of Ansaldo company's factories in the Liguria territory. That by the end of 1880 rises from 870 to 3000 workers and in 1903, owns factories on 34.000 ha in the strategic area of the region.

On the contrary the realization of railway lines in the rest of the country without factories for the production of rolling stock is characterized by the steady recourse to the foreign market.

The slow industrial impulse conditions have negative reflections on the technical development even in the residential building sector. In fact due to a moderate increase of population in the productive areas there isn't urgent need to build housing for workers as in the rest of Europe.

In 1887 the increase of the customs duty on the steel import, brings about a turning of sector and it starts industrial model. This phase is characterized by public orders in the railway and military sector and by location of new settlements in the center and in the south of Italy, the steel factories of Terni, then those of Piombino and Bagnoli.

The First Experiences in the Metal Construction

In this productive context notwithstanding the start-up of the production of new materials, first among the other cast iron, in Italy the cultural interest for the masonry architectures is still very strong. It detects a significant typological as technical-structural progress, mainly within Turin area. On the contrary in Milan, which along the years remains a preferred site for experimentation about the house in steel, around 1860 the works by engineer Giuseppe Mengoni realizes the first planning and building experiences with steel through the realization of Vittorio Emanuele gallery and later on, in Florence three covered markets.
The project of the gallery turns out to be innovative not only for the roofing with iron and glass, but also for the mixed structure with brick iron and wood that characterise the outside buildings, anticipating the trend to the interbreeding of techniques that becomes a distinguishing mark of modern construction in Italy.

With regard to the introduction of the steel use, it is not of less interest for the project of the railway station of Turin Porta Nuova by engineer Alessandro Mazzucchetti, built in 1868, where the roofing surface has a bearing structure made up with iron arches leaning within the walls. In addition to this, the project of the Milan railway Station, made by Ulisse Stacchini in 1912, but built later, which, in spite of the functional modernity of the framework, shows a facade architecture different from its content: the five arched spans roofing and covers 204.21 meters of bay.

The line of progressive development of techniques and realizations with steel in the specificity of Italian context comes up with two different direction: the first one is directly related to the cultural context of the avant-garde with particular reference to the Futurism Movement and to the definition of new paradigms of Modern Architecture.

The second one is related to practical needs linked to the earthquakes' emergency after the devastating event of Messina in 1908. Therefore the steel constructions in Italy, particular referring to the residential ones, are organised with regard two different themes: on one side the safety theme and on the other side the technological experimentation in the context of modernism Movement with obvious and mutual conditioning.

**The Steel for the Technical Progress: Experimental House**

The experimentation about steel house topic, is articulated in two different moments; the first before the war and autarkic period, that sees Milan and its Triennale Exposition, central place either of cultural discussion, or of several demonstration type realizations; and the second after war conflict with significant experiences starting from 1950s to first years of 1970s.

Inside Triennale the experimental steel house topic has the maximum expression because connected not only to innovation technique, but also to the problematic of formal language and new functional typologies. The 5th edition, for the first time in Milan in the Palazzo dell'Arte venue, the idea is to build in the Sempione Park, “six new residential typologies, with steel, wood, masonry brick and plaster”. The will is to define the centrality of house thematic for italian architects, influenced by Waissenhof. The Griffini, Paludi and Bottoni project of sea house, realized by Carpentry Bonfiglio, has steel structure with vertical elements made of steel tubular profile and horizontal elements in steel beams (type U NP 22). The envelope is
executed by magnesite panels. With “sea houses” there are three collective residential buildings (Pagano architect group and Daneri) realized as a model to scale 1:1, with several technical references and construction details. Two buildings have a steel structure and were constructed one in 20 days and the other in 28. Pagano building is completed with walls, only on higher floors, while in the other one the steel structure is visible. The steel performances, in structural meaning, are in evidence through the elimination of two pilasters from last but one level, and its slab is sustained by steel tie-beam soldered to a roof beam. In 6th Triennale Edition is organized with Residential Exposition, also Exposition of construction system and building materials, to acquaint the people about the principal construction system and its components. In this edition that G. Pagano proposes the realization of a real experimental residential quarter for Milan, practice representation of a total modern neighborhood. This initiative was interrupted due to the political situation at this time, autarkic and Abissinia war. In the 7th Edition in opposite of the “International Exposition of Mass Production”, in direction of building industrialization, was organized also the “Exposition of Autarkic Building” with construction system and formal language all within historic tradition. Only after the war, QT8 is realized, but the positive conjuncture, either cultural or temporal, for technique experimenttion and steel use of 2+40s, is finished, all interventions in the experimental quarter are in reinforced concrete, while the research pursues in the typology system and architectural characters. On the contrary, in the 1950s there are more initiatives and occasions for the steel experimental house; in Bruxelles exposition, inside CECA pavilion, Zavanella project's of “single steel house” was showed. The house is projected with modular elements connectible and detachable. The structure is made by 8 vertical rods in normal profile; the floor, lifted from ground, is leaned on the frame of beams and is constituted of corrugated sheet-iron, forming a continuous flat with air space. The roof leans on beams conjunction frame and a set of small trusses in steel profiles. The external walls are defined by steel modular elements connected to structure with panels outside, in sheet to high resistant, and inside in plaster. In the period between 1960s and 1970s the residential building adopts prevalently concrete-masonry system and the steel house return to be object of more studies and research.

In the first exposition of Prefabrication, during trade fair dedicated to house, organised by Mostra d'Oltremare Company (Naples 1958), a particular section is dedicated to steel construction and with the contributions of more societies is assembled a residential building, at two floors, totally in steel. This material is used, in addition to resistant frame, also for floors, window and door frames, interior walls, ceilings, covering elements, including also the service block. The building was completed only partially for allowing visitor to see the different phases of realization and used components. All is very different in relation to the Triennale Exposition, in 2+30s, either from technological potentialities point of view or formal quality. In the trade fair there is a collection of products and possibilities of integration for building the “house all in steel”.

The international competition, announced by CECA in 1966, for the “project of industrial residential unit”, wants to give signs of the positive attitude to industrialization and defines the application of industrialization basis elements for the different residential typologies; the steel use with criteria of economic and technical suitability, functional flexibility, and an annual production of 10,000 flats. A experimental project, favored by CECA, Italsider, Public Work Ministry, is realised to Piombino, in the first of the seventies. The project, defined by one national group of designers (F. Gorio, M. Grisotti, E. Mandolesi, A. Petrignani) foresaw the realization of 316 apartments with three typologies: blocks of 9 floors with ground floor on *pilotis*; line buildings with two floors on *pilotis* and single houses of one floor with the garden. The collective buildings are projected on modular 110x110 centimetres, and have a load-bearing structure constituted by perimeter pilasters and beams in steel, while the staircase hollow and the small court are realised by reinforced concrete. The single houses are constructed with masonry techniques. The walls in the steel buildings are constituted by masonry with air space and brick.

**Figure 1:** Experimental steel houses
In the sphere of research is also collocated Italsider competition initiative, in the 1981, for “Project of building anti-seismic system with steel structure”, between the proposals, University of Naples, with professor Vitale, presents a project of “Adaptive System to mixed structure”. The structural system is divided into two subsystem: one with steel structures of linear type, vertical rods, floor carpentries to double frame and over-structure of cover; the other with vertical structures in reinforced concrete constituted by bi-dimensional elements. The floors are mixed and realized with corrugated sheet-iron and concrete casting.

The Steel for Security: Anti seismic House

In the years of first Italian experiences in modern techniques, with steel and reinforced concrete constructions, also for civil buildings, happens the major earthquake of Messina, in Sicily (1908), which opens the discussion about the statically safety in building sector, starting prescribing new rules. In relation to the ministry experts commission work, choose by Government, was enacted a law number 193 of 1909, that introduces basic innovations about the resistance calculations, and suggested, as reference, a building typology, called “casa baraccata” (shanty house), characterized by wood structure with beams, pillars and stiffening inside the brick masonry

Although connected to “casa baraccata”, the enacted rules induced positive effects, the project of several patents and some researches about steel structure houses fit to be resistant to seismic forces, for, on one hand, the innovation of new construction typologies, and, on the other, the definition of the consistent resisting morphologies. Several of projected and produced patents defined steel construction systems to which mount the frame-work and stiffen the structure, proposing again a model, technologically progressive, of the “casa baraccata”. The “Minelli system” was based on steel stay-bars in vertical position connected to those horizontal located at top of floors. In the “Foresti system”, the steel bars were distributed to regular steps on whole masonry structure, and connected to special perforated brick blocks

In this period more were the determining factors for the partial diffusion in using steel, particularly in the residential building: in the technical treatise, the reinforced concrete was showed as the better material for seismic and fire resistance; the fast evolution of innovative products, in the brick sector, with an improvement of construction speed and lightening of loads and, besides the absence of technical regulations. The first technical regulations, for steel construction, enacted in 1916, excluded its application just in the building residential sector, against steel producers expectations, allowing it only for constructions related to railway network. Although there were not a specific rule to build with steel frame-work system in the seismic zones, classified as first and second categories by Royal Low Decree number 431 of 1927. Only in the Royal Low Decree number 640 of 1935, at the article 16, all
concerning construction systems; the reinforced brick masonry exceed in favor of all structures fit to be resistant to stress of compression, traction, bending and shear, without excluding the use of steel construction, but imposing particular restrictions for fire protection.

The technical rules, for anti seismic construction, makes a reference to decree number 640, about the building systems to be used in new constructions, also of residential types. The constructions, also residential, could, to 1909, utilize the steel to realization separate building components: floors, lintels, but also sheet-steel for ceilings and single or double walls. It is necessary to wait the 1927 in order to have an explicit statement about the use of steel beams in construction of floors, even if it is limited to ordinary masonry buildings, showing an evident contradiction to the steel frameworks, also totally in steel, were accepted. The steel use, in the anti-seismic house, is re-proposed, during the XX century.

In the first years of INA-Casa, the steel is at the border of building activity, which privileges other technologies for residential realization, notwithstanding the availability, inside of steel national market, of several structural shapes.

On May 5th 1976, Friuli Venezia Giulia region was struck by a major earthquake involving a wide area involving 108 small villages. The event dimension imposed a rapid and effective rebuilding work. Due to this fact the district administration of Udine and AIP (Italian prefabrication society for building industrialization) promoted competition for “project of construction system” assigned to Friuli rebuilding according the requests and local living traditions. Among the projects there is one of roman architects and engineers group which proposes the use of prefabricated units use with steel anti-seismic structure. The proposal, never realized, planned settlements that were different in dimension and typologies (detached house, tenement house). In the construction system there were steel structure, panel floors with reinforced concrete, lightened or pre-compressed, walls with prefabricated concrete reinforced panels. Another earthquake, in November 1980, is the event which attracts significant public economic resources assigned also to houses construction and really open the way to steel utilization in the rebuilding. The disaster concerns several region in south Italy, Campania, Puglia, Basilicata: Naples is entirely involved by seismic event. For the principal city of the region and the small towns of district, the extraordinary program defines the realization of 28,000 apartments. On two front, Naples and Monteruscello, were started real laboratories of industrialized building. In the first, the steel application is extended also to “case-parcheggio” (parking buildings), necessary for residential mobility operations related to program realization; in the second, the steel was used in significant way within particular systems trying, each time, to take the component to its maximum capability, to make easy assembly operations in relation to technical capacities of unskilled workers, or to adapt the system to anti-seismic requirements.
For disaster cases, and in particular to the homeless person emergency needs, the use of steel in the specific house typology is emphasized.

The temporary house, that is a house for exceptional situations, or for occasional living, like in the holiday houses, is the unique field in which it appears culturally acceptable. These are not permanent structures. The temporary house, become, from this point of view, a preferential sphere in which they have to be experimented for their performances: new possibilities as transformability, functional flexibility and enlargement. The topic, in the first phase around 1950, is related to production development of some new building components, prefabricated reinforced or insulating panels, to be used for vertical external walls and for covering floor, integrated with windows system, different in sizes and typologies. The steel structure is chosen because this material assures the realization of detachable connections for an unlimited number of times.
The emergency house topic is in the first place again due to the earthquakes. Every now and then it is necessary to store temporary houses to be used in these particular situations; from this point of view the district agencies and the public corporations, as Civil Protection, initiated several initiatives. The Italian Red Cross promotes a competition for the project of emergency intervention residential unit, the requirements of competition are: the basis units have to be projected with components criteria. Promotion instruments for the emergency houses realization are also started by, for example, IACP (autonomous institute of popular houses). The consortium of Emilia Romagna region IACP promotes another competition; the project proposes the integral prefabricated systems of functional blocks, totally pre-assembled in steel works. With this three-dimensional system, it is possible to realize, inside the iron works, the union of component block, including finishes and installations, guaranteeing lightness.

The Steel for Programming: The Steel House

It is necessary to wait for 1950s, during the post-war rebuilding for returning to the steel houses. The ideal place is still Lombardia region, to Lecco, venue of Badoni Society that has projected and realized Feltrinelli House. Many years have elapsed and something is changed: the steel structures project doesn’t treat inside of steel-works but it is entrusted to outside. Badoni Society gives the appointment to engineer Gino Grove, who had cooperated, at the end of 1930s, to the realization of “Palazzo dei Congressi” steel covering, at Eur district in Rome, for which the society was entrusted the project.

In the period between post-war rebuilding and economic boom, the house construction is entrusted INA-Casa Agency. From 1949 to 1963, split in two phases of seven years each one is realized several projects for 350.000 houses, nationwide.

However “Fanfani Program”, not accepting an industrialization policy, defines that the workmen's houses are constructed in building yard, with not skilled-workers, to employ the maximum number of contractors and workers.

To realize, a total of 236 apartments, in high-rise buildings of nine and fourteen floors, Italsider used steel structures, for staircases, and used the same material for envelope elements, walls and window and door frames.

At the same time FEAL, Milan society that produces functional blocks and steel window and door frame, start to study a construction process called VAR M 3, which, over following changes, is defined to beginning of 1980s system.

In the middle of 1970s, the initiatives are sporadic either in public sphere, or private. The “decennial residential program” will not succeed in starting the use of steel
applications in the residential building. IACP of Genoa, for example, orders to CMC of Livorno, the residential realization of 90 flats, in Genoa.

On the contrary of Italsider to Prà, C.M.F. chooses the beams use in corrugated sheet-iron, collaborating with structural components, and for junction of pilaster-beam chooses the bolted solution rather than the welded one. The San Marco residential plant, in Verona, with its 148 apartments of 160mq surface each one, represented a more interesting private initiative, in relation to the dimension and the technical experimentation. This aspect concern mainly not the steel structure elements, realized using normal profile, connected by bolted junctions and flange coupling.

This period is closed by competition of Lombardia Agency (1978) for the repertory of exemplary projects. Only one society, among those selected, proposes steel application for vertical structures, but in the phase of contracting prefers other building techniques.

Figure 3: Temporary house
1980s are characterized by Basis system, showed during SAIE (Italian building trade fair), this system allows the fast construction of residential buildings with controlled price and several typology and architectural solutions through a high level use of steel products.

The promotion has success and several building co-operative societies realize consistent interventions in Lazio and Puglia regions.

The authors emphasized the historical developments and case studies related to the historical developments in the case of steel in buildings. The emphasis was the housing units, including disaster and emergency shelter.
References


