archiDOCT 12 (2) Relevances 2

Prefabricated Housing Construction Throughout History

Maria Piqueras Blasco, PhD[1a], Ivan Cabrera i Fausto, Professor[2b]

[1] Department of Continuum Mechanics and Theory of Structures, Universitat Politècnica de València, [2] Director of the School of Architecture, Universitat Politècnica de València

Keywords: Prefabricated construction, historical development, motivations, efficient solution, housing.

archiDOCT

Vol. 12, Issue 2, 2024

This paper explores the historical evolution of prefabricated housing construction, from its origins to its contemporary development. Prefabricated construction has been used since the 19th century as a fast and efficient solution for the creation of structures, notable for the off-site fabrication of components, which optimizes execution times. Over time, this technique has evolved from being used in situations of emergency or temporary need, such as in World War II, to becoming a permanent and sustainable alternative in modern architecture.

The analysis of the historical evolution allows us to identify the interests and motivations that have driven the use of prefabricated construction. These include the need to solve housing crises, the interest in reducing construction costs and the desire to innovate in terms of design and sustainability. Industrialization and technological progress have also played an important role in its adoption, allowing for greater flexibility in materials and assembly systems.

Finally, this study concludes that the main motivations behind the adoption of prefabricated construction lie in two key factors: the speed of assembly, which significantly reduces construction times compared to traditional construction, and the variety in design, which allows prefabricated solutions to be adapted to various architectural and aesthetic needs. These advantages, combined with the possibility of reducing environmental impact and costs, have consolidated prefabricated construction as a viable and attractive option in today's architectural context.

1. Introduction

Prefabricated construction has transformed the architectural sector from its earliest documented uses to the present day, offering an innovative solution to the growing demands for speed, efficiency and savings in the building sector. Throughout history, this technique has been employed in a variety of forms, from simple temporary structures to complex modular systems that allow for the creation of permanent buildings.

One of the earliest documented uses of prefabricated construction dates back to the 19th century, when rapid, transportable housing solutions began to be developed. During the World War II, this technique boomed, due to

a Maria Piqueras Blasco (Borriana, Spain) is an architect graduated from the Universitat Politècnica de València, Spain, in 2016, where she also completed a Master's degree in Architecture. Later she worked in an architect's studio developing heritage restoration projects and in international companies. In 2024 she completed her PhD, focusing her research on lightweight and modular structural solutions for the extension of historic residential buildings. In addition to the constructive-structural area, different factors such as heritage, sustainability and energy efficiency accompany this research. In parallel, since 2019 she contributes to the management and logistics of the VLC Arquitectura-Research Journal of the Escola Tècnica Superior d'Arquitectura de la UPV, she is associate editor of Anuari d'Arquitectura i Societat since 2021, and she is currently a professor at the UPV in the Department of Continuum Mechanics and Theory of Structures.

b Ivan Cabrera i Fausto (Borriana, 1974) graduated in Architecture in 1998 at Universitat Politècnica de València and earned his PhD in Advanced Analysis of Design of Structures and Foundations in 2016. At the same institution he has been a Full Professor since 1999 and Director of the School of Architecture since 2016. In 2010 he was Visiting Professor at the Illinois Institute of Technology at Chicago and in 2023 Invited Researcher at the Massachusetts Institute of Technology at Cambridge. Moreover, he has taught as guest lecturer in institutions such as the Universitetet i Stavanger (Norway), the Politecnico di Milano (Italy), the Yildiz Teknik Üniversitesi (Turkey), the Technische Universiteit Eindhoven (Netherlands) or the Universidad Autónoma de Encarnación (Paraguay). In 2013 he was awarded the Docent Excellence Prize by the UPV Social Council and the Education, Culture and Sport Department of the Valencian Regional Government. Between 2017 and 2021 he was President of the Conference of Spanish Architecture Schools. His expertise is in advanced structures analysis and design focused mainly on structures for housing, historical structures and big sport facilities.

the urgent need to construct large numbers of dwellings and buildings in a short period of time. During this period, it established itself as a viable option for both temporary and permanent housing. As technology advanced, the materials used in prefabricated construction also evolved, allowing for greater durability, flexibility and sustainability in designs.

Over time, the evolution of materials and technologies used in prefabricated construction has improved the durability and adaptability of these structures. From simple timber and metal components to modular concrete and steel systems, prefabrication has advanced to become a sustainable option, reducing material waste and energy consumption compared to traditional methods.

Nowadays, prefabrication has been integrated into large-scale projects, from social housing to high-rise buildings, and has positioned itself as a key solution to address global challenges such as the accelerating urbanization, the housing crisis and the reduction of the environmental impact of construction. This paper explores the historical evolution of prefabricated construction, analyzing its main motivations, achievements and its influence on modern architecture.

2. Research objectives

The general objective of this research is to carry out a bibliographic search of the historical evolution of prefabricated construction. The specific objective is to identify the key interests and motivations that have driven the development of this construction typology, and how it has influenced architecture over time.

3. Methodology and limits of the research

In the course of this study, various scientific platforms were consulted, selected according to the type of information available for the study of prefabricated construction. On the basis of the documentation collected and the bibliographical consultations carried out, the historical evolution of this type of construction was analyzed and identified. Subsequently, the main motivations that have driven its development were critically examined, and the main interests were identified.

4. Background and historical development

4.1. The origins of prefabricated construction

The first references to prefabrication can be found in the 16th century, by Leonardo da Vinci. It was in 1516 when the King of France, Francis I, commissioned the polymath to design new towns in the former Loire region of France. In order to develop the new dwellings and the entire urban development, Da Vinci proposed the placement of a production center in the original area of each new town. In this way, he intended to manufacture the different elements and their subsequent transport, thus establishing a radius of action for the construction of the buildings. Each of these components and the buildings were designed by himself to accommodate the constructions in a flexible and homogeneous way. In addition, each of the buildings, regardless of typology and use, was designed using the minimum number of construction elements (Aguiló Alonso et al., 1974).

During this same period, the wars between England and France took place (Lantigua De La Cruz, 2015). The war triggered an ingenious construction of prefabricated pavilions made of wood to shelter the combatants. The practice consisted of assembly and disassembly by the soldiers themselves, and subsequent transport by boat as they advanced. This provided solid accommodation, as well as speed of movement and assembly (Pérez, 2008).

4.2. Precursor of prefabricated wooden houses

In the early 19th century, the construction of the *Portable Colonial Cottage*, built from wood and developed by the carpenter Herbert Manning in 1833, was a remarkable milestone for the prefabrication of architecture. The most pioneering aspect of these dwellings was the decomposition and assembly by numbered pieces, classified and manufactured in the workshop, where they were later dismantled and transported by ship to their destination. Once they arrived at their location, they were assembled in a simple way in order to formalize the house. Likewise, all the elements that made up the housing were standardized and adapted to the dimensions offered by the raw material at the time.

The first dwellings were popularized by emigrants who left for the English colonies, mainly from Australia and South Africa. It was a few years later when Manning designed several proposals with differences in size and price, it was at this time, when the houses began to be a commercial product within reach of more people (Bergdoll & Christensen, 2008).

4.3. Early prefabrication systems

Undoubtedly, the major milestone event in industrialised construction relates to the emergence of the system known as the *Balloon Frame* (Fig. 1). The innovative system was born in Chicago, and is often attributed to George W. Snow around 1832, although there are no documents that definitively confirm this. In fact, this achievement has also been associated with Augustine Taylor (Serra Soriano et al., 2016).

The system is based on the construction of a structure made up of thin timber slats, which are joined together with industrial nails to form a frame. Constructively, this system was based on laths of sawn timber that were joined together at right angles by means of nails to form structural frames or baskets (Basket Frame according to the book written by G. E. Woodward and F. W. Woodward in 1865). The sleepers, which were reduced by half at the corners, rested on the foundations. Another remarkable point is the lightness, since in order to optimise the material and its resistance, the slats were cut with the optimum orientation of the fibres (Serra Soriano et al., 2016). These were cut in the workshop and adjusted on site in different arrange-

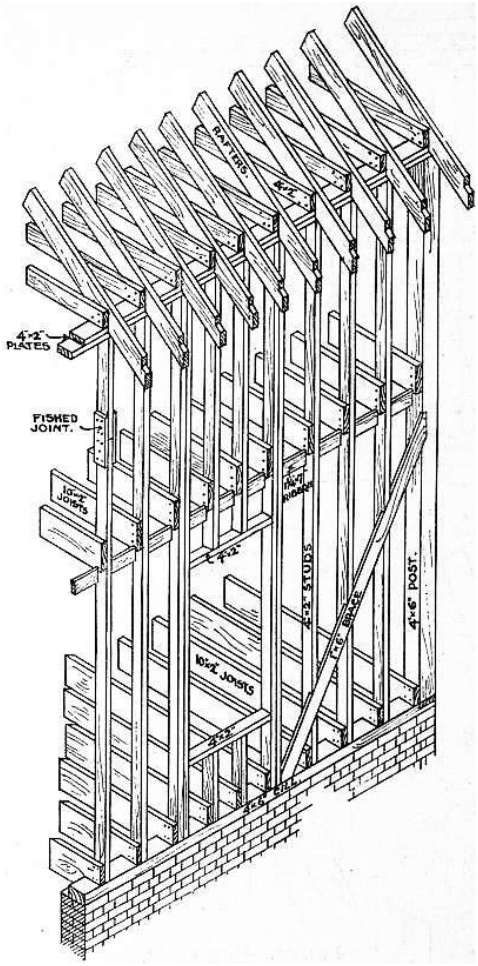

Figure 1. System Balloon Frame

Source: Wikimedia Commons, https://upload.wikimedia.org/wikipedia/commons/3/33/EB1911_Carpentry_Fig._36_-_Balloon_Frame.jpg

ments according to the needs of the programme, even up to three storeys (Ovando Vacarezza, 2015). The attractiveness of this system comes from the use of locally sourced materials, together with its speed of assembly, lightness and economic accessibility (Sarmirnto Ocampo, 2013).

This system led the American company Sears, Roebuck & Company to market a large number of houses in different shapes, prices and sizes from mail order catalogues (Fig. 2). The company was also one of the first to use plasterboard and central heating for interior partitions (Terrados Cepeda, 2012).

4.4. Prefabricated construction in the 20th century and its relation to urban planning and social housing

4.4.1. Proposals by architects

It was between 1911 and 1917, when Frank Lloyd Wright teamed up with the Richards Company to design the so-called *American System-Built Houses* (Sánchez González, 2016). For the architect, the intention of architecture was to improve the quality of individuals, and he sought to design for all types of people. These houses were centred on the idea of standardization and prefabrication. In other words, each of the elements that made up the house, such as beams, roofs, windows and even doors, were made in a workshop. The great difference of this design, compared to others, was the value of individual identity. Wright developed these flats with the intention of giving each model a personalized design, rather than the intention of creating *repetitive types*. The idea was to produce the same shop-fabricated elements, but to fit them together in different ways. With this in mind, the intention was to reduce manufacturing and assembly times, while at the same time reducing costs, both in terms of materials and labor. However, to provide the client with an individuality of the home (Sánchez González, 2016). The elements were manufactured in the workshop and then moved to the site where they were fitted together and the home was formalized.

With the idea of individualization and adaptation of dwellings in mind, Le Corbusier also devised a housing model called *Dom-Ino* in 1914. It is a modular structure made of concrete in the form of a skeleton, in which the vertical elements are released. In this way, the enclosures are separated from the structural load to combine different dwellings according to needs (Gardinetti, 2014). The system concept and the distinction between structural and non-structural elements set guidelines for subsequent prefabricated and modular architecture.

Another architect who also studied prefabricated architecture and its benefits was Richard Buckminster Fuller in 1927-29 with the *Dymaxion Houses*. These experimental houses and their theoretical model are based on the conception of three words that give their name to the house itself: 'dynamic' (DY), 'maximum' (MAX), and 'tension' (ION) (Sánchez González, 2016). The architect sought to generate an economical and efficient model that could be mass-produced and easily transported. Representative of the model was its hexagonal floor plan based on a central stainless steel structure from which the rest of the building, roof, floor and walls, were supported by radial cables (Bergdoll & Christensen, 2008). In addition to the functionality of the space, Fuller tried to give it an energy-efficient approach. To this end, the user could regulate the interior temperature through air flows by opening or closing the top of the house. The Dymaxion Houses remained a prototype, but their novel design and the idea of prefabricated, modular housing represent an innovative vision.

4.4.2. Urban planning and social housing

In the early years of the 20th century, movements emerged calling for decent and affordable housing for all classes. This led great architects to study the opportunities offered by prefabricated and modular architecture. Especially in terms of affordability. Thus, the building efficiency and standardization brought about by industrialization contributed to the thinking of new building forms and techniques (Banham, 2002). Along with this, the rapid growth of cities and the need for workers' housing helped the use of industrialized construction techniques.

This encouraged an approach to the new architecture of urban areas and social housing based on serialization and

Figure 2. Sears, Roebuck & Company cover and example from the catalogue, 'The Hamilton', model no. 102 and 158

Source: Sears Roebuck Catalogue, 1908, https://upload.wikimedia.org/wikipedia/commons/b/b7/SearsHome102.jpg

modular repetition. These concepts were in line with the fundamental principles of the Modern Movement, which advocated functionality, rationality and the elimination of unnecessary ornamentation in architectural design.

The application of modular serialization and repetition was particularly relevant in the context of social housing. As the demand for housing was high, standardization and repetition of elements allowed architects and urban planners to respond quickly to this need without compromising quality or architectural coherence. Modular housing complexes, such as Le Corbusier's *Unité d'Habitation*, illustrate how the combination of the same or similar housing units could generate an organized and functional community.

4.5. The first modular systems

4.5.1. The relevance of Gropius in prefabrication

In the second decade of the 20th century, Walter Gropius, founder of the Bauhaus School, was the pioneer of the concept of what we know today as *prefabricated housing*. The architect revolutionized modern architecture, both educationally and theoretically, marking a before and after. Gropius, together with Adolf Meyer, presented what is known as *Baukasten im Groβen* or *Large Module* in 1923 (Fig. 3). It is a design comprising six different modules, which, depending on how they are combined, offer different programme options, making this project a wide variety according to needs (Gropius, 1966). This was one of the first contributions to the theoretical knowledge of industrialized and modular construction. In fact, Gropius already showed an interest in industry and mass production from his beginnings as an assistant, and this was latent in his later designs (Serra Soriano et al., 2016).

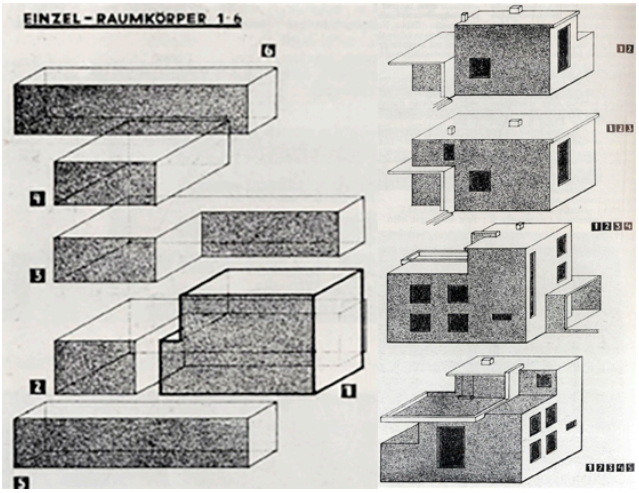

Figure 3. *Baukasten im groβen*, Walter gropius, 1923

Source: Architectural Projects, ETSA Sevilla, https://proyectos4etsa.wordpress.com/2011/10/31/baukasten-im-gro%CE%B2en-walter-gropius-y-adolf-meyer-weimar-1922-2/

In 1927, for the Stuttgart Housing Exhibition, which lasted approximately three months, Gropius designed two prefabricated houses. The models offered an industrial and prefabricated assembly system, demonstrating his high level of project design and assembly. The intention of these dwellings was to offer a response to the economic context of the majority of people at the time. In other words, affordable housing, with rapid assembly, and with an adaptable and flexible design.

The next example is the *Steel House* of 1927. This project was built in the town of Dessau and designed by Georg Muche and Richard Paulick, members of the Bauhaus School. It was called the Steel House because of its structure, and the enclosure that surrounded it, made from 3mm thick steel exterior plates with thermal insulation, air chamber and mortar slabs. The project tried to adapt, reducing or enlarging itself, using strictly modulated panels. It was an 80 m2 house made up of two bodies and resting on a concrete foundation. However, what gave the project its value was its adaptable design using panels and the dry use of steel (Strike, 2004). The great disadvantage of the house was its poor thermal comfort, given that it was cold in the winter months and hot in summer (Sánchez González, 2016). Also, the use of the steel structure was considered heavy, and this made Gropius reconsider the choice of other materials in future projects.

An example of this is the *Copper Houses* of 1931. These five-room dwellings were manufactured in a workshop and dry-assembled on site. It consisted of asbestos-cement cladding on the outside, plus a corrugated copper sheet. On the inside, it was covered with asbestos-cement boards, and the structure was made of wood. The whole system had the joinery incorporated in the workshop, and in situ it was only a question of screwing each of the panels together (Strike, 2004).

The situation after the Second World War left a latent need for housing (Caja, 2021). That is why, in 1942, Gropius together with Konrad Wachsmann presented the *Packaged House*. Undoubtedly, the most distinctive feature of this project was its modulation, speed of assembly and, above all, its connection system. The project involved joining rectangular load-bearing panels, positioned vertically and horizontally depending on the design of the house in question, which could be used for walls, floors and ceilings. Different panels were designed, opaque, with openings for windows and doors, and even panels of different sizes. In such a way that, depending on how they were joined together and the needs of the house, they could be adapted in one way or another. Its assembly system allowed for a wide variety of connections between the different panels. It was a connector that could fit the panels in the shape of an 'L', in a 'T' or in a cross, and vertically or horizontally. All this allowed the system great flexibility and the option of extending the dwellings. In spite of the great success that they expected from the housing system, it did not happen as expected, and therefore, the *Packaged House* remained rather as a thought for the later typologies of prefabricated houses due to its important contribution in the anchoring system (Herbert, 1981).

4.5.2. Modular systems in post-war architecture

After 1945, during the post-war period, there was a need for new housing, as might happen nowadays despite for very different reasons (Piqueras-Blasco & Cabrera-Fausto, 2022). This demand, by then, found an answer in modular systems, producing quick and economical housing (Karle, 2021). The speed of assembly, cost reduction and ease of construction and transport were the main advantages

Figure 4. Tennessee Valley Authority (TVA)

Source: Library of Congress Prints and Photogrphs Divison Washington DC. 20540 USA, 2014

Figure 5. CIAM, Team 10 in Otterlo

Source: Wikimedia Commons, https://upload.wikimedia.org/wikipedia/commons/d/d7/Congres_Team_10_in_Otterlo_-_Team_10_Meeting_in_Otterlo.jpg

(Ovando Vacarezza, 2015). An example of housing offered in the United States came from the Tennessee Valley Authority (TVA) (Fig. 4). These are trailer-like residences designed as emergency housing, although later families looking for affordable accommodation began to use them as well (Kelly, 1951).

4.6. The continuous interest in modular construction. CIAM and its groups

The *Congrès International d'Architecture Moderne* or CIAM was created in 1928 with the intention of discussing the transformation of the city and the improvement of its social modes of living. Also, many of the concepts discussed were how to transform housing to a more industrial and productive method (Fig. 5). In 1947, after the Second World War, the need to propose solutions for the urban planning of different cities and their mass construction was raised. Due to different opinions, CIAM finally disappeared. In spite of this, and thanks to the meetings, different groups were formed. On the one hand, the *Archigram* group was created in Europe, and at the same time, the *Metabolist movement* was formed in Japan.

One proposal that gained interest from the European group was the *Plug-in City*. This approach competed with

Figure 6. The Nakagin Capsule Tower

Source: Jordy Meow, 2013

the classic idea of the city, and proposed the creation of modular residential units connected to a central mega-core, which contains the city's necessary services. However, the most notable of these is Warren Chalk's *Capsule Houses* (Fig. 11). These are towers made up of different prefabricated modules, which are interchanged according to the needs of the inhabitants.

The Japanese movement supports the idea of functional transformation based on technological progress and the development of construction based on modular mega-structures. Kisho Kurokawa's most notable building project was the *Nakagin Capsule Tower* built in 1972 (Fig. 6). It consists of two communication and service cores, to which prefabricated modules are attached, with the idea that they can be replaced and relocated.

5. Interests and motivations in the evolution of prefabricated architecture

A chronological sequence of the most significant highlights and the evolution of prefabricated architecture has identified a temporal development divided into five fundamental stages (Fig. 8):

1. Early ideas of off-site construction: first ideas and concepts related to off-site construction.
2. Easy-to-assemble dwellings: creation of dwellings that could be assembled more quickly and easily than conventional constructions.
3. Systems for day-to-day manufacturing: development of systems that enabled the efficient production of building components and modules on a large scale.
4. Urban thinking: transition towards the consideration of prefabricated solutions in the context of urban planning (Llop Torné, 2022).
5. Mobility in housing: mobility and adaptability of prefabricated housing, opening the door to versatile and mobile housing solutions (Pallasmaa, 2023).

These stages correspond to the evolution of thoughts and ideas in prefabricated and modular construction. The most representative points along the historical evolution and its stages have also been identified. These aspects outlined describe the main motivations of the designs (T. 1). The purpose of this critical overview is to establish the interest of prefabricated architecture and how it has evolved over the years. Therefore, the predominant points identified are:

From these ten points and thirteen projects or designs, the main motivations are speed of assembly and variety in design. This is followed by the reduction of materials, and very close behind by the ease of assembly and transport. A graph of the points identified and their attractiveness in the projects as a whole is shown below (Fig. 7, 8).

6. Conclusions

Prefabricated housing construction has proven to be an adaptive and efficient technique throughout history. The evolution of this methodology, from its beginnings in the 19th century to its contemporary applications, reveals a clear trend towards the optimization of construction time and costs. Through the analysis of its main milestones, it can be seen that the key motivations for its development have been the need for rapid responses to housing crises, cost reduction and advances in technology and design.

The two predominant motivations that have driven the adoption of prefabricated construction are speed of assembly and flexibility in design. The ability to significantly reduce construction time and offer adaptable solutions to diverse architectural and aesthetic needs has established this technique as a viable option in today's context. In addition, prefabricated construction contributes to sustainability by minimizing material waste and improving energy efficiency. Therefore, prefabricated construction remains a relevant and dynamic solution that confronts modern challenges with historical innovations.

ACKNOWLEDGMENTS

HBIRT3-2023-5. Plan Irta 2023. *Vicepresidencia Segunda y Conselleria de Servicios Sociales, Igualdad y Vivienda*.

Table 1. Identifying features throughout history

Manufacturing optimization	Use of local raw materials with efficient transport, thus reducing travel time.
Ease of transport	Easy movement of the elements
Ease of assembly	Easy and affordable construction, either because few tools are needed, or because it is an intuitive assembly
Reduction of materials	Efficient use of materials, avoiding material wastage
Speed of assembly	Quick to build, and with reduced lead times
Economic accessibility	Construction solution within the reach of a large part of the population
Low weight	Construction solution with attention to the lightness of the materials and the different elements.
Variety of design	Versatility and/or flexibility
Energy saving	Sustainable solution with reduced energy consumption
Mobility	Mobile and transportable product

Source: Own elaboration, 2024

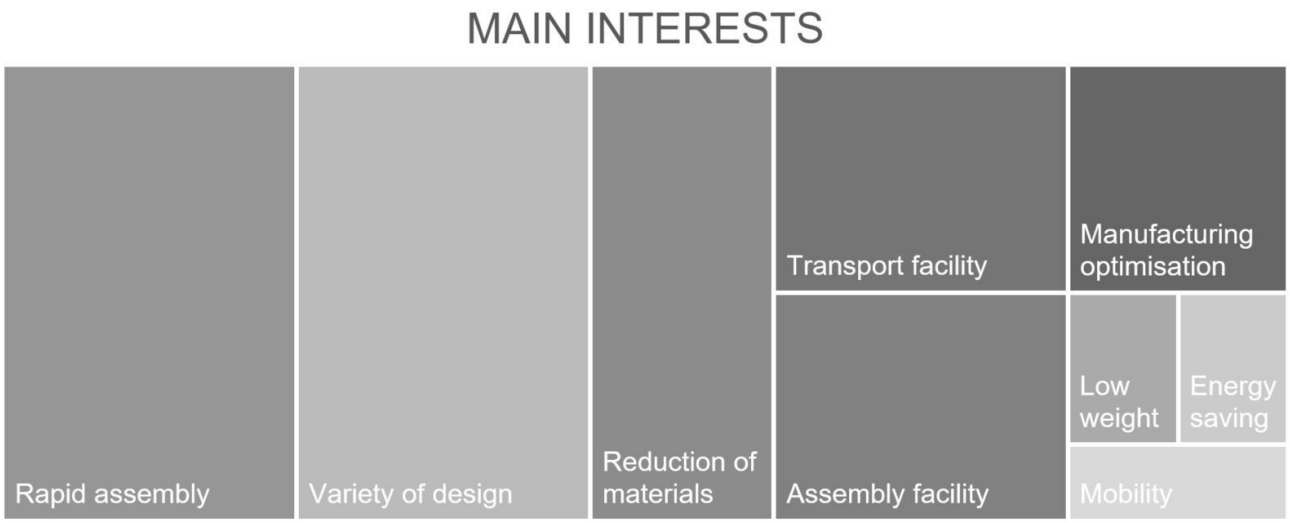

Figure 7. Main motivations of the projects analyzed during the evolution of the project

Source: (Piqueras-Blasco, 2024)

Submitted: January 15, 2024 BST, Accepted: September 15, 2024 BST

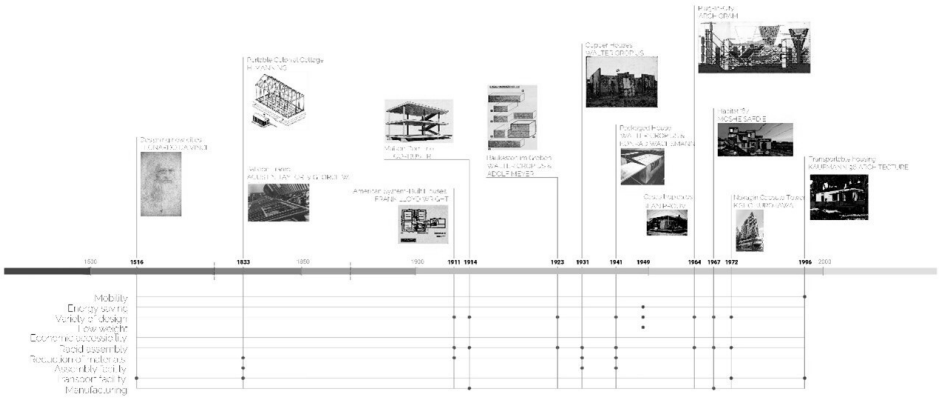

Figure 8. Chronological sequence with identification of stages, main projects and identifying features

Source: (Piqueras-Blasco, 2024)

References

Aguiló Alonso, M., Arandes i Renú, R., Echevarría Sáinz, F., Espinosa Ochoa, J. M., Fernández Ordóñez, J. A., López Baillo, J. F., & J. S. S. (1974). *Prefabricación: teoría y práctica. Tomo I*. Editores Técnicos Asociados.

Banham, R. (2002). *A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture, 1900-1925*. MIT Press.

Bergdoll, B., & Christensen, P. (2008). *Home Delivery: Fabricating the Modern Dwelling*.

Caja, M. (2021). Reconstructing Historical Context. German Cities and the Case of Lübeck. *ANUARI d'Arquitectura I Societat*, *1*, 38–58. https://doi.org/10.4995/anuari.2021.16108

Gardinetti, M. (2014). *Dom-ino: Soporte independiente, planta libre y planos verticales autónomos*. Tecnne.

Gropius, W. (1966). *La nueva arquitectura y la Bauhaus*. Lumen.

Herbert, G. (1981). *The Packaged House: Dream and Reality*. Technion-Israel Institute of Technology, Faculty of Architecture and Town Planning, Documentation Unit of Architecture.

Karle, D. (2021). Piggybacking Historic Architecture: Air Rights and the Subdivision of Space. *ANUARI d'Arquitectura I Societat*, *1*, 312–330. https://doi.org/10.4995/anuari.2021.16152

Kelly, B. (1951). *Prefabrication of houses*. MIT Press.

Lantigua De La Cruz, S. (2015). *Prefabricación ligera por paneles enfocados en la vivienda*. 1–153. https://riunet.upv.es/handle/10251/49728

Llop Torné, C. (2022). Depopulation, Overcrowding in Growing, Shrinking or Changing Regions: From the Collapse of Territorial Polarization to New Horizons? A Renewed Mosaic of Territorial Habitat. *ANUARI d'Arquitectura I Societat*, *2*, 14–28. https://doi.org/10.4995/anuari.2022.18813

Ovando Vacarezza, G. (2015). *Criterios técnicos del proyecto con módulos tridimensionales ligeros: las casas del Solar Decathlon 2005 y 2007*. http://oa.upm.es/40687/1/GRACIELA_OVANDO_VACAREZZA.pdf

Pallasmaa, J. (2023). Existential Homelessness. Placeless and Nostalgia in the Age of Mobility. *ANUARI d'Arquitectura I Societat*, *3*, 16–43. https://doi.org/10.4995/anuari.2023.20471

Pérez, C. E. (2008). *Industrializados a base de elementos prefabricados de hormigón* (p. 7).

Piqueras-Blasco, M. (2024). *Estructuras prefabricadas y modulares para ampliación vertical de edificios residenciales existentes* [Universitat Politècnica de València]. https://doi.org/10.4995/Thesis/10251/207110

Piqueras-Blasco, M., & Cabrera-Fausto, I. (2022). A study of relevant features for over-elevation as a strategy for urban renewal. In *Structures and Architecture a Viable Urban Perspective?* (pp. 487–494). CRC Press. https://doi.org/10.1201/9781003023555-58

Sánchez González, J. C. (2016). *Construcción Modular Ligera Energéticamente Eficiente* [Universidad Politécnica de Madrid]. https://oa.upm.es/40342/1/JUAN_CARLOS_SANCHEZ_GONZALEZ.pdf

Sarmirnto Ocampo, J. (2013). Antecedentes de la vivienda industrializada como propuesta ecológica. *HITO. Revista de Arquitectura*, *27*, 28–41.

Serra Soriano, B., Díaz Segura, A., & Merí de la Maza, R. (2016). Estudio y aplicación del sistema balloon frame a la industrialización de la vivienda: el caso de las American System-Built Houses de Frank Lloyd Wright. *Informes de La Construccion*, *69*(546).

Strike, J. (2004). *De la construcción a los proyectos : la influencia de las nuevas técnicas en el diseño arquitectónico, 1700-2000*. Reverté.

Terrados Cepeda, F. J. (2012). *Prefabricación ligera de viviendas. Nuevas premisas*. Universidad de Sevilla.