BUILDINGS FOR HOUSING: 
STEEL TECHNOLOGIES IN THE TWENTIETH CENTURY

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ABSTRACT

In house architecture, the steel technologies use has constituted, specially 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, the autarky, and cultural background doesn’t 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 technique 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 syntactic and linguistic potentialities.

Key words: Temporary house, Anti-seismic house, Experimental house, Steel house.
The Iron and Steel Italian Industry

Since before the unification of the country, the productive Italian area was characterised 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 one. The national situation, in the iron and steel sector, was characterised by the presence of poor settlements situated in areas with ferrous mining resources, and by a production that didn't exceed 13.00 t of cast iron.

After Italy unification, the situation doesn't change, but become 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 harbour 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, owes factories on 34.000 ha in the strategic area of the region.

On the contrary the realization of railways line in the rest of the country without factories for the production of rolling stock, is characterised 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 increasing of population in the productive areas there isn't urgent need to build housing for workers as in the rest of Europe instead.

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

The problem of material supplying is also worked out. Since the beginning of the 20th century the iron and steel Italian industry actually gained steel by the scrap remitting, while material token out from the iron mines was exported; as the production growth, the Italian government gives the mines to the biggest manufacturing firms forbidding them to export the materials.

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 realise 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 isn't of less interest the project for the railway station of Turin Porta Nuova by engineer Alessandro Mazzucchetti, built in 1868, where the lines roofing surface has a bearing structure made up with iron round 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 the lines with various dimensions and heights covers 204,21 metres 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 that one of the technological and linguistic experimentation in the context of modernism Movement with obvious and mutual conditioning.

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

Within the cultural direction of Futurism, for the first, changes the way of considering the new techniques and materials, and can round up, in Italy, the first technological experimentation connected to the use of steel, conduced by engineer Guido Fiorini, called “tensistruttura”. Fiorini projects a structural type where the steel is reduced to the minimum, and the structure is subjected only to traction and any floor is realised independent to upper floors weight. The new structural model is applied, between 1932-1934, for Officine Savigliano Society, in two different residential typologies, for families and singles. The buildings thought eight floors height, and same about a
hundred length, has an envelope realised with aluminium sheet with thermal insulation and external metal plate.

After the experience of Melis-Bernocco, at Turin, with the realization of the Società Reale Mutua of Insurance build steel structures, finished in the 1932, follows the experience of Ludovico e Alberico Barbiano di Belgiojoso, that realise, at Milan, Feltrinelli House (1034-35) with a steel structure, projected and built by Antonio Badoni Society, changing the first concrete solution.

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 ‘50s to first years of ‘70s.

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 define the centrality of house thematic for Italian architects, influenced by Waissenhof experience. The Griffini, Paludi and Bottoni project of sea house, realised by Carpentry Bonfiglio, has steel structure with vertical elements made of steel tubular profile (type Mannesman) and horizontal elements in steel beams (type UNP 22). The envelope is executed by magnesite panels. With “sea houses” there are three collective residential buildings (Pagano architect group and Daneri) realised 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 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 beam of roof. In 6th Triennale Edition is organised 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, G. Pagano proposes the realization of a real experimental residential quarter for Milan, after called QT8, practise representation of a total modern neighbourhood. 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 organised also the “Exposition of Autarkic Building” with construction system and formal language all within historicism tradition. Only after the war, QT8 is realised, but the positive conjuncture, either cultural or temporal, for technique experimentation and steel use of ‘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 ‘50s there are more initiatives and occasions for the steel experimental house; in Brussels 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 ‘60s and ‘70s the residential building adopts prevalently concrete-masonry system and the steel house return to be object of more studies and researches and also of enterprises.

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 services block. The building was completed only partially for allowing visitor to see the different phases of realization and each used components. All is very different in relation to the Triennale Exposition, in ‘30s, either from technological potentialities point of view of 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 characters of industrialization to open cycle, 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, favoured by CECA, Italsider, Public Work Ministry, is realised to Piombino, in the first of seventies years. The project, defined by one national group of designers (F. Gori, M. Grisotti, E. Mandolesi, A. Pettrignani) 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 sight.
In the sphere of research is also collocated Italian 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 sub-system: 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 realised with corrugated sheet-iron and concrete casting.

The Steel for Security: Anti-seismic House

In the years of first Italian experiences in modern techniques field, with steel and reinforced concrete constructions, also for civil buildings, happens the terrible earthquake of Messina, in Sicily (1908), that opens the discussion about the safety in building sector, starting a prescribing rules advancement. In relation to the ministry experts commission work, choose by Government, was enacted a number law 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 movements, for, on one hand, the innovation of new construction typologies, and, on the other hand, 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, technological progressive, of the “casa baraccata”. The “Minelli system” was based on steel stay-bars in vertical position connected to those horizontal located to top of floors; in a different way in the “Foresti system”, the steel bars were distributed to regular steps on whole masonry structure, and plugged in 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 growth. 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, the Association of iron industries, later nominated Anfimi (national fascist association of the metallurgical Italian industries), promotes, between 1931-35, three competitions for steel structure buildings, in particular the second is dedicated to studying anti-seismic residential project. In reference to the Royal Low Decree number 640 of 1935, in the article 16, all concerning construction systems, the reinforced brick masonry exceeds in favour of all structures. They fit to be resistance at the some time to stress of compression or traction, bending and shear, without excluding the use of steel construction, but imposing particular contrivances 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, utilise 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 since the steel frame-
works, also totally in steel, were accepted. The steel use topic in the anti-seismic house, is re-proposed, during all the XX century, after calamitous event, or inside research and study field or in relation to emergency intervention dimension, connecting. In particular in the 60s the anti-seismic house forms part of general discussion about pre-fabrication and industrialization topic.

In the residential rebuilding period, after the earthquake, it has not recourse to steel construction. 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 violent 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) promote an ideas 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 prefabricated units use with steel anti-seismic structure. The proposal, never realised, planned settlements that were different in dimension and typologies (detached house, tenement house.). In the construction system there were steel structures, 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 rebuild. The disaster concerns several regions in south Italy, Campania, Puglia, Basilicata: Naples is entirely involved by seismic event. For the principal city of region and the small towns of district, the extraordinary program defines the realization of 28.0000 apartments. To the earthquake emergency has to be added, a few time later, the emergency of Brady-seism, which, for Pozzuoli, in the 1983, become to such critical levels that it is necessary, in relation to government drastic decision, to rebuild a new town in the Monteruscello Locality. On two fronts, Naples and Monteruscello, were started real laboratories of industrialization building. In the first, the steel application is extended also to “case-parcheggio” (parking houses), necessary starting 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 assemblage operations in relation to technical capacities of unskilled workers, or to adapt the system to anti-seismic requirements.
Still regarding to calamitous events, and in particular to phase of homeless person emergency management, is connected the use of steel in the specific house typology, the temporary one. 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 appear culturally acceptable the idea of a prefabricated house, non-related then, with an issue of permanency and firmness.

The temporary house, become, from this point of view, a preferential sphere in which have to be experimented performances and new possibilities as transformability, functional flexibility, enlargement, combinability.

The topic, in the first phase around to 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 unlimited time.

In this period are projected and then prefabricated holiday or artistic house, while the temporary house for emergency are showed, in several trade fairs, by producers especially with new technical and construction solutions for envelope and new plastic materials for joint seal. Single blocks are also proposed for residential (Morteo-Cornigliano), detachable, to box shape in sheet coated with zinc superposing a roof to guarantee good thermal requirements.

The emergency house topic is in first plane again due to an earthquake calamitous event within the discussion of ‘60s and ‘80s. Every now and then it is necessary to have temporary houses storage to be used in these particular situations; from this point of view the district agencies and the public corporations, as Civil Protection, start off 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 union criteria; have a surface about 10-16 mq; make possible services realization, guarantee the facility of components assembly, also using no specialised persons, transport the disassembled unit on lorries of medium dimensions, the application of basis unit on irregular and not much proof ground without foundation specific works. 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 proposals regard the integral prefabricated systems of functional blocks, totally pre-assembled in steel works. With this three-dimensional system is possible to realize, inside the iron works, the union of component block, including finishes and installations, guaranteeing lightness characteristics, facility assemblage, reduced bearing structures, resistance to wear and tear, joints seal, and dimensional relation between basis elements and road transport rules.

In 1978, the Salvit society, second classified in the IACP competition, produces a building system with three three-dimensional blocks, prefabricated, disassembled, realised in steel works, included finishes and all installations: the A block, (150x740 cm) with bathroom, bedroom and kitchen, B block (300X490) with living and entrance, C block (250x740) with one more bedroom, wardrobe, and dining room. The block structure is in zinc steel with gantry primary beams and tubular profile to rectangular section, and secondary beams with cold-working profiling. The envelope is formed by concrete-panels, with air space of thermal material, by 10 cm of thickness. The blocks can be assemble rising vertical direction for three floors, while on horizontal plane it is possible to realise a intensive typology combining a single house of two front one on the street the other on the small internal courtyard. The temporary house topic is subject, in these years, of much studies and researches,
incited by several initiatives from national and international agencies, in particular, working in promotion and development steel sector. The Civil Protection Agency asks to architect Pierluigi Spadolini, for a project of “residential modulus of quick use” (M.A.P.I.). The architect proposes a block totally constructed in steel work, which can be placed onto the ground in 20 minutes. This block is a technical prototype with high quality level, either for materials use and technology or for the components design. The residential cell is an installation self-contained and functionally flexible. Other researches and studies are concerned with temporary house for emergency, defining the project problem essentially about means and modality of transport, preferring to preassembled blocks, due to the not easy and expensive storing and maintenance, the system with mix of components assembled and frame work preassembled to low obstruction, which takes final shape only in the running phase. The temporary house can be studied in relation of container sizing, in which the preassembled block is transported, defining the dimension, to closed configuration, like as a rectangular parallelepiped; after, with a suitable rotations and translations sequence of wall panels and structure components, in relation to a single or double hinges, is defined a running shape of block with surface of 12-15 mm.

Figure 3: Temporary house
The Steel for Programming: The Steel House

It is necessary to wait for ‘50s, during the post-war re-building for returning to talk about 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 ‘30s, to the realization of “Palazzo dei Congressi” steel covering, at Eur district in Rome, for which the society was entrusted the works.

Engineer Grove, called later by Pierluigi Nervi for steel structures executive projects of “Palazzo del Lavoro” (1959-61), in Turin, for Italy ’61, and of Cartiere Burgo, Mantova (1961-63), projects a steel structure to soldered knots, which weight, total building volume including external walls, is 12 Kg/mc. The building height is more than fifty metres, overhangs the city, confirming that an important application of steel construction, applied moreover to residential building, can be produced also in Italy, without to have to resort to external experiences.

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

However “Fanfani Program”, not accepting a building and yard 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.

An exception to this technical policy is represented by a particular intervention, the residential neighbourhood of Prà in Genoa. This is the single Ina-Casa program to provide “a large use of steel”.

To realise, for a total of 236 apartments, all its employees, four line build, with nine and fourteen floors, Italian use steel structures, also for staircases, and use the same material for envelope elements, walls and window and door frames, with exception of two buildings head in which the walls were constructed in air space masonry.

Also for the floor, after projected in corrugated sheet-iron on small beams frame, is applied a different technical solution, more traditional, in concrete and masonry, because cheaper.

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 80s. The system, in the more
innovation version, includes the use of steel resistant elements (pilasters HEA 180 and beams standard type “rep”) and frame with standard type predalles panels lightened with polystyrene, like as steel window and door frame.

Just only this system with steel construction elements, among eight of “prefabricated mono-dimensional elements”, is included into IASM publishing (institute for development Italian central area assistance) for pointing out the critic topics of building, in Italy, in relation to residential sector particularly sensible because more fragmented. The Feal system, applicable to other typologies, is cheap only with a minimum intervention of 30.000 mc, then for 100 apartments.

In the middle of 70s, the initiatives are sporadic either in public sphere, or private, and also the “decennial residential program” not succeed in starting the steel diffusion application in the residential building. IACP of Genoa, for example, orders to CMC of Livorno, the residential plant realization of 40.000 mc and 90 flats, in Genoa, at the Borzoli locality.

On the contrary of Italian 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 then 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, realised using normal profile (HE for pilasters IPE for beams), connected by bolted junctions and flange coupling, but the floors to thickness of beam and the modality of construction. In fact, concrete casting is realised with a support of reticular beam connected to primary beams with particular contrivance that allows the reuse of gantry.

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.

80s are characterised 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. In 1985 due to the enterprises successful is establish a service company, Sidercard of Genoa, to advantage of all technical operators.
More recent realizations are oriented in directions of improving versatility use and formal solutions. The project, first in the '90s, realized in the centre of s. Donà di Piave, proposes some suggestions of “tensistruttura” of engineer Fiorini, but this residential building appears not clear in the morphological structure and too much heavy in the technical and linguistic solutions.

Figure 4: Steel house.

References