Steel, aluminium, plastic: the "unbearable lightness" of architectural modernity. The Centrale d'Allocations Familiales building of the XVth Arrondissement in Paris (1953-1959)

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Abstract

The Caisse Centrale d'Allocations Familiales de la Région Parisienne (or CCAFRP, shortened to CAF) was built between 1953 and 1959 as regional headquarters of a new post-war agency, the Central Fund for Family Allowance. Designed by French architects Raymond López (1904-1966) and Michel Holley (b. 1924), it was a work of enlightened modernity, in which the architects broke new ground in terms of urban concept, structural design, engineering and specification. A spectacular steel frame supported façades of tubular aluminium sections, with translucent panels of reinforced polyester infill. The CAF would be the talk of the town, hailed by the press as a "world first" in its assertive, not to say militant deployment of the most innovative technical and constructional solutions. One can argue that in the CAF, technical innovation was more than just the guiding principle of the design – that it became in effect the essence of a truly new paradigm in modern architecture. .

Key words

Technical innovation, France, 1950s, steel frame, curtain wall, reinforced plastics, Raymond Lopez

Avant-garde architecture in the name of Social Security

The reconstruction of the French State after the Second World War marked a radical transformation in the state's management of Social Security. One of the chief measures brought in by the Government was the establishment, in 1946, of the *Caisses d'Allocations Familiales* (or CAF). A system of helping families at home was swept aside in favour of a centrally planned programme of social assistance, and this required the construction of a new regional headquarters and nerve-centre for the new service. Raymond Lopez, "an architect of good standing, with the most favourable of references", was commissioned by the CAF in Paris to create the first of these centres on a substantial triangular site in the 15th Arrondissement [1]. The objective was unambiguous: a modern, functional building that would use the latest architectural ideas to communicate the symbolic image of the newly reformed social security services. Lopez, aided by Michel Holley, a younger architect and project manager in Lopez's office, responded to the challenge with a remarkable building now regarded as one of the finest commissioned by the French civil service in the post-war years [2]. (Fig. 1)

The originality of the CAF begins with the layout plan, a departure from the conventions of urban design that typify the historic cityscape of Paris *intra muros*. Different volumes, arranged in a carefully controlled composition guided chiefly by functional considerations, form a coherent ensemble around a central nine-storey slab housing the CAF offices, thus maximising the outlook above and beyond the confines of the plot. (Fig. 2) Though inseparable from the site layout, the block of offices, later dubbed the *Tour Lopez*, is of special architectural interest, with the form and the construction of its principle element intimately linked and intentionally stressed by the designers. The *Tour Lopez* reveals an intelligently conceived layout, with offices served by a double interior passageway, clearly expressed in the careful modelling of volumes and enhanced by the skillful choice of materials. For historians of construction, too, it is an important case study because of its systematic use of truly pioneering technology. The spectacular steel frame, the fully suspended curtain walls, and the scale on which plastics were used long before they were commonly used in the building industry, show the architects, with support from industry, freely experimented novel matrerials and methods of construction and, in doing so, took a commanding lead over conventional architectural production in 1950s Paris.

Figure 1. CAF, 1959. Kreel postcard.

Steel structure: an ideological issue

The choice of steel was primarily a matter of lightness. One of the key issues for 20th-century architecture, the development of a form of lightweight construction that was quicker and cheaper to than other forms of building was the subject of countless studies in the post-war years. Components and systems in steel were especially attractive, but so, too, was construction using the many lightweight alloys on the market that, like steel, offered innovative procedures of production to ensure high performance and optimum constructional economy. From Édouard Albert's tubular steel structures to the refined *self-lift* systems such as the dramatic system devised by Jean Fayeton for the tower blocks at Porte de Lilas, this line of research pointed to the future of standardised, modular building, a future founded on the prospect of unfettered industrialisation with the promise of all its speed and productive power. The buildings of tomorrow, where "wetting up, pressing in, trowelling on, dubbing out, sealing in [would be replaced] by screwing, tightening, welding and press-forming" [3], had become by the late 1950s a subject of fascination. Visions of building sites where "piles of gravel are replaced by packages" [4] were seen as models pointing the way to an architecture of 'assembly' rather than of 'construction'. The pristine, shiny construction environment seen in photos of industrialised systems became an object of fascination, an "ideal formula for the modern building site" [5]. Ideologically charged, dry assembly systems now acquired a new exemplary status as intrinsic to modernity in architecture.

Figure 2. CAF, 1959. Archives CAF de Paris, ACAF.

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The Lopez scheme developed out of the general enthusiasm for steel, the "total construction material [6]. In the case of the CAF, the peculiar complexity and conditions governing the programme prevented the architects from devising a truly industrialised approach to construction, but the logic of steel and the rationality of steel frame construction dominated their thinking [7]. (Figs 3-4) The CAF lies somewhere between the experimental buildings created using fully industrialised techniques, an important starting point for Lopez and Holley and their decision to use steel, and construction of a more 'artisanal' nature, an "intermediate process" [8]. The construction site was not merely the final sequence in a process that controlled every detail through design, where a 'meccano' kit of parts including the external cladding was merely bolted together; work on site remained a fundamental phase in the conception, an occasion for further adjustment and ongoing revision. As specialist journals pointed out [9], for the CAF the architects used the latest technology such as *Machine Union-melt* welding; but the actual construction remained somewhat 'traditional', notably in its use of crane-based assembly. Equally, the designers did not envisage the use of industrialised components or standard items chosen straight out of a catalogue, except for the steel sections used for the uprights, including the I-DIN 100 sections, the largest available from stock. Instead, the designers made use of components that were partially prefabricated but finished on site by specialist workers who still needed to have those very skills whose loss would be blamed on the industrialisation of the processes of construction [10]. This approach was still a long way away from the ideal of construction carried out by builders in 'white coats', but it was an attempt on a purely symbolic level to move as close as possible to this paradigm..

Figure 3. CAF, steel frame during erection, 1957. Photo Henri Longepierre. Archives privées Henri Longepierre.

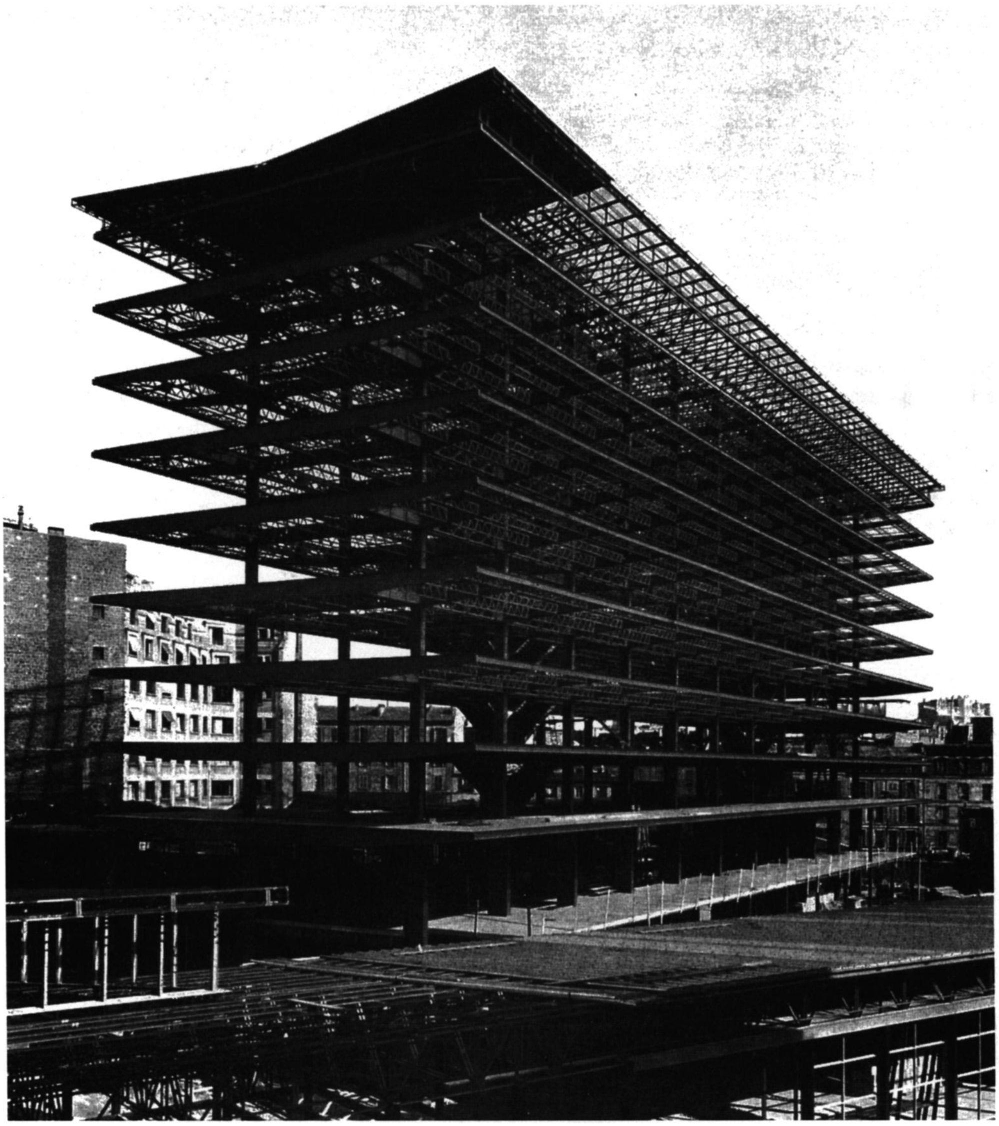


Figure 4. CAF, steel frame during erection, 1957. Caisse Centrale d'Allocations Familiales de la Région Parisienne, leaflet, 1959.

The "spectacular" metal frame of the Tour Lopez

The structural principle is simple, and its realisation faultless. The office building's metal skeleton, developed by Raymond Lopez and his team assisted by the firm of Schwartz & Hautmont, consists of eleven symmetrical portal frames, set back to the centre-line of the building and supporting cantilevered brackets. (Fig. 5) Structurally, it corresponds to the "two-legged" section that we recognise as the archetype for office buildings – ideal on account of the interior layouts that the concept permitted [11]. Although there are many well-known examples of the principle used in this way, it was rather unusual for it to be built in steel. Against the backdrop of international architecture in the post-war years, this is one of the CAF's most original features. Unlike a monolithic structures in reinforced concrete, to achieve this in steel demands expert handling of the post-to-beam assembly in order to compensate for the lack of upright supports around the perimeter and offset the considerable stress effects imposed by the cantilevers. Thus, while the metal frame of the CAF may not be particularly impressive as a technical achievement, it was one of the most intelligent buildings of its time in the way it harnessed the progress made in steel frame construction. This made possible the creation of a pioneering design that exploited the advances made in modern industry, notably in the development of assembly techniques like the use of electric welding and high-tension bolts rather than riveting [12]. This quality of innovation is evident in the design of the beam-to-post nodes, which combined electric welding "of the highest quality" of the soles with high performance bolts in the webs of the members aided by horizontal gusset-plates and vertical stiffeners. (Fig. 6) Welding allowed a jointed assembly fully enclosed within the thickness of the elements [13] rather than the complicated accretions typical of riveted construction and their demand for space. Here assembly occurs entirely within the thickness of the floor, greatly facilitating the planning and fitting-out of the office floors [14]. The almost monolithic character derived from the efficiency of these assemblies and their tightly controlled performance guarantees the rigidity of the portal frames, and these in turn largely ensure lateral bracing.

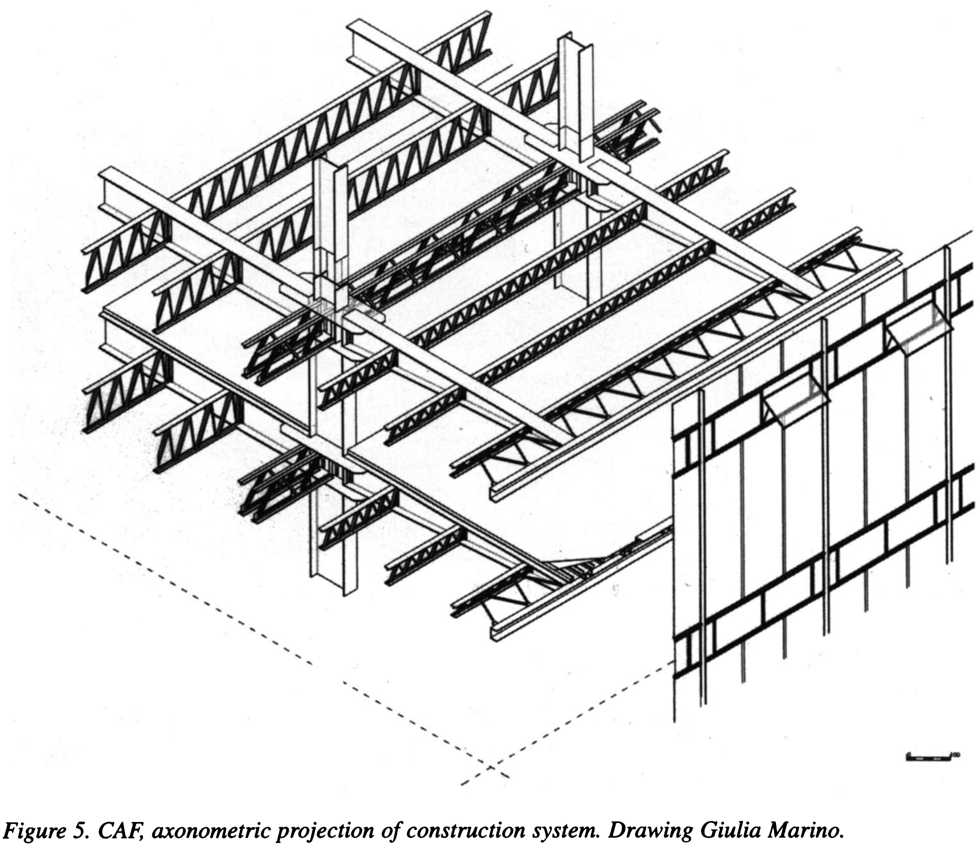


Figure 5. CAF, axonometric projection of construction system. Drawing Giulia Marino.

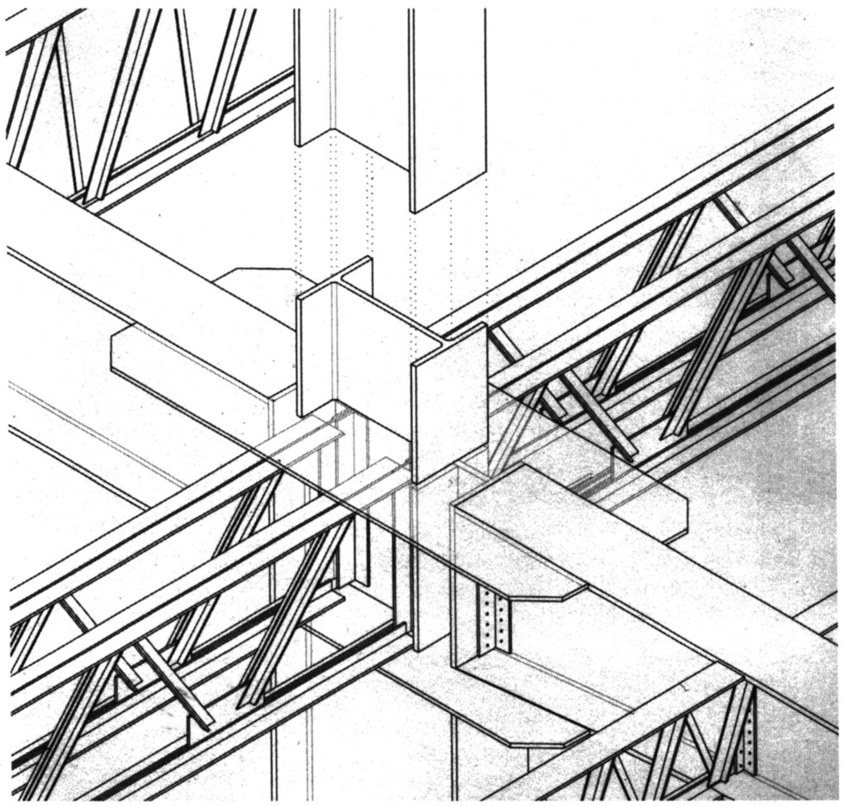


Figure 6. CAF, axonometric projection of post-beam assembly. Drawing Giulia Marino.

While highly accomplished in terms of static behaviour and in the effectiveness of the interior layout, the design details for the structural frame of the CAF are also of tremendous tectonic value and contribute greatly to the building's sculptural expression. Quite literally revealed through the lens of photographers of the calibre of Lucien Hervé and Robert Descharnes, the building came together piece by piece. The architectural establishment looked on eagerly and hailed the "spectacular" artistry of this starkly imposing and ruthlessly symmetrical piece of engineering.

Light in weight and independent of the floors: the suspended curtain wall

With outer uprights eliminated, the metal frame of the CAF is clearly different from the 'cage structures' common since the 19th century. The "two-legged" frame would have major consequences for the design of all the constructional members. The maximum weight that the cantilevered steel beams could carry was 15 kilos per square metre. The quest for lightness evident in the choice of steel for the frame became an equally important challenge in the design the envelope. This took the form of a curtain wall fully suspended from the lattice beams of the reverse-sloping double roof in order to avoid the considerable deflection occurring at the outward point of the cantilever. The novel notion of a suspended curtain wall, a true "curtain" akin to Marcel Lods' idea of the "membrane, with no mechanical role of its own" [15], seems obvious and consistent with the structural design. But the innovative solution actually devised only came about through a laborious process of design that is worth recounting in detail.

Rigidity of components and flexibility of assemblies: the Wallspan grid

In March 1953, Aluminex-Chamebel won the tender for the façades of the CAF with the American *Wallspan* aluminium-alloy grid already patented in Britain by their British partner, Williams & Williams Ltd [16], who had also obtained a patent in France and Belgium a few weeks before the start of the CAF project [17]. The *Wallspan* grid seemed to be the ideal response to the problem of the considerable deflection occurring at the outer edges of the floor because of its flexibility under expansion: "the difficulties in using walls [screens] as a result of differences in expansion-contraction through the main supporting frame on which the various floor decks rest and the walls" [18]. This ability to flex, the *Wallspan* grid's biggest advantage and subsequently a crucial innovation for post-war office architecture, was achieved using highly rigid tubular elements joined by way of fixings that allowed them to move vertically in relation to one another.

The use of "hollow rectangular tube sections", a speciality of the firm of Chamebel since the pre-war years [19] and favoured because of its economy of fabrication [20], is a distinguishing feature of the *Wallspan* grid [21]. Rectangular-section tubes in aluminium alloy, forming the main skeleton of the grid, were designed in such a way as to ensure maximum mechanical resistance. The cross-sections were dimensioned by taking into account "the judicious use of metal", to give "optimum modulus of inertia in the main plane of loading by transfer of metal to areas furthest from the neutral fibre, i.e. the shorter sides of the rectangle" [22]. (Fig. 7)

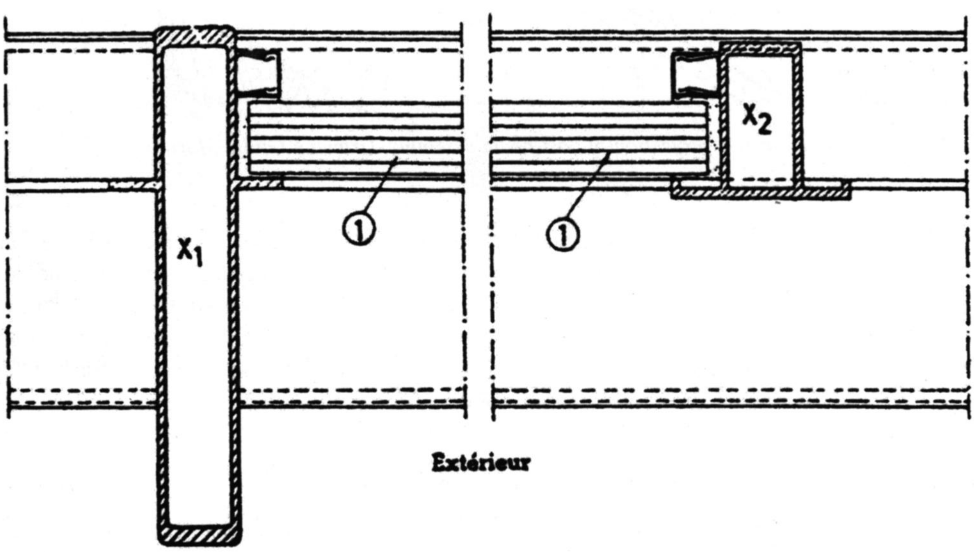


Figure 7. CAF, detail of Wallspan grid, tubular sections. Techniques et Architecture, 6 (1958).

Besides researching the maximum mechanical resistance of the components, achieved by selecting alloys best adapted to the structural role they were to play [23], the designers also wished to achieve flexibility between the elements, particularly in connection of mullion to transom. This is described by the patent in the following terms: "horizontal supports [...] are carried at each end on verticals; at one end of the horizontal, using an assembly component fixed rigidly to the vertical support and fitted into the hole of the horizontal support, so forming a precise but loose fit, one of the assembly components is fixed, whereas the vertical at the other end is not fixed" [24]. The principle is straightforward:

horizontals are screwed, pinned or riveted to the U-section rigidly attached to the mullion on one side, but more freely interlocking at the other end so they can slide in response to sideways movement.

In the standard version of the *Wallspan* then in use, the same principle is used for the vertical elements, each one fixed at the lower end to the edge of the floor deck and interlocking at the top end into the next element "in a way that [...] allows it to slide vertically" [25]. This sliding (or telescopic) joint was quite common in curtain walls characterised by continuous vertical members running up the façade [26], and finished here in a synthetic seal that would guarantee a perfect rain-poof envelope while being plastic enough to allow relative movement of different parts at the same time.

Adapting the Wallspan grid to the structural features of the CAF: a novel solution

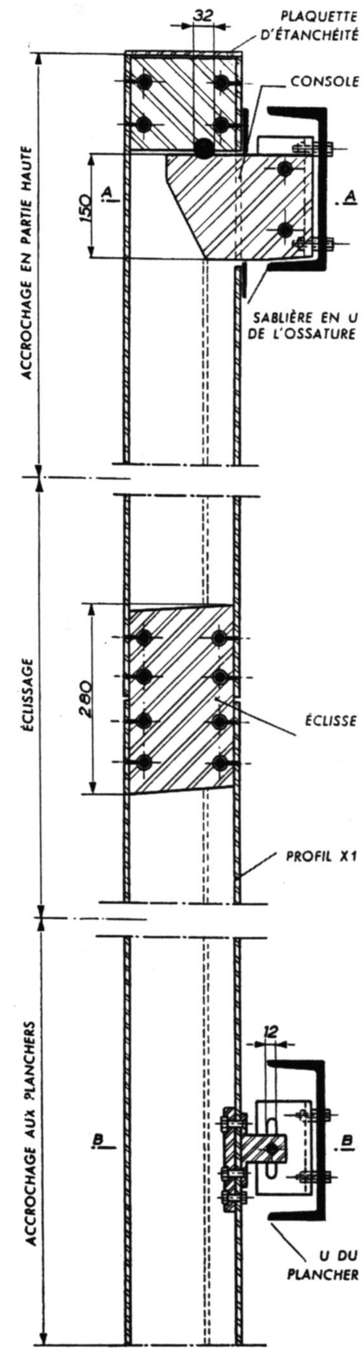
The *Wallspan* model was selected "off the peg" by the architects in the Lopez design office [27] and still had to be adapted to the special structural characteristics of the CAF. The classic solution described above, one that would be used in countless finished designs up until the 1970s, quickly showed itself to be ill-suited to the cantilever system used for the CAF, where deflection at the outer edges would have produced significant deformations in the vertical elements. Between December of 1954, the date of submission, and the summer of 1955, Henri Longepierre, the architect at Lopez in charge of project's execution and monitoring, and the engineer Robert Janniaux, technical manager at Aluminex-Chamebel, worked together closely to develop an alternative solution that would ensure a reliable connection between curtain wall and frame while resolving the problem of deformation in the mullions. They eventually opted for total suspension of the grid from the topmost deck of the frame, a choice that made full use of the characteristic features of the Franco-Belgian grid model.

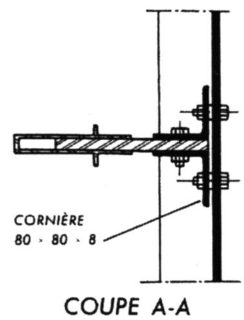
With this decided, they then developed a grid principle based on the rigidity of the vertical elements. This was to be achieved by combining the mechanical resistance provided by the tubular section of the components was with an assembly system firm enough to guarantee complete continuity through the mullions, in order to make them rigid and therefore increase resistance. In the patent, the idea was for an assembly system flexible enough to allow a degree of movement of the parts in relation to each other. In practice, however, the designers substituted this for a different approach which involved a fixed assembly relying on a high degree of stiffness through the mullions for its effectiveness. Consecutive elements plated together, corresponding to two storeys' height or 6.40 metres, were subjected to tests at the *Centre Technique de l'Aluminium* using a "pull-tester" [28] to test experimentally the nature of the aluminium alloy used for the connector plate [29] as well as the method of fixing it to the mullion [30]. This allowed the engineers "to ascertain that the assembly so formed offers a resistance well in excess of the strains to which the façade mullions are liable" [31] (Figs 8-9).

While work progressed on the rigid assembly needed for stiffness in the vertical elements, designers worked on the engineering for the suspension of the grid from the upper deck. The metal frame calculated by the engineers Schwartz-Hautmont was in fact modified to increase resistance and allow it to bear the full additional load imposed by the suspended façade. The initial idea for a portal frame with brackets like those for the other floors was soon scrapped in favour of a double lattice beam with two reverse-inclined faces [32], with "a belt of U-bars from which to hang the translucent façade panels through the full eight storeys, the ensemble being calculated to support the façade loads" [33]. The suspension system, illustrated in section in the first version of May 1955 and then in axonometric in the final version – not dissimilar to the initial version - produced in December of the same year [34], was fixed to the U-section profile around the building's perimeter. Extremely simple in design and concealed from the outside world for reasons of architectural clarity, this true "mechanism" is achieved by sitting the vertical mullions on a bracket, with the aid of a firring piece, fixed to the floors and slotting them into place. Mullion and bracket, quite independent of one another, are held by means of a hinge or guider situated in the grooves machined into the sleeve and bracket which keeps them in place while allowing for expansion and contraction. Loose support under horizontal wind loads is meanwhile ensured by the way the bracket is fixed to the floor, using an aluminium alloy frequently used in joinery (A-GS) and treated using anodic oxidation. This element is held fast by two angle-pieces bolted to the U-shaped beam-plate of the frame, which has oval-shaped slots in which the element can slide horizontally.

Figure 8. CAF, Wallspan grid during assembly. Photo Henri Longepierre. Archives privées Henri Longepierre.

The suspended grid system was devised to "take up the vertical loads of each mullion, including accidental overloading" [35]. Meanwhile the hooking arrangement for attaching the grid to the floors had to absorb vertical movement due to deformation of the cantilevered brackets on the one hand, and expansion-contraction resulting from the continuity of the façade on the other; according to Janniaux, the two together might potentially total up to 70 mm.. Specially devised for the CAF, the mechanism made it possible to "accommodate relative movements through a 12mm-diameter aluminium alloy finger" welded to a bearer bolted to the mullions and "sliding in a vertical slotted aperture in the wings of two angle-pieces bolted to the U" [36] around the building's perimeter [37].





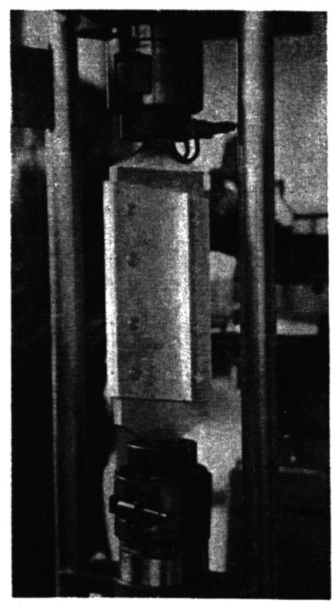


Fig. 7. — Essai de l'éclissage au Centre Technique de l'Aluminium ★ Checking the jointing at the Centre Technique de l'Aluminium ★ Ensayo del entablillado en el Centro Téchnico del Aluminio.

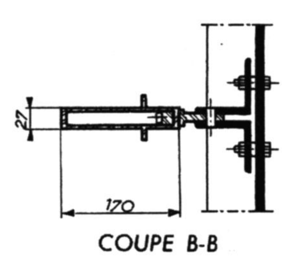


Fig. 4, 5 et 6. — Détail d'un meneau montrant l'accrochage articulé en tête, l'éclissage des éléments constitutifs et la fixation coulissante aux planchers ★ Detail of a mullion showing the articulated head fixation, the joining of the constituent parts and the sliding fixation to the floors ★ Detalle de un crucero de ventana mostrando la uniôn articulada en cabeza, el entablillado constitutivo y la fijaciòn resbaladiza en los pisos.

Figure 9. CAF, Wallspan grid and façade suspension mechanism. Revue de l'Aluminium, 268 (1959).

A building clad "totally in plastic": reinforced polyester panels

The need for maximum weight reduction also extended of course to the infill panels used with the *Wallspan* grid (Fig. 10) and from the very early days the designers considered glass reinforced polyester as the best way to approach the design of the panels. As with the steel structure and the aluminium façade, the choice of plastic had a considerable symbolic importance. Marcel Lods was openly confident in the potential of reinforced polyester: "bright and colourful, stable, a poor conductor... a marvel indeed!... a chance to lift the art of building out of the doldrums" [38]. Looking to experience in North America, a generation of architects followed suit. They showed a remarkable energy and determination to innovate as they embarked on a fervent quest to embrace this "revolutionary new material" with its many advantages. As surface finishes, plastics had lost ground in the inter-war period as semi-synthetic *Linoleums* and later *Formica* (not to mention the many laminates and veneers imported from North America) [39] became more widespread. Now, in the 1950s, they came into their own in the building industry, sparking what René Coulon, Professor at the École Nationale Supérieure des Beaux-Arts in Paris, would characterise as a "a revolution more fundamental than had been the development of the vault centuries ago" [40]. Lopez and his architects were ready for the challenge, though the large-scale diffusion of synthetics on the French construction market was still a few years off. As the journal *L'Architecture d'Aujourd'hui* [41] emphasised, the decision to use polyesters was decidedly adventurous; the stage-by-stage development of the infill panels would demonstrate this with total clarity.

Figure 10. CAF, Wallspan grid and Héliotrex paneels during installation. ACAF.

Héliotrex panels: "a new industrial product"

As we have seen, development of the panel was extremely rapid. At the start of 1953, architects were obliged to import resins from America as well as to modify production methods used in the marine and aeronautics industries by companies such as La Rochelle-based S.C.A.N. in order to develop their panel prototypes to conform to the specifications put forward in the tender package for the cladding. Between then and May 1954, the date on which the invitations to tender were issued [42], three firms appeared on the market with the resources to bid effectively for the panel contract using hydrocarbon resins for the first time in France. Though at the time Saint-Gobain was also beginning to produce polyesters, the ones used for the CAF were manufactured by Houillères du Nord.

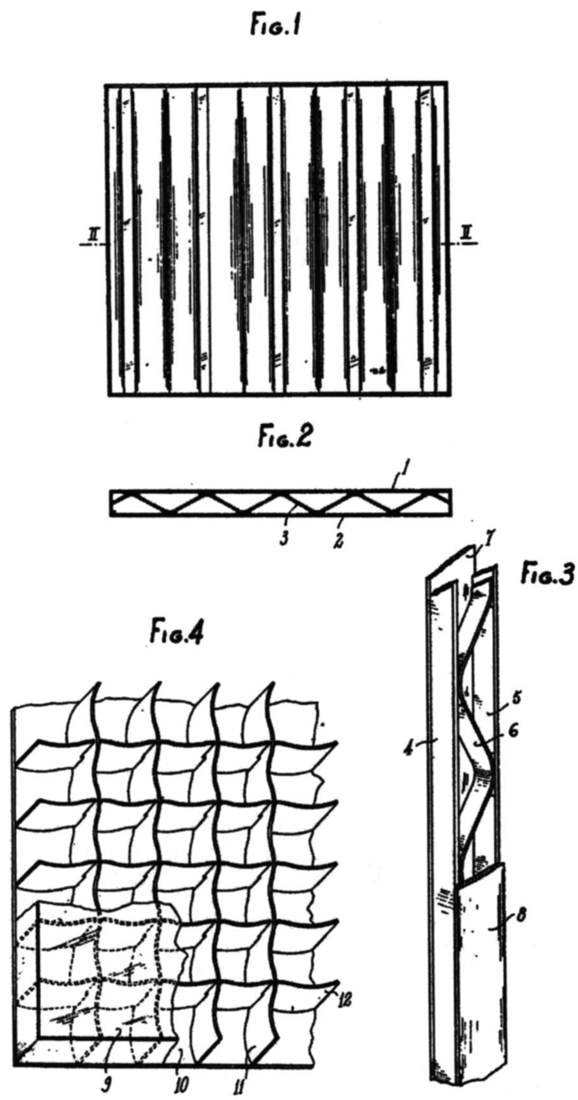


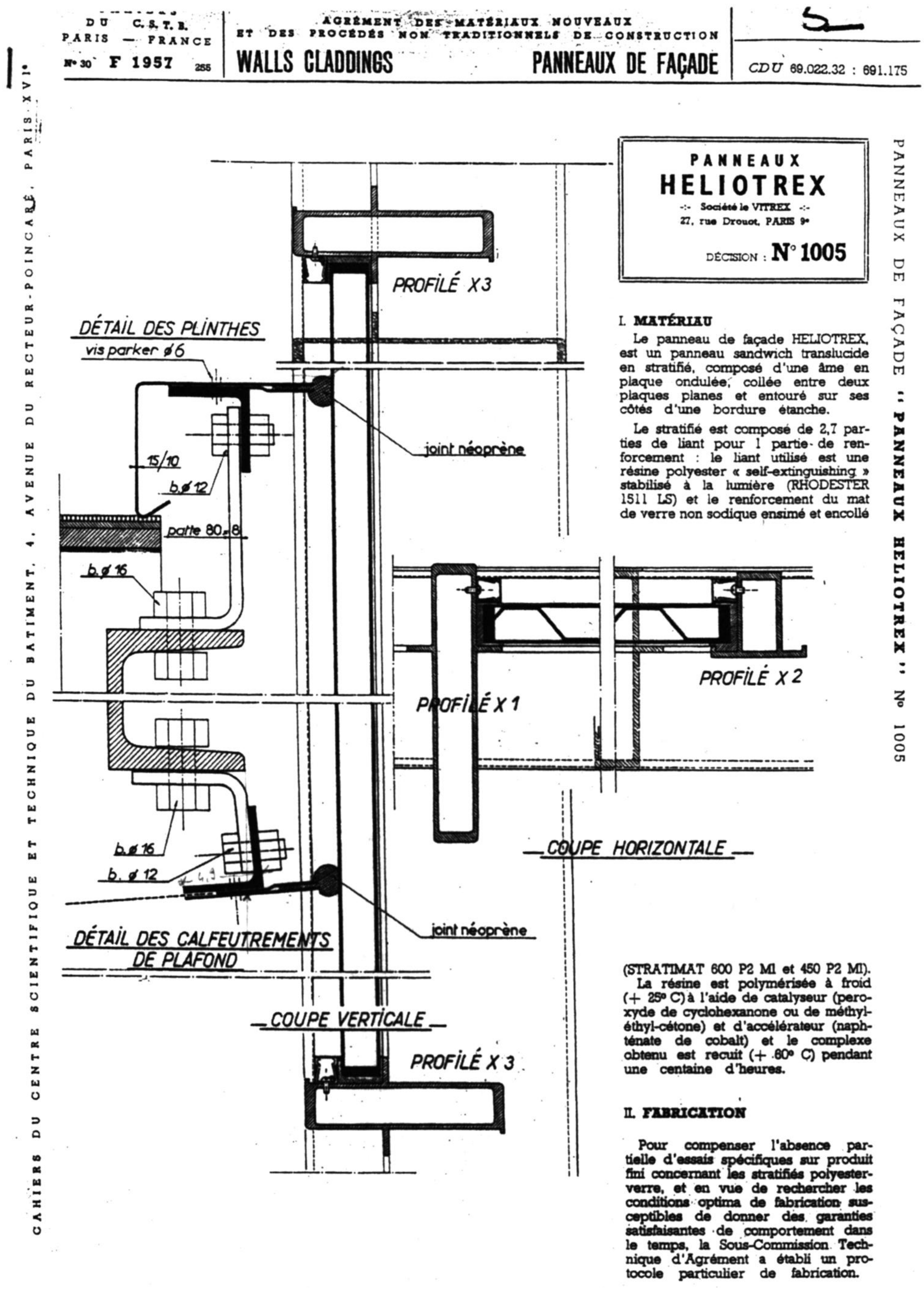
Figure 11. Société Le Vitrex, Héliotrex patent, December 1954.

Vitrex, the manufacturer whose "proposal came closest to achieving the desired quality at the desired price",[43] was preferred over E.U.R. and Genin of Lyon. The *Héliotrex*, the model proposed by Vitrex and patented in France as Vitrex put in its submission, was "a new industrial product [...] comprising two panels with an inner core of one or more corrugated sheets bonded together as a rigid element [...] produced using stratified materials such as glassfibre-polyesters" [44]. (Fig. 11) As a brand new industrial product, additional performance testing was conducted to a programme drawn up by Vitrex. The tests on the *Héliotrex* units were carried out by the *Centre Scientifique et Technique du Bâtiment* (CSTB),under the supervision of its senior engineer, M. Fallard, and Jean Laval, manufacturing director at Vitrex, starting with "a small initial production run of panels to be installed on site and on a mock-up office created for testing" [45]. The trials not only investigated the composition and characteristics of the panels, but also the manufacturing system that was to be employed [46]. After one year, a "Manufacturing Protocol" and an "Acceptance Protocol" were drawn up "to compensate for the absence of tests on finished products in laminated glassfibre-polyesters" [47]. After approval by the CSTB (which, significantly, limited their use to the CAF alone), 27 tonnes of *Héliotrex* panels were made at Vitrex beginning in February 1957, using a process that retained a certain artisanal quality [48]. They were fitted into the *Wallspan* grid by a simple method [49] two workers "slid" the panels in place from inside, between floors, working from the top down, and fixed them with cover-strips clipped to the uprights of the grid. Neoprene joints were then applied to the panels along the length of the façade to provide a weather-tight protective seal (Figs 12-14).

Technical values achieved through detailed design of constructional components

In 1957, an article, *"A new approach to Materials"*, in *Architectural Forum* presented a snapshot of the synthetic materials available and noted how architects' attitudes had changed radically with the appearance of this new range of products [50]. The interest of the *Héliotrex* panels lies, among other things, in the quite exceptional procedure involved in defining the nature of infill products. Central to this approach was research to develop the performance of the material through working essentially on its form and physical composition rather than by associating it with other components in a series of layers.

Technical literature on panel design for lightweight façade infill units routinely suggested the superimposition of "three elements: an external skin, an insulation material and an internal finish" [51], most often involving different materials combined together and thus able to respond in an appropriate fashion to the specific constraints to which they they would be subject. The *Héliotrex* panel was made entirely out of laminated polyester, a *monomaterial*, and this went against the conventional grain in the most radical way as stressed by Jean Maréchal in a reference to the CAF in an article on glass textile-reinforced plastics: "in this building, the panel forms a single entity" [52]. The design of the shape of the ribs in the inner core, as well as the proportions of resin to fibres, was carried out in such a way as to achieve maximum mechanical performance. The inner core took on the role of air gap, increasing the insulating properties of the infill unit. In determining the thickness of the faces as well as the choice of polyester, good thermal behaviour had to be factored in and the resin mix, correctly proportioned, was dosed with pigments to give a suitable colour and additives for fire resistance, essentially chlorine that would later result in problems with the toxic emissions. Perfection of the panel and management of its performance characteristics were thus wholly focused on the chemistry of the polyester, its incorporation with the glass-fibre matting, and the shape of the unit. In essence, it was an approach not far removed from the "pensée technique" [53] philosophy that Jean Prouvé had developed around the theme of pressed steel.



DU C.S.T.B.
PARIS — FRANCE
N° 30 F 1957 255

AGRÉMENT DES MATÉRIAUX NOUVEAUX
ET DES PROCÉDÉS NON TRADITIONNELS DE CONSTRUCTION

WALLS CLADDINGS PANNEAUX DE FAÇADE

CDU 69.022.32 : 691.175

CAHIERS DU CENTRE SCIENTIFIQUE ET TECHNIQUE DU BATIMENT, 4, AVENUE DU RECTEUR-POINCARÉ, PARIS XVI°

PANNEAUX DE FAÇADE " PANNEAUX HELIOTREX " N° 1005

PANNEAUX
HELIOTREX
Société le VITREX
27, rue Drouot, PARIS 9°
DÉCISION : **N° 1005**

I. **MATÉRIAU**

Le panneau de façade HELIOTREX, est un panneau sandwich translucide en stratifié, composé d'une âme en plaque ondulée, collée entre deux plaques planes et entouré sur ses côtés d'une bordure étanche.

Le stratifié est composé de 2,7 parties de liant pour 1 partie de renforcement : le liant utilisé est une résine polyester « self-extinguishing » stabilisé à la lumière (RHODESTER 1511 LS) et le renforcement du mat de verre non sodique ensimé et encollé (STRATIMAT 600 P2 MI et 450 P2 MI).

La résine est polymérisée à froid (+ 25° C) à l'aide de catalyseur (peroxyde de cyclohexanone ou de méthyl-éthyl-cétone) et d'accélérateur (naphténate de cobalt) et le complexe obtenu est recuit (+ 60° C) pendant une centaine d'heures.

II. **FABRICATION**

Pour compenser l'absence partielle d'essais spécifiques sur produit fini concernant les stratifiés polyester-verre, et en vue de rechercher les conditions optima de fabrication susceptibles de donner des garanties satisfaisantes de comportement dans le temps, la Sous-Commission Technique d'Agrément a établi un protocole particulier de fabrication.

Figure 12. CAF, Héliotrex panels, CSTB certificate. Cahiers du CSTB (février 1957).

The artisanal dimension was much in evidence so that production that should have been largely industrialised often came closer to *bricolage*. But this was *bricolage* of an intelligent kind, which made good use of the skills possessed by the manufacturing firms, their production experience and, above all, their willingness to innovate. Progress in the metallurgy and chemical industries after 1945, with ever more sophisticated machines and equipment, allowed the possibilities offered by the nature of materials themselves to be developed considerably. Mastering the behaviour of materials, their compatibilities and the variety of possible surface treatments led to a tangible improvement in the quality, or rather qualities, of elements which could then respond better to given uses. Efficiency, versatility and precision in the processing of primary materials through the development of specially designed factory techniques and refinement of the methods introduced in the inter-war years allowed manufacturers to fashion improved part industrially manufactured products. In addition, the testing of the behaviour of materials, for example by assessing mechanical resistance to predicting life-cycles, made it possible to establish benchmarks for quality. In this way, manufacturing firms became leading actors and central to the process of architectural design. This came to be seen as a fluid and versatile field ideally placed to explore and craft new solutions out of fixed sets of limitations. The transfer of ideas from the marine and aeronautics industries to outward-looking and dynamic manufacturers working in the building industry now became a source of inspiration for new technical approaches.

Figure 13. Vitrex publicity – Héliotrex panels L'Architecture d'Aujourd'hui, 83 (mai 1959)

Figure 14. CAF, envelopes, 1959. Photo Henri Longepierre. Archives privées Henri Longepierre.

We can treat the text that accompanied the call for tender for the CAF façade components as a key way of measuring the impact of these new values. The specification virtually turned the design process upside down. The architects confined themselves to listing in the tender specification the precise performance characteristics required of the panels, leaving to the suppliers the initiative to define the nature of the product. The architects thus set out minimum values for thermal insulation, along with thermal expansion coefficients for panel units. They fixed light transmission coefficients, or translucency levels at 50%, along with guidelines on how to cut the sample pieces for testing with the luxmeter. They defined different aspects of mechanical resistance: impact, flexion in relation to floor-deck deformation and reduced water absorption, improved water resistance, ease of maintenance, aging control, particularly of colouration [54]. For fire resistance, the required that panels had at least to be *self-extinguishing*, or better still totally non flammable. Weight, a crucial issue, was not to exceed 10 kg/m^2.

This process of setting performance requirements for different components, which we now refer to as *performance-based* tendering, was virtually unknown in the 1950s, and illustrates quite how far ahead were the ideas of Lopez and his office had progressed by this time. They were already close to the 1980s notion of *continual innovation* [55]. The CAF project provided a special opportunity for experimentation and innovation, for developing a product one step ahead of the norms of conventional production. Lopez and his client developed a new approach to building that offered a genuinely competitive alternative to everyday practice that provided an inspiration to industrial manufacturers keen to develop new ways of working with the construction industry. As the tender procedure shows, the CAF exemplified an important paradigm shift. Here were industrial practices well ahead of the curve. The project anticipated the shift "from object to product" [56] in the highly competitive environment of the building industry as it sought to meet the demands – to use an ambiguous definition - of post-industrial building or an architecture of the 'third phase' that came to prominence in the 1970s. This was a major triumphs for Lopez and his team, and yet further reason to recognise the key importance, both technical and historical of the CAF.

Conclusion

As we have indicated, *Wallspan* curtain walling was widely used in Europe and this permitted the continual refinement of the basic approach. By the 1970s, the most sophisticated versions of the systems' tubular components incorporated discontinuities to prevent thermal bridging and offered, through the use of plastics, an assembly that was very flexible in its application. Although *Wallspan* was a standard product, the CAF's suspended curtain wall was a 'one-off' and very different from contemporary applications such as the remarkable Caisse des Réassurances in Paris, designed in 1955-58 by Jean Balladur, and the Centre for Nuclear Development at Fotenay-aux-Roses, designed in 1956-61 by Pierre Laborde, where a more 'traditional' solution was adopted, with the framing of the curtain wall mounted directly on the floor slabs.

The innovative importance of the CAF's curtain wall in France after WWII is principally due to the novel structural concept of suspending the façade from the steel-frame structure of the building. The resulting search for maximum rigidity of the vertical members, and the ingenious detail for fixing the cladding invite comparison, in terms of constructional performance, with the envelopes of buildings with large, open plans rather than typical office towers or blocks. We should think, for example, of a comparison with the large-scale projects of Jean Prouvé. His largest project was the huge façade for the great hall of the CNIT at La Défense, designed in 1954-58 by a team of architects lead by Robert Camelot, Jean de Mailly, Bernard Zehrfuss, with Jean Prouvé as the engineer for the façade and Nicolas Esquillan as the engineer of the concrete shell roof. The entirely transparent, suspended façade was approximately 220m x 45m and stiffened by internal mullions. Prouvé was also the façade engineer for the great glass curtain wall of the central hall that looks out over the entrance to Orly airport, designed by architect Henri Vicariot 1947-57 and finally completed in1961.

By the same token, the importance of the curtain wall of the CAF extends well beyond France and stands as a key exemplar in the history of the development of the techniques of lightweight construction. It is something entirely different from yet another faithful reworking of the cladding principles used on Lever House in New York (1951-52), designed by Skidmore, Owings and Merril, led by the firm's partner Gordon Bunshaft. This was the true 1950s model for a generation of curtain walls whose orthogonal geometry was realised using open sections able to slide freely up and down in order to accommodate mechanically the movement of the building's façade. Alongside the *Fenesterwall* system, developed during the 1950s by Crittall, the well-known English company, and the *Vistalite* system developed rather later by the Wednesbury Steel Construction Company, the use of tubular components in the *Wallspan* façades of Williams and Williams mark the façade of the CAF building as an essentially European achievement.

Developed to respond to the structural constraints imposed by the height of the building rather than to the problems of movement between the different elements of a façade of the typical American tower, systems of curtain walling using tubular elements enjoyed widespread use in Europe, often on the basis of British patents. The curtain wall of the CAF should rightly be considered as the precursor of these later variants. Its manifestly experimental character – so evident in the originality of the system of suspension – and its development, so obviously assisted by the fundamental contribution of the building industry that was growing so rapidly at the time, were major factors in the success of the Lopez office at the CAF building. They constitute yet further grounds for proclaiming in the broadest possible terms the building's technical and historical value that, sadly, was given too little attention during its recent renovation.

Biography of the author

Giulia Marino is a graduate in architecture from the University of Florence. She obtained the Diploma in advanced studies for her work on *Preservation of modern and contemporary built heritage* at the Institute of Architecture, University of Geneva in 2006. She was a scientific collaborator at the Foundation Braillard Architects in Geneva from 2004 to 2008. Since 2005 she has worked as scientific assistant in the Laboratory for Techniques and Preservation of Modern Architecture at the EPFL-ENAC in Lausanne, and enrolled as a PhD student at EPFL-EDAR in 2008.
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Steel, aluminium, plastic: the "unbearable lightness" of architectural modernity. The Centrale d'Allocations Familiales building of the XVth Arrondissement in Paris (1953-1959)

References

[1] For a more thorough study of the issues presented in this paper, see the monograph study : G. Marino, *Un Monument historique controversé : la Caisse d'Allocations Familiales du XVe-arr. à Paris – 1953-2008*. Paris: Éditions Picard, 2009, 270 pp.

[2] The heritage significance of the CAF was recognised by law upon its Inscription to the *Inventaire* in 1998. This protection, having been recommended by a committee of specialists, was annulled in 2002 after a long and tempestuous legal dispute which pitted the Ministry of Culture (defending the statutory measure) against the Ministry of Social Affairs (custodian of the building). The ensemble recently underwent serious renovations involving the demolition of one third of the buildings and substantial alterations to the originals.

[3] M. Lods, "Les constructions américaines – à la recherche d'une solution au problème mondial du bâtiment", *Revue de l'Aluminium*, 242 April 1957), pp. 395-408 : 408.

[4] *Ibidem*, p. 407.

[5] A. Thiebaut, "L'industrialisation, la filière métal et le savoir-faire des professionnels", F. Seitz (ed.), *Architecture et métal en France, 19e – 20e siècles*. Paris: Éditions de l'École des Hautes Études en Sciences Sociales, 1994, pp. 132-136 : 133.

[6] J.-B. Ache, *Acier et Architecture,* Paris: éditions Arts et métiers graphiques, 1966, p. 7.

[7] Michel Holley tells of the enthusiasm that greeted the Lopez firm's involvement in the MRU Competition for the Rotterdam quarter in Strasbourg (with engineer Camus and the Forges de Strasbourg) for the development of a prefabricated structural system using both steel and concrete. The choice of a steel frame for the CAF was made in this context. Michel Holley, interviewed 7 December 2004.

[8] L. Leonard, "Panorama des procédés de préfabrication et d'industrialisation, de la philosophie à la pratique", *Construction*, Tome XX, 5 (May 1965), p. 177-178 : 177.

[9] See also the special mention made of this type of assemblage in the article in *L'Acier-Stahl-Steel* ; cf. R. Lopez, M. Reby, "Caisse Centrale d'Allocations Familiales de la Région Parisienne, Conception architecturale", *Acier-Stahl-Steel, Revue internationale des applications de l'acier*, 22e année, 9 (September 1957), p. 337-339.

[10] Thiebaut, "L'industrialisation", (note V) p. 135.

[11] Designs contemporary with the Tour Lopez that also use this section are numerous and often featured on the cover of architecture journals. For the Jespersen building by Arne Jacobsen in Copenhagen (1953-1955), and the Unesco building in Paris by Marcel Breuer, Bernard Zehrfuss and Pier Luigi Nervi (1953-1958), cantilevered floors were presented as a guaranteed way of obtaining the required flexibility in modern and functional architecture. R. A. Coulon, P, Genes, "Architecture des ensembles administratifs", *L'Architecture d'Aujourd'hui*, 82 (1959). See also: J. Joedicke, *Bürobauten*. Stuttgart: Gerd Hatje, 1959.

[12] F. Seitz, "Les entreprises de construction métallique et le secteur du bâtiment en France au XXe siècle", *Le culture della tecnica- rivista dell'Amma*, 9, New series (December 1997), pp. 45-73 : 62.

[13] Welding assembly made its appearance between the wars with certain emblematic projects that retain a rare level of quality, such as the Clarté building, Geneva, by Le Corbusier (1929-1932). The widespread use of assembly techniques «capable of offering advantages over the riveted assemblies used until then», along with the first specific codes and regulations (*Circulaire* of 30 April 1946, Ministère des Travaux Publics et des Transports; *Règles C.M. 46,* Ministère de la Reconstruction et du Logement), began to appear after the war. Cf. C. Mondin, "La charpente soudée", *Construction Moderne*, 9 (September 1955), pp. 307-311 : 307.

[14] Horizontal joint plates assume the role of gussets in both directions, receiving cross-pieces and brackets, as well as the double lattice joists longitudinally; these parts, shop-welded to the heads of the

uprights, ensure distribution of loads through the interconnnecting vertical and horizontal members of the main frame, which also simplifies assembly on site. The various elements are fixed to the prefabricated node unit. For assembly a combined approach is used, with welding in the flanges and bolting in the webs with the help of a top-plate pre-welded to the node and angle-pieces for fixing.

[15] M. Lods, "Les murs-rideaux à l'ordre du jour", *La construction moderne*, 4 (1959), p. 14.

[16] J. Fox Williams, *Improvements in or relating to Curtain Walling*, Pat. N° GB 8282/53, submitted 25 March 1953 and licensed 15 March 1954 ; Published in *Journal of the Patent Office*, London, 8 June 1955.

[17] R. Lopez, M. Reby, *CCAFRP, Construction des bâtiments administratifs rues Viala – Saint Charles Dr. Finlay, Rapport sur l'examen des projets et des soumissions des lots n° 1 et n° 2,* 20 December 1954, p. 8 ; Archives CAF de Paris (ACAF).

[18] Châssis métallique belge, or 'Chamebel', *Perfectionnement aux murs écrans*, Pat. N° BE 527577, submitted 24 March 1954, licensed 15 April 1954, published in *Journal du Service de la Propriété intellectuelle du Royaume de Belgique* 9 November 1956, p. 2.

[19] One of the specialities of Chamebel was the industrial production of tubular metal components for buildings; as early as 1937, the firm had filed for a patent for its *Procédé de fabrication de profils tubulaires pour châssis métalliques*, which was designed to get around the problems linked to edge-to-edge welding and deformation of components due to excessive heat. Further studies were made after the war as the firm developed (and then patented) a number of processes for making its profiled units right up until the late 1960s.

[20] Grid components (mullions, transoms and secondary uprights) could be of the same cross-section; their interchangeability, more difficult with composite profiles, makes fabrication more efficient as the elements can be made as standard-production units.

[21] The use of rigid components was highly original: apart from the *Wallspan*, tubular frames were not found in the most common assembly manuals for lightweight façades between 1950-1960. In conventional curtain walling the preference for the main frame members was for either open sections (I- or T-section bars) for stiffeners/joint covers, or composite sections (typically assemblies of L- and U-section bars in drawn or press-formed rather than extruded metal) whose respective movements assist (or ensure outright) free expansion-contraction of elements.

[22] R. Janniaux, "La Caisse Centrale d'Allocations familiales de la Région Parisienne, Raymond Lopez et Marcel Reby architectes", *Revue de l'Aluminium*, 268 (September 1959), pp. 941-955 : 943.

[23] Extrusion of 30 tonnes of aluminium alloy profiles was done by Cégédur at its factories in Issoire, and by the Société Cuivre et Alliages in Ham.

[24] Le Châssis métallique belge 'Chamebel', *Perfectionnement aux murs écrans*, (note XVIII), p. 6.

[25] *Ibidem.*

[26] See also the telescopic assembly system for the uprights of the Pirelli skyscraper, Milan, where the upper element locking into the lower one is connected by a 'fork' to the dynamic joint fixed to the floors. This allows free expansion of the façades; cf. M. A. Crippa, P. Petraroia, "L'edificio Pirelli, sede della Regione Lombardia: sfide e prospettive di un restauro", *Il restauro del grattacielo Pirelli, i problemi della conservazione dei nuovi material*, brochure published by Regione Lombardia for the XXth International Colloquium *Scienza e beni culturali* (Bressanone, 13-16 juillet 2004).

[27] The principle for the *Wallspan* («[an] invention relative to structures of exterior walls of the type denominated as screen walls for buildings [...] usually of the type incorporating a metal or reinforced concrete frame») was suited to the design of façades consisting of panels mounted between floor levels as well as 'integrated' curtain walls in the proper sense. Composed of several pieces fitted together, it allowed a multitude of combinations of vertical grids (spacing depending on the infill panels) and horizontal grids. *Mur écran Wallspan "Aluminex-Chamebel", in Panneaux de façade et murs-rideaux en alliage légers*, publication by Aluminium Français, n.d. [1959], n.p. ; Le Châssis métallique belge 'Chamebel', *Perfectionnement aux murs écrans*, (note XVIII).

[28] R.Janniaux, "La Caisse Centrale d'Allocations", pp. 941-955 : 944.

[29] Rather than the Duralinox H5 A-G5 alloy initially planned (high resistance, often used for elements classed as «subject to large stresses»), Duralumin A-U4G was preferred, an alloy described in manuals as «suitable for structures subject to very large stresses», M. Costeraste, P. Bandet, "Fabrication et utilisation des gros profilés filés en aluminium et alliages légers", in *Revue d'Architecture*, D2 (September 1958), pp. 897-905.

[30] Rather than heavy section twin fixing studs as initially planned, smaller studs were used (22mm to 18mm in diameter), to ensure grip when the machine was on maximum power (15000 kg, rather than 1200 kg which the elements would have been subjected to in real conditions). R. Janniaux, "La Caisse Centrale d'Allocations", pp. 941-955 : 945.

[31] *Ibidem.*

[32] The late decision to use a suspended façade is revealed in a note in the CAF records, a contract amendment of July 1955 regarding supplementary works executed by Schwartz-Hautmont, including «an extra sum for metal framework as a result of freely suspending the curtain wall façades». R. Lopez, M. Reby, *CCAFRP, Construction des bâtiments administratifs, Avenant n° 1 au marché,* 31 December 1959; ACAF.

[33] R. Lopez, M. Reby, "Caisse Centrale d'Allocations", (note IX), pp. 337-339 : 347.

[34] Aluminex-Chamebel, *CCAFRP, R. Lopez architecte, façades Wallspan, plans n° WP 11751*, 25 May 1955 and 29 December 1955; ACAF.

[35] R. Janniaux, "La Caisse Centrale d'Allocations", pp. 941-955 : 943.

[36] *Ibid*em.

[37] Chamebel would return to the suspension system in 1964, filing for a patent for a curtain wall fixing system using an articulated assembly comprising a pivot sliding into a guider fixed to a section of the steel frame, very similar to the first design for the CAF. Cf. Le Châssis métallique belge 'Chamebel', *Dispositif pour la fixation de panneaux de murs-rideaux*, Pat. N° FR 1.387.409, submitted 24 January 1964, licensed 21 December 1964; published in *Bulletin officiel de la Propriété intellectuelle*, n° 5, 1965.

[38] Marcel Lods, quoted by J. Maréchal, "Plaques ondulées et murs rideaux en plastique renforcé au verre textile", *Annales de l'Institut Technique du Bâtiment et des Travaux Publics*, 150, 13e année (June 1960), pp. 575-588 : 578.

[39] Cf. J. Vene, *Les plastiques*. Paris: PUF, coll. Que sais-je ?, 1948, pp. 79-82. See also: J. Delorme (ed.), *L'extension des matières plastiques dans le bâtiment*. Toulouse: Amphora, 1949.

[40] R. A. Coulon, "Les matières plastiques langage d'une architecture", *Revue Technique du bâtiment*, 28 (March 1956), p. 21.

[41] "Caisse Centrale d'Allocations Familiales à Paris – panneaux de revêtement", *L'Architecture d'Aujourd'hui*, 58 (February 1955), pp. 38-39 : 39.

[42] R. Lopez, M. Reby, *CCAFRP, Construction des bâtiments administratifs rues Viala – Saint Charles Dr. Finlay, Concours pour le lot n°1, cahier des clauses techniques,* 3 May1954, p.17; ACAF.

[43] R. Lopez, "Murs translucides en polyester armé", *Techniques et architecture*, 6, 17e série (January 1958), pp. 90-92: 92.

[44] Gaston Rathier pour Société Le Vitrex (Seine), *Eléments de construction*, Pat N° FR 1.116.248, submitted 9 December 1954, p. 2.

[45] Lopez, "Murs translucides en polyester armé", (note XLIII) p. 91.

[46] *Ibidem*, p. 92.

[47] "Panneaux Héliotrex – Société Le Vitrex, Paris, Agrément des matériaux nouveaux et des procédés non traditionnels de construction, décision n° 1005", *Cahiers du CSTB*, 30 (February 1957), p. 1.

[48] Plates were assembled manually by two men, either by gluing at the polymerisation stage of the resin, or by adding other materials (which seemed to increase cohesion of the component parts, the primary source of mechanical resistance). Henri Longepierre architect, interviewed 25 May 2006.

[49] With the 7 kg/m^2 of the *Héliotrex* units the suspended façade weighed between 14 and15 kg/m^2.

[50] "A new approach to Materials – The molecular remodeling of matter promises an endless stream of new building materials", *Architectural Forum*, 1, vol. 106 (January 1957), pp. 104-106.

[51] See for example *Techniques françaises des façades légères – murs-rideaux et panneaux de façade*. Paris: Eyrolles – CIMUR, 1965.

[52] J. Maréchal, "Plaques ondulées", (note XXXVIII), *pp*. 576-588 : 586.

[53] See B. Reichlin, "Pensée technique, techniques de pensée", *Jean Prouvé, La poétique de l'objet technique*, exhibition catalogue (eds. Franz Graf, Bruno Reichlin, Vitra Design Museum, Weil-am-Rhein, 2006). Weil-am-Rhein: Vitra, 2006, pp. 60-77.

[54] R. Lopez, M. Reby, *CCAFRP, Construction des bâtiments administratifs rues Viala – Saint Charles Dr. Finlay, Concours pour le lot n°1, cahier des clauses techniques,* 3 May 1954, p. 6; ACAF.

[55] G. Giallocosta, *Riflessioni sull'innovazione, Architettura e produzione edilizia nei regimi di complessità delle fasi storiche di sviluppo del costruire*. Firenze: Alinea, 2004.

[56] G. C. Argan, *Destino e Progetto*. Milano: Il Saggiatore, 1965, p. 27.