VOL. 11, NO. 1 (2025)

THE INDUSTRIALIZATION OF CONSTRUCTION IN THE SECOND HALF OF THE XX CENTURY

TEMA
Technologies
Engineering
Materials
Architecture

e-ISSN 2421-4574
DOI: 10.30682/tema1101

Cover illustration: MBM factory in Trezzano sul Naviglio (Milan), Italy.

TEMA
Technologies
Engineering
Materials
Architecture

e-ISSN 2421-4574
ISBN online 979-12-5477-596-7
DOI: 10.30682/tema1101

Vol. 11, No. 1 (2025)
Year 2025 (Issues per year: 2)

Publisher:
Ar.Tec. Associazione Scientifica per la Promozione dei Rapporti tra Architettura e Tecniche per l'Edilizia
c/o DICATECH - Dipartimento di Ingegneria Civile, Ambientale, del Territorio, Edile e di Chimica - Politecnico di Bari
Via Edoardo Orabona, 4
70125 Bari - Italy
Phone: +39 080 5963564
E-mail: info@artecweb.org - tema@artecweb.org

Publisher Partner:
Fondazione Bologna University Press
Via Saragozza 10
40123 Bologna - Italy
Phone: +39 051 232882
www.buponline.com

TEMA: Technologies Engineering Materials Architecture
Vol. 11, No. 1 (2025)
e-ISSN 2421-4574

RAYMOND CAMUS' FIRST BUILDING SITES IN LE HAVRE, 1949-1953. A TESTING GROUND BEFORE CONQUERING THE WORLD

Natalya Solopova

TEMA
Technologies
Engineering
Materials
Architecture

e-ISSN 2421-4574
Vol. 11, No. 1 - (2025)

DOI: 10.30682/tema110011

This contribution has been peer-reviewed.

Abstract

In just six years, the French engineer Raymond Camus achieved remarkable success. In 1950, he initiated the production of concrete panels in an abandoned warehouse at the port of Le Havre. By 1956, he signed a contract to export his heavy prefabrication system to the USSR (Union of Soviet Socialist Republics). The article describes Raymond Camus' pioneering projects in Le Havre. Between 1949 and 1953, Camus constructed 10 apartment buildings and 65 detached houses, employing his heavy prefabrication system. In 1949, he leased a disused hangar at the port of Le Havre to establish his workshop for casting concrete panels. The initial panels were crafted manually by unskilled laborers and transported by semi-trailer to the construction site of slot 17, where the first residential building utilizing the Camus system was assembled. Raymond Camus developed a comprehensive process, from producing panels in the workshop and their transportation to the construction site to assembling them into buildings. Within just nine months, Raymond Camus's firm succeeded in assembling the first residential building made from prefabricated panels. The construction efficiency quickly garnered a strong reputation for both Raymond Camus and his technology. Subsequently, he was commissioned to develop slot 21. His growing experience led to the construction of two more apartment blocks for the French railway company (SNCF – *Société Nationale des Chemins de fer Français*) and several single-family homes, further refining his techniques in both panel manufacturing and their technical design.

Keywords

Raymond Camus, Heavy prefabrication system, Concrete prefabricated panels, Housing, Le Havre.

Natalya Solopova
Architect, independent researcher, Paris (France)

Corresponding author:
e-mail: nsolopova@yahoo.fr

1. INTRODUCTION

The large-scale destruction in France caused by the bombing raids of the Second World War presented politicians, architects and engineers with a challenge to build a lot, quickly and with a scarce and unskilled labor force. Therefore, the technique of prefabricating residential blocks and assembling buildings from precast units was introduced as a remedy for rebuilding the destroyed housing stock.

Although the industrialization of the construction sector is rooted in the context of reconstruction following the Second World War, it should nevertheless be viewed as a part of a broader context. The technique of prefabrication is part of the debate on Modernity. Modernity was a set of ideas that loomed in Europe from the 1920s onwards [1]. It was based on discus-

sions on accessible housing for the working class in Germany and France and inspired by the productivity of Henry Ford's assembly lines. So, in Germany, architects Bruno Taut and Ernst May made the first social housing developments, while Walter Gropius devised standardized components for building construction. In France, the architects Eugène Beaudouin and Marcel Lods, together with the engineer Vladimir Bodiansky, built apartment blocks in the cité de la Muette in Drancy (1934), where they experimented with a rationalized method of dry assembly of metal frames and concrete panels manufactured in a factory located directly on the building site.

The patents and companies of Raymond Camus, the French engineer originated from Le Havre, are part of this vast field of Modernity. In June 1948, Raymond Camus registered a patent for the construction of prefabricated apartment blocks. Camus explained that the originality of his invention lay in the industrial manufacture of large-scale elements so that "each element constitutes, in principle, an entire face of the wall of a room [2]. Camus writes: «What is a room? Four walls, a ceiling, a floor. Why assemble them from a thousand pieces when modern technology now makes it possible to easily manufacture these elements in a factory, and to transport, handle and assemble them with minimal effort? [3]».

Camus's invention made it possible to assemble whole dwelling rooms from six panels precast in a factory: four panels for the walls, one for the ceiling and one for the floor. Camus laid great stress upon the fact that the larger the components of a building were, the fewer joints were needed on the façade. According to Camus, a large number of joints leads to imperfections during assembly and requires excessive labor to assemble them.

In the submitted patent application, the façade panel is approximately 10 cm thick and consists of a reinforced concrete frame, which serves as a load-bearing structure, an external finishing layer (ceramic tiles, stone chippings), and lightweight concrete that fills the panel. The window frame openings are embedded in the mold when casting the façade panel. However, a thin façade panel does not resolve the issue of thermal insulation, so in the patent, Camus proposes assembling the façade from two rows of panels. The first row comprises façade panels, and the second consists of smooth panels facing the interior. The air gap between the two rows of panels acts as thermal insulation. Interior partition panels consist of a reinforced concrete frame and filler. Both sides of these panels are finished to allow for painting or wallpapering. During the pouring stage, door frames and electrical wiring are embedded in the molds.

The floor slabs between stories also consist of two panels. The lower panel is load-bearing, with longitudinal and transverse stiffeners, and one of its sides is factory-finished to serve as the ceiling for the room below. The upper panel, which is thinner, served as the floor of the apartment and was factory-finished with parquet or ceramic tiles.

2. AUGUST PERRET'S MASTER PLAN FOR THE CITY OF LE HAVRE

In November 1944, le *Ministère de la Reconstruction et de l'Urbanisme* (the Ministry of Reconstruction and Urban Planning), or MRU, was created to oversee reconstruction operations. The ministry's senior officials, such as Director of Construction Adrien Spinetta and Director of Architecture Pierre Dalloz, believed in prefabrication as a remedy for the housing crisis. In order to manage the reconstruction of the devastated cities, the MRU appointed Head Architects for urban reconstruction. Thus, Auguste Perret, a prominent specialist in concrete architecture and a proponent of the prefabrication system, was sent to Le Havre, a city badly damaged by the war. Perret designed a new general layout for the city, based on dividing the city center into rectangular lots (*îlot*) so that each lot accommodates 750 inhabitants per hectare [4].

In 1949, the *François-Ier* reconstruction cooperative, which owned lots 17 and 21, put the architects Henri Loisel, René Vallin and Raymond Audigier in charge of building housing there.

On each of the two lots, Henri Loisel integrated the existing buildings and placed four new houses aligned with the streets, forming a rectangle with a large courtyard accessible through the spaces between the buildings (Figs. 1-2).

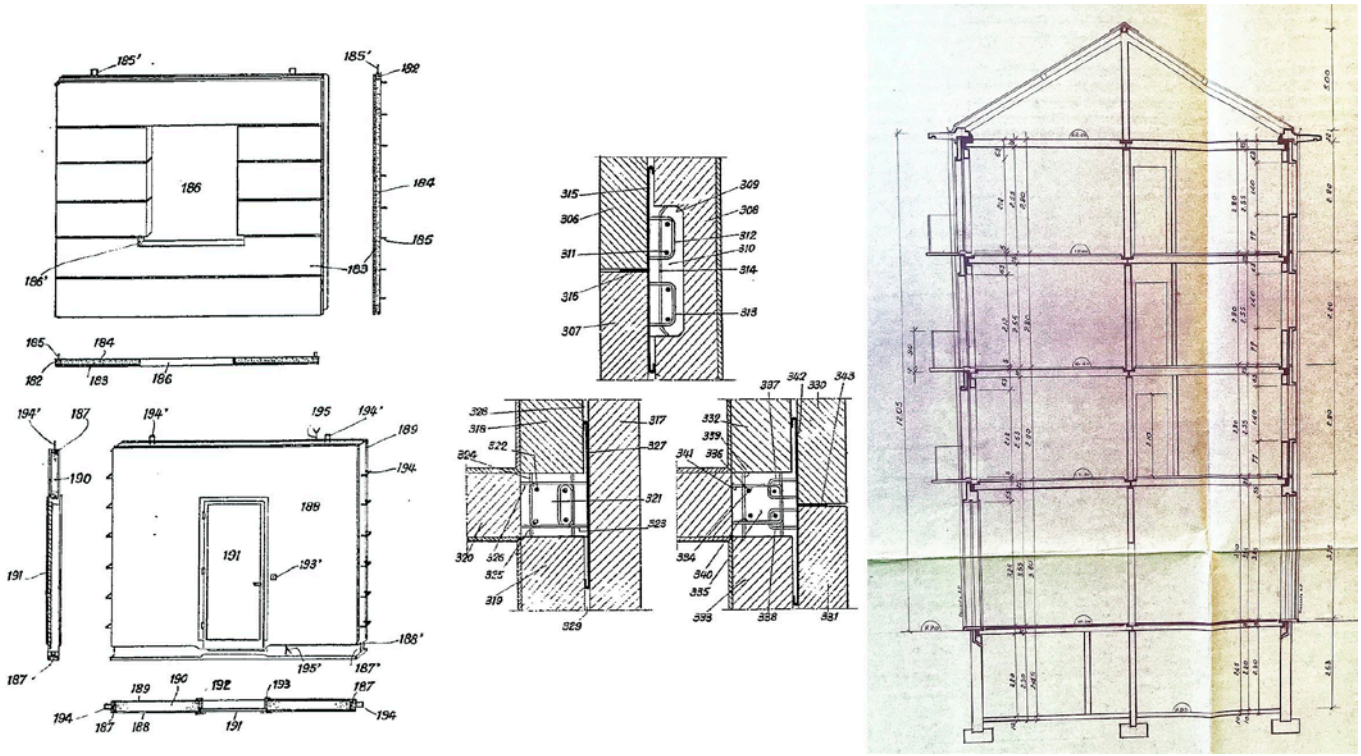

Fig. 1. *Left: drawings from Raymond Camus's first patent: façade and partition panels; horizontal cross-sections of the façade panels. Right: a transverse cross-section of residential Building A, Camus's first project in Le Havre. The drawings show that the façade is assembled from two rows of panels. Source: Patent N 1.009.676, requested on 16 June 1948, delivered on 12 March 1952. AMH, Fonds contemporain, demande de permis de construire, PC 587/49.*

3. PONT 6 AND PONT ROUGE - RAYMOND CAMUS'S FIRST PREFABRICATION FACTORIES

The construction company selected to build the apartment blocks on lots 17 and 21 was Raymond Camus' company; therefore, they were built using Camus's system. To manufacture the panels, in September 1949, Camus rented a disused shed in the port of Le Havre that the American army had previously used as a warehouse. Located in the *rue des Chantiers*, the shed was situated at the edge of Bridge no. 6, one of the structures linking the docks in the port of Le Havre, and so the factory was named "*Usine du Pont 6*" ("*Pont 6* Factory") [5].

By the time the new company, *Raymond Camus & Cie, procédés industriels de construction*, was registered, Camus had hired its first worker who cleared out the warehouse and cast a reinforced concrete base (a "table") onto which molds for the casting of panels would be installed, and next to the table, there were pillars onto which the panels ready for their final curing would be leaned, according to Camus's plans. In the span of three months, the warehouse was transformed into a factory, and around ten workers were hired, of whom only two were professional construction workers. Camus rented out a trailer and a tractor to transport the panels to the construction site, which were sold off by the American army (Fig. 3).

The factory equipment presented an assortment of rough-and-ready contraptions, and most of the tasks were performed manually. The hoisters used to remove the panels from the molds and otherwise handle them were operated manually, the concrete was carried by the workers in wheelbarrows, and the reinforcements were fabricated in the open air, right in the factory yard.

In December 1949, an application was filed for a construction permit for the first building situated on lot 17, the building "A" [6]. The construction began on Wednesday, May 3, 1950. Interviewed by the La Havre newspaper, Raymond Camus said: «I would just ask you to note that yesterday, on Wednesday, you took photos of bare foundation. Today, at 6 pm, half of the basement elements have been installed [7]».

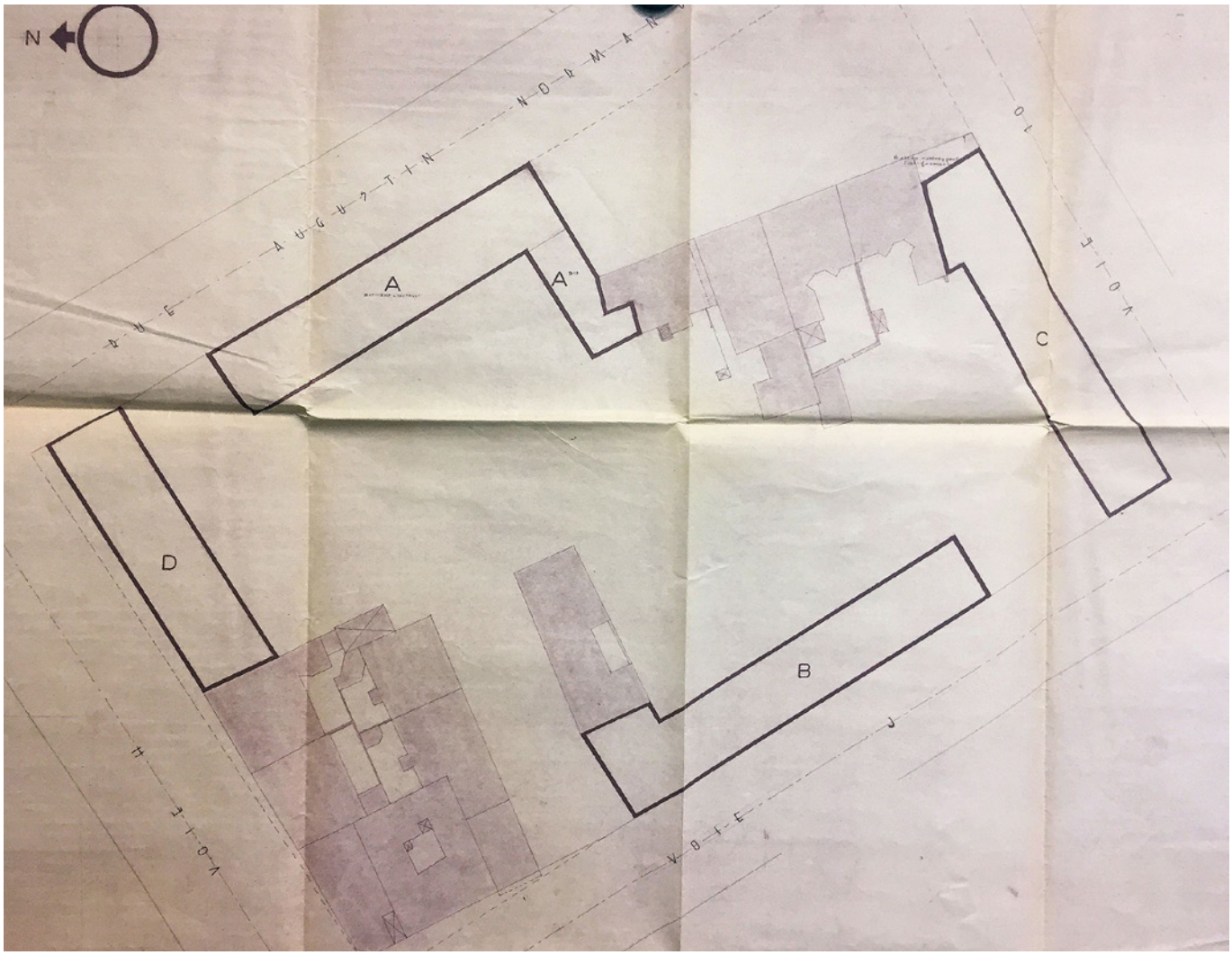

Fig. 2. *Henri Loisel, René Vallin and Raymond Audigier (architects), Raymond Camus (building contractor), Lot (Îlot) 17, Le Havre, general plan, drawing from the construction permit, 1950. Source: AMH, Fonds contemporain, demande de permis de construire, PC 587/49.*

In the architectural design of the first residential building "A", constructed according to the patent, the façade was made of two rows of panels with an air gap between them. However, upon starting the casting process, Camus abandoned this approach. Although two panels weigh less than one thick panel and are easier to maneuver in the factory and on-site, installing two rows of panels is more labor-intensive. Camus simplified the design by replacing the two rows of panels with a single sandwich-type panel that is 30 cm thick.

At the "*Pont 6* Factory", the panels for Building "A" were manufactured in layers in horizontal molds. The first layer placed at the bottom of the mold is the inner wall finishing: plaster for living areas or tiles for wet areas. Then, a layer of concrete was poured, reinforcement and insulating materials were laid, and another layer of concrete was poured. The outer wall finishing, reconstituted stone, was laid last.

The panels were left to dry in their molds for 48 hours. After that, they were removed from the molds and leaned against the pillars to acquire their rigidity (Fig. 4). After 4 to 5 days, the panels were loaded onto trailers and transported to the construction site, where a team of ten workers from Camus's company assembled the panels for Building "A". The 3.3 m x 2.8 m panels weighed four tons each, requiring the use of high-power lifting equipment.

Raymond Camus set up a complete cycle from molding units in the factory to their transportation and subsequent assembly at the construction site. He planned a timeline for the prefabrication of the components to match the progress of the construction; the components were stored and transported to the construction site in a

Fig. 3. *View of the "*Pont 6 *Factory" in 1949, with a trailer transporting prefabricated components to the construction site on lot 17. Source: AMH, fonds Claude Pagenot, photo 86Fi 0021.*

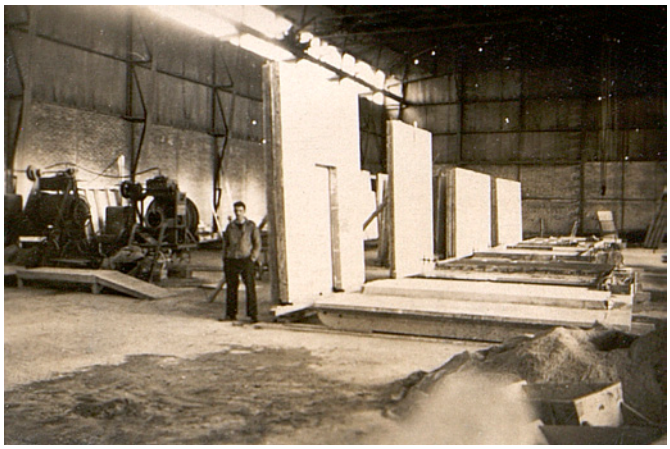

Fig. 4. *"*Pont 6 *Factory", the panels removed from the molds are drying, on the floor the concrete tables on which the panels are cast, around 1950. Source: AMH, fonds Claude Pagenot, photo 86Fi 0016.*

precise order. Each component had a reference number. Around 700 components were needed to assemble Building "A". Within a week, two apartments were assembled.

Building "A" is composed of 12 apartments laid out on three floors and 7 shops on the ground floor. Each apartment comprises three living areas: two 10 /11 m^2 bedrooms and a 15 m^2 living room. The service rooms include a kitchen, a shower room, a toilet and a drying room. The rooms are laid out around a corridor. The living rooms face the street, while the service rooms face the courtyard (Fig. 5). The roof of Building "A" is built using a traditional approach: a timber framework covered with tiles.

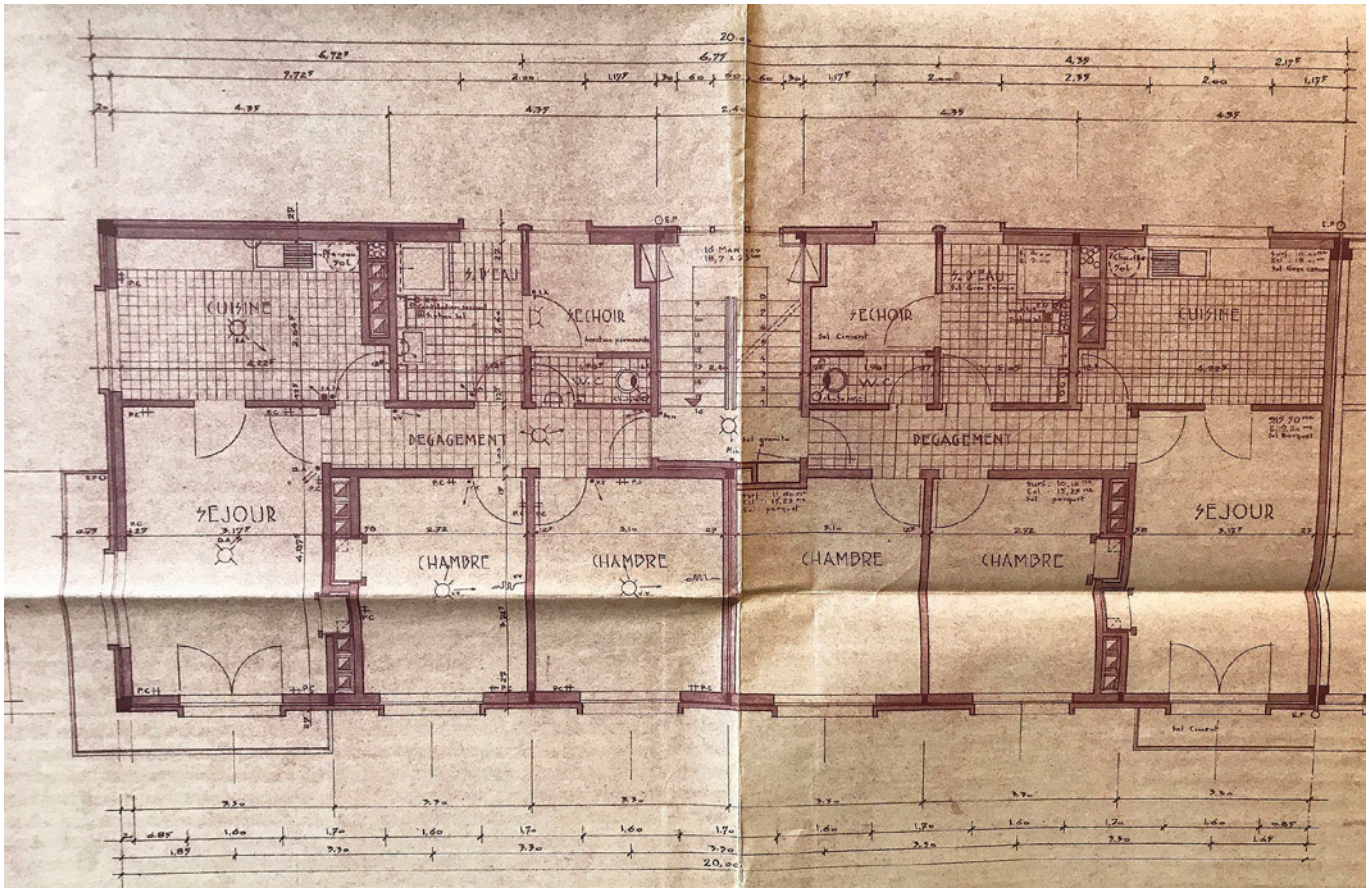

Fig. 5. *Lot 17, Building "A", plan of 3-room flats, drawing from the construction permit, 1949. Source: AMH, Fonds contemporain, demande de permis de construire, PC 1949/587.*

While designing the layout of Building "A", the architects encountered large-scale prefabricated elements for the first time – the façade panels, the width and the height of a room. They left the joints between the façade panels visible and, to make them appear smaller, they opted for outer wall finishing, a tile pattern that gave the illusion that each large panel was made up of smaller ones. The protruding frames around the windows add diversity to the façade as a whole and create a "dialogue" that brings the joints and the outer finishing of the panels in tune with each other. The balconies placed on the sides and in the middle of the building emphasize the symmetrical composition of the façade. The vertical zigzag design of their metal railings creates smaller-scaled accents on the façade contrasting with the large concrete panels (Fig. 6).

On January 29, 1951, Building "A" was inaugurated in the presence of Pierre Courant, Mayor of Le Havre, André Marini, Director of the CSTB and Robert Le Chevalier, Chairman of the *François-Ier* cooperative [8]. Camus opened the ceremony and handed the keys to the cooperative's chairman. Abbé Marie made a blessing, and the officials visited the apartments. In his speech, Courant spoke highly of the performance of the Camus system: «[I am] particularly pleased to see that thanks to the system used here, a rapid completion is possible, which ensures that future residents will have good and comfortable houses. On the other hand, this system makes it possible to employ non-specialist construction workers whose only knowledge is their own goodwill [9]». Le Chevalier expressed his satisfaction: «This system was offered by Mr. Camus, who is now able to build houses like this one in three months, according to HBM standards, and who personally supervised the laying of the eight hundred elements that form the building [9]». As *Le Havre Libre*'s correspondent reports, the occupants moved in on the very day of the inauguration: «The officials had barely made the round of the building when a movers' van was already waiting at the entrance [9]».

The three other buildings constructed on lot 17 are buildings "B", "C", and "D". The buildings are 4 floors high, and their interior arrangement is similar: two or three rooms facing the street and service rooms facing the courtyard. The façade panels of these buildings are decorated differently: they are smooth and have no tile patterns.

With the start of construction of the next lot, no. 21, in 1951, the production capacity of the "*Pont 6* Factory" was well exceeded. To cope with the increase in orders, Camus rented another shed in the port of Le Havre, situated this time next to the *Pont Rouge*. The "*Pont Rouge* Factory" was better equipped with automated hoisters and an overhead crane.

Lot 21 is composed of four rectangular 4-story buildings: "E", "F", "G", and "H". The houses contain 8 shops and 51 4- to 5-room apartments. The roofs of these four buildings are flat, and the smooth façade is composed of panels with visible joints (Fig. 7).

Fig. 6. *Lot 17, Building "A", view at the end of the construction works, around December 1950. Source: Michel Camus archives.*

Fig. 7. *Lot 21, on the right buildings "G" and "F", seen around 1955. Source: Société Raymond Camus et Cie: Architectural documents on some of the buildings built since 1949 using Raymond Camus' system, promotional brochure, around 1960 (Natalya Solopova archives).*

4. 65 HOUSES IN ROUELLES LA POMMERAIS AND HARFLEUR BEAULIEU

The speed and quality of the construction process carried out by Camus on lots 17 and 21 earned his system a good reputation, and he was awarded a new contract, again working in a team with architect Henri Loisel, to build 65 individual houses on two sites in the communes bordering Le Havre: 34 houses in the *Pommeraie* district of Rouelles and 31 houses in the *Beaulieu* district of Harfleur. The construction permit was issued in 1951, and the houses were completed in 1953 [10]. The houses were built on behalf of the *Comité interprofessionnel du logement* (Interprofessional Housing Committee) [11].

It is important to stress that the patent registered by Camus in 1948 describes a two-story detached house measuring approximately 6 m x 6 m, with each of the four façades made up of four 3 m x 3 m panels. The detached houses in Harfleur and Rouelles, in essence, resemble the one described in the patent: two-story houses, each façade made up of four large panels – two on the ground floor and two on the first floor.

The only difference is that the façade is assembled from 30 cm-thick panels instead of two rows of panels with a gap between them, as it was supposed in the patent. The rectangular floor layout measures 8.5 by 6 meters. There is an entrance hall, a kitchen and a living room on the ground floor, three bedrooms, a toilet and a shower room upstairs. Each house is equipped with a garage and a laundry room. The ceiling height is 2.5 m. The façade has a very purist shape, cube-like with a flat roof. Exposed horizontal and vertical joints between the panels emphasize the minimalist look of the façade. They were assembled at a rate of three houses a week (Fig. 8).

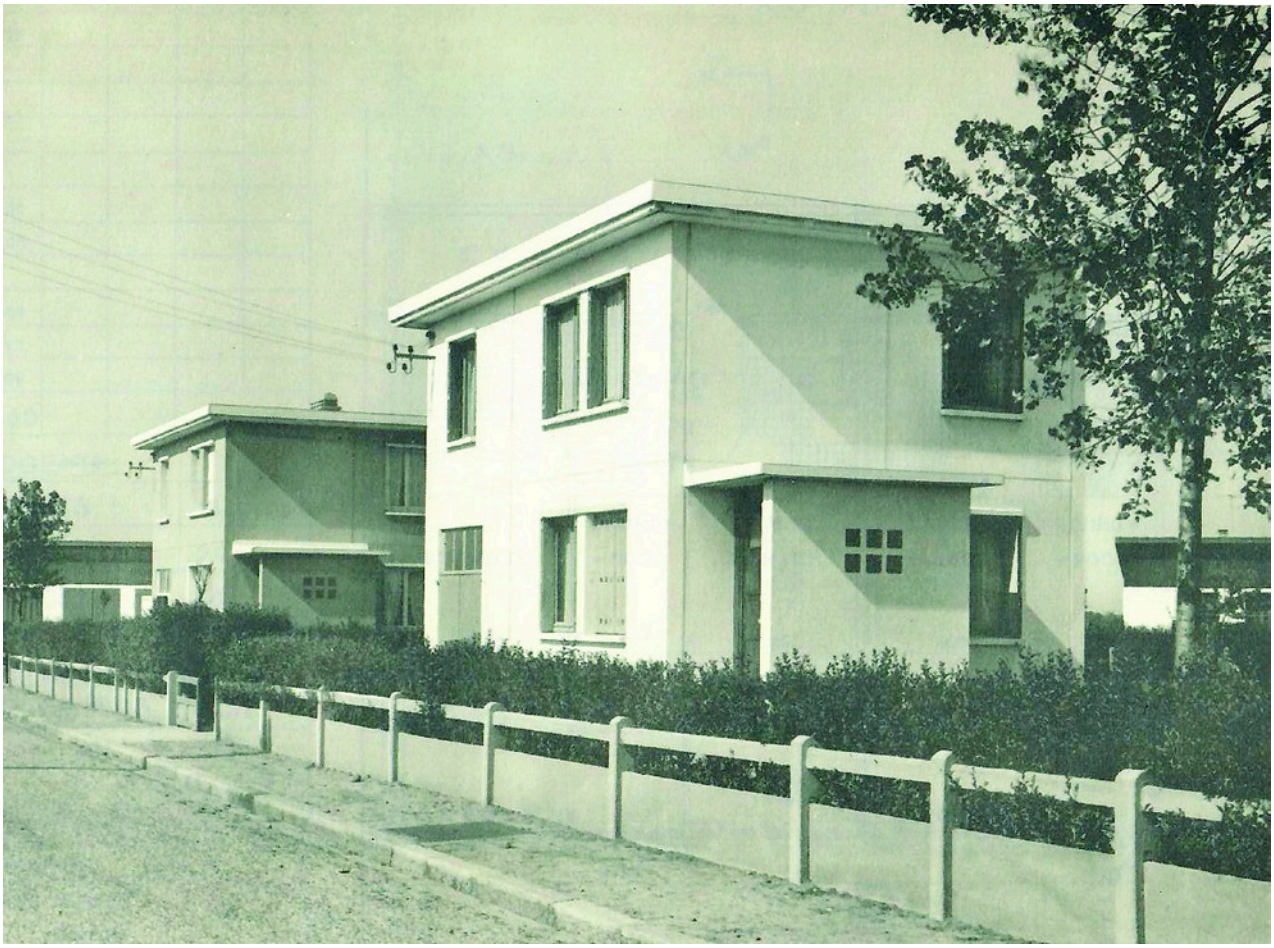

Fig. 8. *Individual house in Harfleur, photo around 1955. Source: Société Raymond Camus et Cie: Architectural documents on some of the buildings built since 1949 using Raymond Camus' system, promotional brochure, about 1960 (Natalya Solopova archives).*

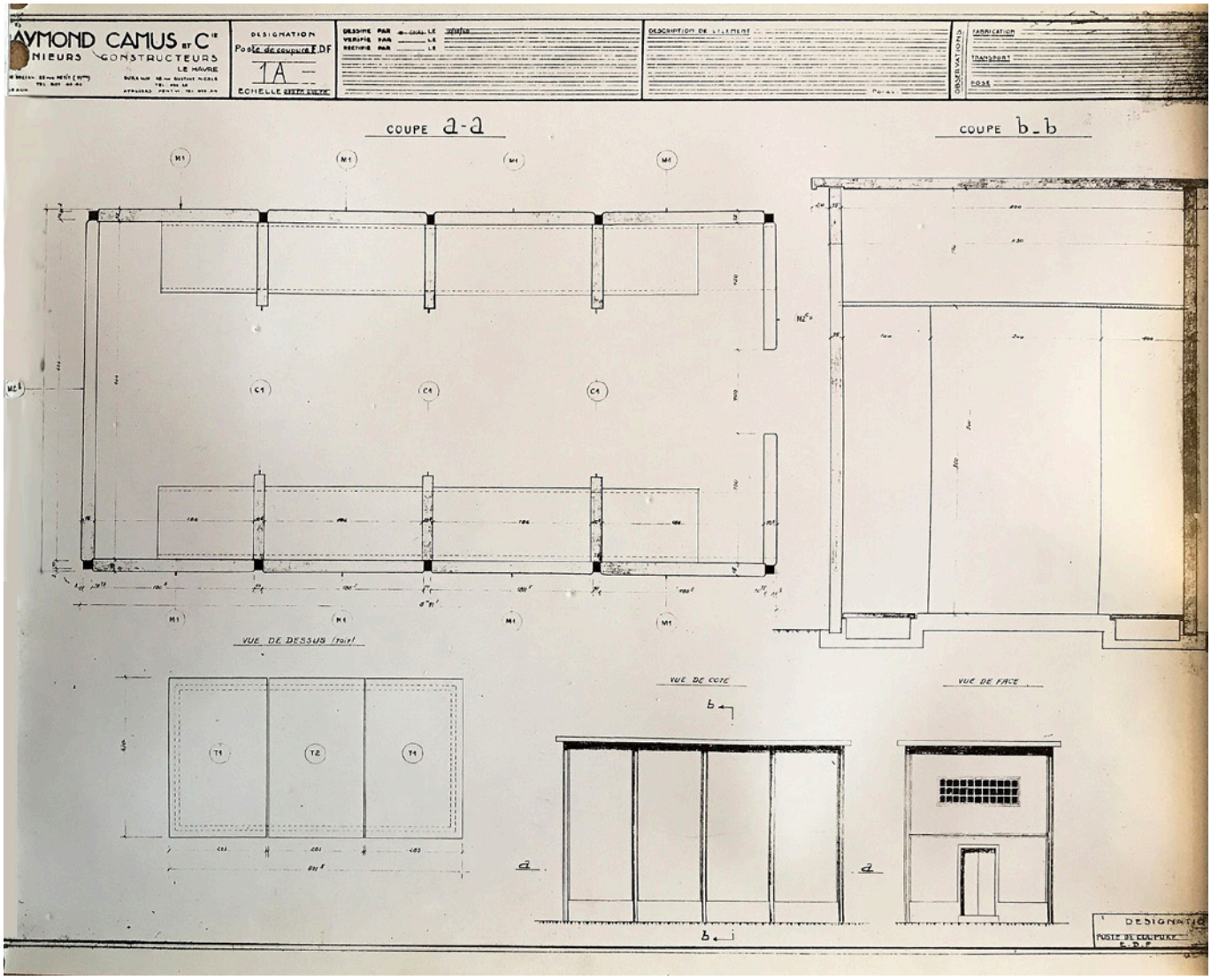

Fig. 9. *Electrical transformer substation. Source: Michel Camus archives.*

5. A SMALL STRUCTURE – A SHED FOR AN ELECTRICAL TRANSFORMER

Raymond Camus was playing a game to see how fast panels could be assembled. In the Pommerais district, a 35 m^2 shed designed to house an electrical transformer was erected in a single day. The shape of the shed was purist and the joints between the panels were apparent. Glass blocks above the entrance door added a certain finesse to the austere look of the façade (Fig. 9).

6. HOUSING FOR *SOCIETE NATIONALE DES CHEMINS DE FER FRANÇAIS* (SNCF)

The third and the last housing project built by Camus in Le Havre together with Henri Loisel, from May 1952 to October 1953, was the construction of 30 apartments for the SNCF (*Société Nationale des Chemins de fer Français* – National Company of the French Railways). They were allocated across two buildings in this way: 10 apartments on *Boulevard d'Harfleur* (since then demolished) and 20 apartments on *Place des Expositions*.

Loisel designed two rectangular five-storey buildings with flat roofs. The plan of each building reproduces the layout of lots 17 and 21: the building is 8.2 m wide, and the staircase serves two apartments per floor. Inside the apartment, the living rooms are separated from the service rooms by the corridor. On the façade, Henri Loisel experimented with contrasting rhythms: the vertical frames of the windows contrasted with the

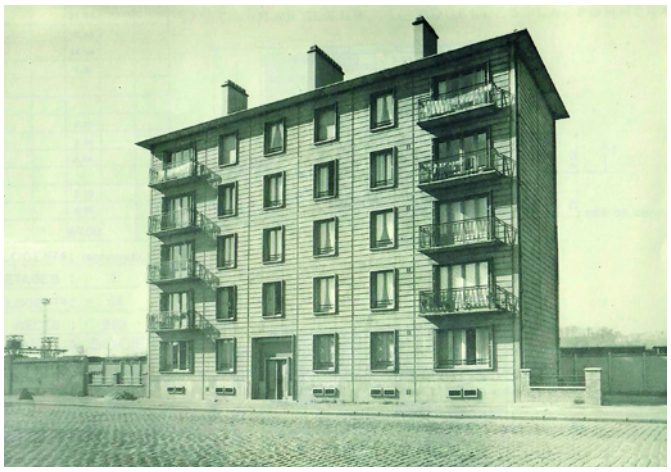

Fig. 10. *Dwelling house built for SNCF on Boulevard d'Harfleur (demolished), Le Havre, 1952-1953, view 1953. Source: Société Raymond Camus et Cie: Architectural documents on some buildings built since 1949 using Raymond Camus' system, promotional brochure, around 1960 (Natalya Solopova archives).*

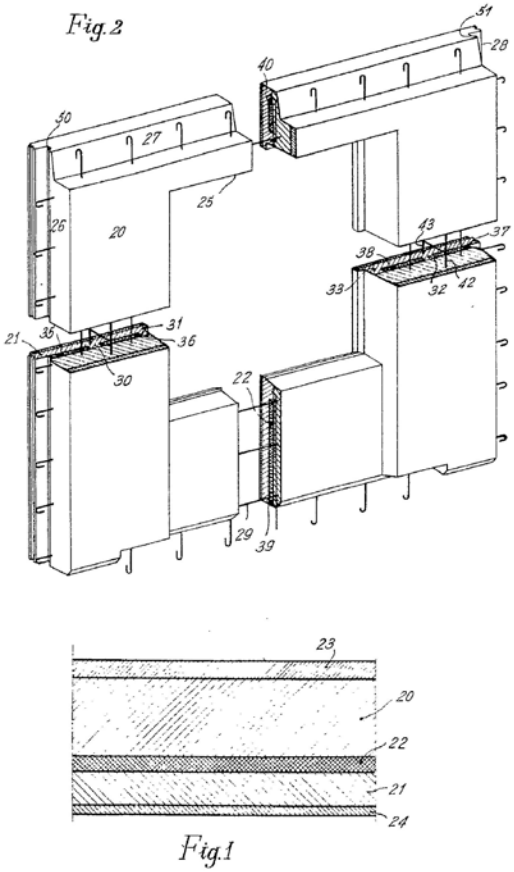

Fig. 11. *The horizontal cross-section and axonometric view depict the Camus panel, which he had been producing in his factories since 1954, but did not patent until 1957. Patent N 1.166.339, requested on 15 February 1957, delivered on 16 June 1956.*

horizontal pattern of the panels. The zigzag railings on the balconies gave these buildings a certain elegance; from an architectural point of view, the complex is the most successful of all those built by the Loisel-Camus team in Le Havre (Fig. 10).

Raymond Camus's first successful building sites in Le Havre, completed between 1949 and 1953, represent a short but favorable period for the French engineer. In four years, 209 apartments were built according to his system using an unskilled labor force. Camus tested and improved the design of his panels. He developed a complete cycle for the building construction chain – manufacturing of the components at the factory, transportation to the building site, and assembly of the components into residential buildings.

Once construction in Le Havre was completed, the Pont 6 and Pont Rouge factories were closed. From then on, Camus gets down to larger-scale projects. From 1955 onwards, the components factories using the Camus system were built in Montesson as part of the Paris Region program to build 4,000 dwellings and, in Forbach and Lens, to build housing for miners in the North of France and the Lorraine mining basin.

By 1956, at least four factories in France were already producing panels using Camus's technology. However, the design of these panels differed from the one Camus patented in 1948. In 1956, Camus signed an agreement with the USSR (Union of Soviet Socialist Republics) to transfer the technology for panel production, as well as the equipment for two factories.

The panels and their casting method needed to be patented urgently. In 1957, Camus filed a patent for a sandwich-type panel. The panel consists of three layers: the outer, thinner layer with a decorative façade finish; the middle layer, which is a polyester thermal insulation; and the third, load-bearing layer, which is thicker. The patent also details the production technology used in the factory. The panels are cast in heated horizontal molds that can be rotated 90 degrees. To speed up drying, the molds are covered with bells where water heated to 140 degrees circulates (Fig. 11).

7. CONCLUSIONS

Raymond Camus quickly transitioned from artisanal panel manufacturing in a port hangar in Le Havre to an industrial, well-equipped production process. Shifting

the main construction operations to the factory, where the work process was not dependent on weather conditions and unskilled labor could be utilized, along with efficient production organization, yielded excellent results. The system Camus created, which integrated production, transportation, and installation of the panels, worked effectively. Entire housing blocks were constructed rapidly. The results were so convincing that the USSR adopted Camus's model as the basis for its own industrial housing construction system – room-sized panels produced and assembled by a single enterprise.

In the 1950s and 1960s, Camus's industrial construction system helped address the acute housing shortage. However, after seventy years, residential buildings constructed with Camus's panels no longer meet modern noise and thermal insulation standards. Moreover, the uniform panel housing developments have had a negative impact on both the city's architecture and its urbanism. Nevertheless, Camus's system remains a significant part of social and family history, as several generations have grown up in these homes. Camus's system is also an integral part of the history of Modernity in architecture, one of the most important periods in 20th-century architectural history.

Authors contribution

Conceptualization, N.S.; Investigation, N.S.; Resources, N.S.; Writing, Original Draft Preparation, N.S.; Writing, Review & Editing, N.S.

Funding

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

[1] Cohen J-L, Grossman V (2014) La modernité, promesse ou menace? France, 101 bâtiments 1914-2014. Éditions Dominique Carré-Institut français, Paris, pp 8–15

[2] Patent no. 1.009.676 applied for on 16 June 1948, granted on 12 March 1952. AMH, Fonds contemporain, demande de permis de construire, PC 587/49.

[3] Anonymous (1950) Un Havrais réalise la préfabrication totale. Le Havre, May 5

[4] Brocard R (1955) La reconstruction de la ville du Havre. La Technique des travaux 31(1–2):3–19

[5] Claude Pagenot (2019) Interview with Natalya Solopova. Le Havre, January 17

[6] AMH, Fonds contemporain, application for planning permission, PC 587/49. Planning permission for buildings B, C and D was submitted in October 1950

[7] Anonymous (1950) Un Havrais réalise la préfabrication totale. Le Havre, May 5

[8] Anonymous (1951) The François-Ier cooperative inaugurated its first building, No. 17, the day before, and it was immediately occupied by disaster victims. Le Havre, January 30

[9] Anonymous (1951) Lion P, Le propriétaire, Monsieur M. Lussac a reçu les clefs du premier immeuble du N17. Le Havre, January 30

[10] Saunier F (2012) Pour une histoire des grands ensembles de l'agglomération havraise. Revue culturelle du Havre 4:28

[11] Anonymous (1952) Trois pavillons par semaine construits selon le procédé Camus à la Pommeraie. Le Havre, March 13