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The skin and bones of structure. A brief history of how Mies van der Rohe revealed the skeleton of the house

Szkielet i obudowa. Krótka historia tego, jak Mies van der Rohe wyeksponował konstrukcję budynku

In 1907, Mies van der Rohe built his first work, Riehl House, in Potsdam, a classic house with a rectangular floor plan, a structure of brick load-bearing walls with a plaster of slaked lime and a sloping roof (Fig. 1). Although, the construction of reinforced concrete buildings had already begun in Europe in 1890 [2], [3, pp. 54–62], and the first steel-structured skyscrapers in America had made their appearance in 1880 [4, pp. 365–446], the use of concrete and steel had not yet become widespread, so Mies used traditional construction methods in this first work.

On the outside of the house we observe the trace of a structure that wants to reveal itself. On the longitudinal facade the bas-relief drawing of some pilasters, located at the end of the transverse load-bearing walls, stands out. And on the side facade, which overlooks Lake Griebnitz, the abutments and the architrave of the porch are shown in semi-shade. The first device reminds us of the presentation of the facade wall used by the architects of classical Rome and the Renaissance[1]: an ornamental structure in bas-relief, defining a wall. The second device reminds us of the classic Greek tool of the peristyle in the semi-open spaces that surrounded temples[2]. But in essence, this first home by Mies is a clear example of a house with a hidden structure. There is no clue to its structural reality. You cannot see the brickwork, the formation of the lintels, or the thickness of the walls. Neither can you see the base of the walls nor the wooden frame that constitutes the roof.

This compact, symmetrical and compartmentalized house scheme, with a brick load-bearing wall structure and sloping roof served as a model for a whole series of subsequent houses: Perls house (Zehlendorf, Berlin, 1911), Werner house (Berlin, 1913), Warnholtz house (Heerstrasse, Berlin, 1913), Urbig house (Potsdam, 1917), Feldmann house (Berlin, 1922) and Eichstaedt house (Berlin, 1922). All these have a structure of brick load-bearing walls hidden underneath the cladding, the only external reference being the decoration in bas-relief, or the walk-way porticoes and open veranda. Only in the Mosler House, built in Potsdam in 1924, do we see a load-

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[1] The architects of classical Rome used to employ classical Greek arrangements in their public buildings, not with a structural, but rather an ornamental function. In this way, the Greek arrangements of columns and semi columns, pilasters and semi pilasters, architraves, pediments and cornices, were applied to the wall surfaces, both facade and interior, establishing a regular rhythm of decoration on the wall surface. This constructive and decorative tradition was recovered in the Renaissance and on the facades of Brunelleschi, Bramante or Palladio, among others; it is very common to see a decoration on the wall, in low or high relief, composed of pilasters, columns, architraves, or other Greek elements. Neoclassicism is also heir to this tradition. In Germany, Schinkel is a clear example. In the Riehl house, Mies only continues this way of building and decorating [5, pp. 25–49].

[2] The peristyle surrounding the nave is the main element of the classical Greek temple; thus, the peristyle was built even before the interior nave [6, p. 224].

Fig. 1. Riehl House, Potsdam, Berlin, 1907 (Müller-Rentsch) [1, p. 22]

Il. 1. Riehl House, Poczdam, Berlin, 1907 (Müller-Rentsch) [1, s. 22]

Fig. 2. Mosler House, Potsdam, Berlin, 1926 (Hans-Christian Schink) [7, p. 65]

Il. 2. Mosler House, Poczdam, Berlin, 1926 (Hans-Christian Schink) [7, s. 65]

bearing wall solution with uncoated, exposed brick, and with stone or rowlock brickwork lintels emphasizing the constructive uniqueness of the openings in the wall (Fig. 2). This idea of exposed brickwork, which Mies tried for the first time in the unbuilt project of the Kempner house (Berlin, 1919), derives from his admiration for the clarity and constructive honesty of the Dutch master H.P. Berlage[3]. And this is his first step towards discovering structure.

The unmasking of steel

As Mies builds his classic, compact, symmetrical houses with a brick load-bearing wall structure and sloping roof, he studies new projects in which compactness and symmetry are partially dissolved and in which the flat roof replaces the sloping roof. This compositional change did not initially imply any alteration to the structure, but over time the brick load-bearing wall gave way to a mixed structure of brick and steel, or reinforced concrete.

In 1927 he built his first modern house, the Wolf House, in Guben. Situated at the top of a narrow, elongated plot of land cascading down via a series of terraces towards the river Neisse, the house consists of a staggered set of volumes of exposed brick with an asymmetrical triple L layout on the ground floor, and a large continuous living area that runs through the dwelling from east to west. The living room is the first large continuous space that Mies builds and extends to the outside with two large cantilevered slabs, one towards the courtyard leading to the dwelling and the other to the main terrace.

To better understand the significance of the Wolf House, let's compare it to the Mosler House, built three years earlier. The structure of the Wolf House, with the exception of its two cantilevered slabs, is not in essence very different from the structure of the Mosler House, a strong brick box. But the shape and space of these two houses are very different: contrasting with the compact prismatic and symmetrical volume of the Mosler House is the set of scattered volumes and the asymmetrical composition of the Wolf House. Compared with the compartmentalized spaces of the Mosler House are the three interconnected spaces of the Wolf House, which are three intersecting rectangles. The structure in both cases is similar: a brick load-bearing wall assisted by the steel substructure of the lintels. Even the brickwork is the same in both cases, a Gothic arrangement with alternating stretchers and headers in all the courses. The structural expression, however, is very different in the two houses. The lintels are displayed in the Mosler House, while in Wolf House the substructure underlying the formation of the openings remains hidden. And the brickwork with its horizontal course passes over the windows as if by magic. On the other hand, there is the cantilevered slab on the main Wolf House terrace. This slab needs an edge beam to support the cantilever. And the beam is evident when viewed from the terrace, but not when viewed from the river (Fig. 3). On the main facade of the house the edge beam disappears, because it is set back from this facade, and because it also remains hidden in the shade. It seems obvious that Mies did not want to show the edge of the beam on this facade, but the abstract presence of a white slab that simply rests on the brick wall.

Another important difference between Wolf House and Mosler House is the external placement of the windows, which means that the considerable thickness of the brick

[3] The Amsterdam Stock Exchange, built in 1903, is a fine example of this constructive clarity and honesty advocated by Berlage. In this building the Dutch master comes up with a visible and explicit architectural construction, in which the structure and, especially, the structural elements of transition are accentuated. The brickwork of the walls is exposed, and both the lintels and the arch stones, abutments and skewbacks of the arches, or the corbels on which the beams are unloaded, are built with grey granite, almost sculptural pieces that contrast with the continuity of the red brickwork. Mies had the opportunity of acquainting himself with Berlage's work during his stay in Holland while collaborating on a work by Peter Behrens, and he even competed against him in the competition for the Kröller Müller family home [8, pp. 32, 60], [9, pp. 71–73].

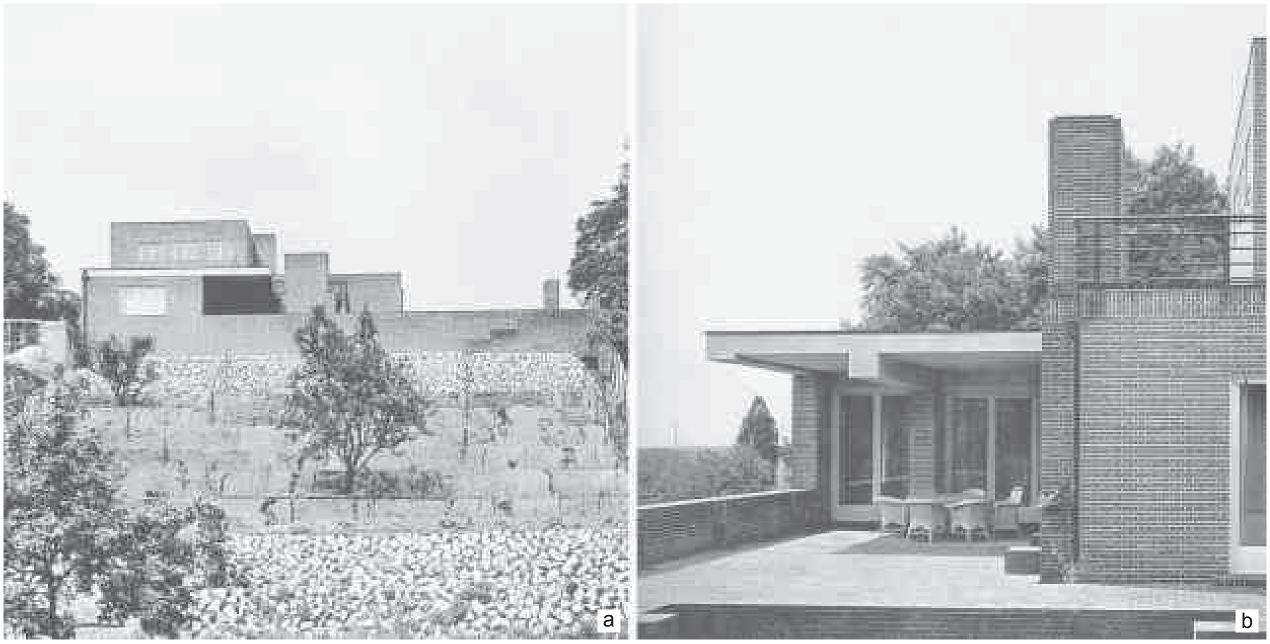

Fig. 3. Wolf House, Guben, 1925–1927: a) view from the river, b) view from the terrace [10, pp. 38, 39]

Il. 3. Wolf House, Gubin, 1925–1927: a) widok od strony rzeki, b) widok od strony tarasu [10, s. 38, 39]

walls – 65 cm in the basement and 50 cm the remaining floors – is not visible from the outside. Not only does the steel remain hidden in this house, but also the brick mass becomes apparently lighter, as if it were a continuous skin rather than a load-bearing wall. Somehow there is a concealment of the structure; a treatment of the brickwork more plastic than expressive [11, pp. 162–165].

One begins to gradually discern a different treatment of structure in the works built by Mies. In the Weissenhofseidlung apartment block in Stuttgart, also built between 1925 and 1927, the structure is partially seen on the facade, as brush-strokes of thin supports alternating between the large horizontal openings (Fig. 4). This is the first steel grid structure built by Mies, and on the facade the columns are absorbed into the brickwork and plaster of cement and white paint. But it was not until he built the houses in Krefeld, between 1927 and 1930, that Mies left a steel column on the facade completely visible for the first time. The quasi-twin Esters and Lange houses continue the compositional systems of the Wolf House: asymmetric floors, interconnection and continuity of space, large openings[4] and cantilevered elements. And the structural arrangement is also continued; a mixed system consisting of brick load-bearing walls and steel substructure. The treatment of the brick is similar to that of the Wolf house, as if it were a brick skin, rather than a massive load-bearing wall. Here, too, the windows are placed on the external side of the facade walls, concealing their enormous thickness. And the brick also passes almost imperceptibly over the hollows, without forming the lintel.

[4] In Esters House Mies would have preferred even larger openings. This is confirmed by a watercolour that is preserved today in the MoMA and in an interview he gave in 1966: *I wanted more glass in the house but the client didn't like the idea* [7, p. 98].

But, as we said, this is the first time that Mies has employed a free-standing steel pillar (Fig. 5). The large overhanging slabs of the porches, which in both houses serve as access to the garden, are supported by a square pillar, slightly recessed from the edge of the white roof deck and painted black, so that by contrast, the white deck seems to float. The steel profile tries to remain in the background, but there it is, for all to see. Surely for Mies, this column was unimportant. We note that he did not place it at the corner of the slab, but set back from it. And it has no base, no capital, no starting point, and no visible beam resting on it. And above all, we take note of its dark color. For Mies, the continuous white plane of the Weissenhofsiedlung housing block was very recent, with those portions of column vibrating on the facade in contrast to the shaded windows. In this case, the only white plane he wants to highlight is that of the porch roof, and nothing else. This free-standing column of the Krefeld houses is a necessary column, but is it a desired column?

There are more places in these Krefeld houses where steel is necessarily exposed. We find it in the mullions of the large openings, although these are also painted in a dark color and camouflaged within the carpentry of the windows. And it is partially visible where it forms the lintels of the windows. In these houses it would seem that the steel is expressing an urge to venture outside, to be present, and to tell us that the age of the brick is coming to an end. Slowly, Mies is assuming the language of modern structure.

The structural grid appears

Villa Tugendhat, built in Brno between 1928 and 1930, is the first single-family home in which Mies uses the steel grid structure. In just a few months, the German

Fig. 4. Facade of the Weissenhofsiedlung Apartment Block, Stuttgart, 1925–1927 (photo by A. Cervilla García, August 2011)

Il. 4. Fasada Weissenhofsiedlung Apartment Block, Stuttgart, 1925–1927 (fot. A. Cervilla García, sierpień 2011)

Fig. 5. Esters House, Krefeld, 1927–1930. View from the garden (photo by A. Cervilla García, August 2011)

Il. 5. Esters House, Krefeld, 1927–1930. Widok od strony ogrodu (fot. A. Cervilla García, sierpień 2011)

architect replaces his brick wall structure, in which the steel substructure is hidden for the most part, with a grid of exposed steel columns (Fig. 6). In September 1928 Mies travelled to Brno to inspect the site, a plot of about two thousand square meters situated on a hillside overlooking the city center. Between 1928 and early 1929 he designed the project, and between June 1929 and December 1930 he built it[5].

Villa Tugendhat has three floors. The first floor, with the main entrance, has three areas, one for the master bedroom, another for the children's bedrooms, and a third for staff accommodation and the garage. Between these three volumes there is a large terrace. And between the parents' area and the children's area is the entrance hall with a semi-cylindrical staircase that communicates with the ground floor. Descending the two flights of stairs we reach the large living area which, despite its open-plan layout has separate areas for the study, the library, the dining room and the piano. Carpets, curtains, an onyx wall and a semi-cylindrical ebony wood screen create these divisions. However, above all, the outstanding feature in this room is the large glazed facade on two sides, with the long 23-meter side facing southwest, and the short 15-meter side facing southeast, enclosing a greenhouse. The entire window is retractable, hidden underground on the lower floor, so that during the summer the living room becomes a large porch with exceptional views of the city of Brno. On the north side of the living room is a terrace leading to the garden, and to the east are the kitchen areas and service rooms. Finally, on the semi-basement floor, are the storerooms and the various facilities and service areas: air conditioning, heating, photo processing room, laundry, and the mechanism for lowering the living room window. In line with Mies's modern compositions, the floor plan of Villa Tugendhat is asymmetrical, dynamic and continuous, despite being a grid structure of rectangular columns[6].

In an interview Greta Tugendhat recalls her impressions on viewing the house for the first time: *At first we saw the floors of a large room in which there were two free-standing walls, one semi-circular and the other straight. We noticed that there were small crosses about five meters apart and asked, What is this? Mies answered calmly. They are the steel supports that are holding up the structure. At that time there was no house with that type of structure, so you can imagine our initial surprise* [15, p. 15].

This structure, which Mies tried out both in Villa Tugendhat and in the Barcelona Pavilion, became a basic tool for his homes in the 1930s. It is a table-type structure[7]. On the one hand, the ceiling, the horizontal slab, and on the other hand the columns serving as support. A table with recessed columns. The structure is formed by steel porticos on cruciform columns[8]. It is a laminated steel unidirectional structure, made up of seven modules in an east-west direction and three modules in a north-south direction. The gallery is rectangular, 4.90 × 5.50 m,

[5] The Villa Tugendhat project was developed almost in parallel with that of the Barcelona Pavilion. Hence the similarities between the two works. At the beginning of July 1928, the German government commissioned Mies to design the Barcelona Pavilion. In October of the same year the design was defined, and between October and February the plans were drawn up. Work began in February and the pavilion was inaugurated on 26 May 1929 [12, pp. 7, 8], [13].

[6] As Christian Norberg Schulz explains, one of the consequences of this open plan is that the load-bearing function becomes independent from the function of compartmentalizing spaces. The columns punctuate the space and the walls of stone, wood, or curtains delineate the spaces [14, pp. 45–70].

[7] The term is from Alberto Campo Baeza [16].

[8] Although today we associate the cruciform steel column with Mies van der Rohe, and especially with his projects for Villa Tugendhat and the Barcelona Pavilion, the fact is that Bruno Taut had already used this type of column in the Versuchspavilion in Berlin in 1928. *Exposición Bruno Taut, Maestro de la Construcción cromática* (Madrid: Fundación COAM, 2011).

and not a perfect square, as one might think, given the cruciform geometry of the pillar. The 5.50 m beams are arranged perpendicular to the large glazed front of the living room and the slabs are parallel.

Probably, if Mies had wished to reflect the arrangement of the ceiling beams on the shape of the column, then he would not have made a cruciform column. This column, with its arms of equal dimensions, also has the same inertia in both directions, that of the beams and that of the slabs. And yet it is the beams that transmit the greatest loads and moments to them. A more rigorous option would have been a column with greater inertia in the direction of the beams. In fact, if we analyze the inertia of the cruciform column, we can confirm that the design criteria of this column go beyond the strictly mechanical (Fig. 6). The column is made up of four L-profiles of 90 mm side and 10 mm thickness, with an inertia of 1,266.48 cm^4. But if Mies had arranged a square group instead of the cruciform arrangement, he would have obtained a column with an inertia of 4,024.36 cm^4. That is to say, with the same elements, he could have obtained a column with four times greater inertia. A much stronger column, simply

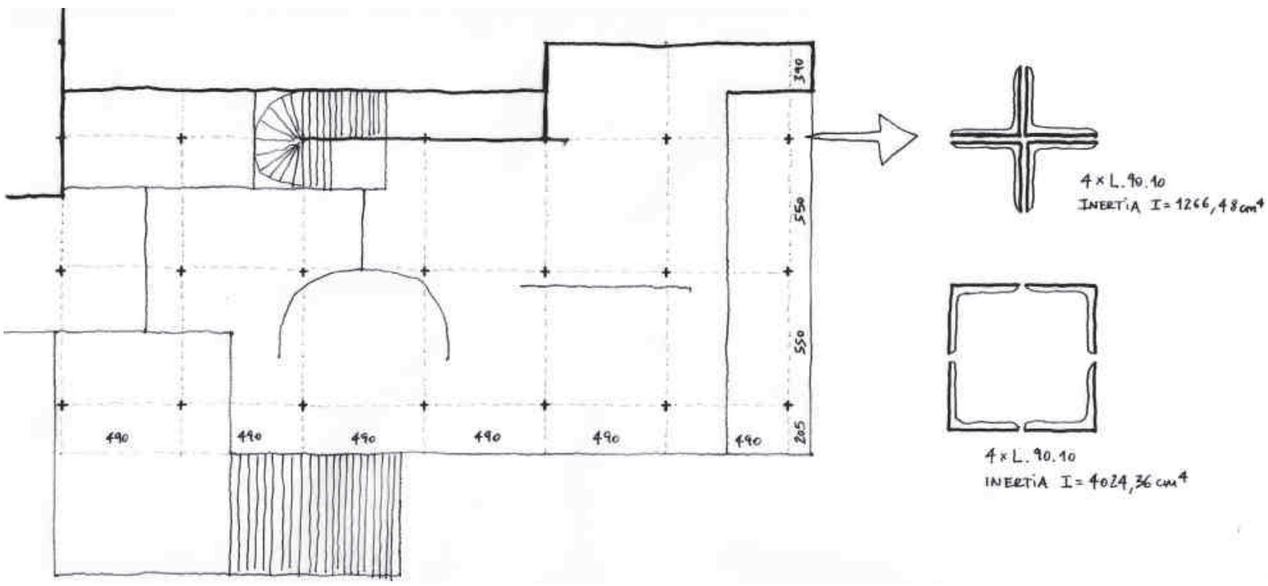

Fig. 6. Structure of Villa Tugendhat, Brno, 1928–1930 (drawing by A. Cervilla García)

Il. 6. Konstrukcja Villi Tugendhat, Brno, 1928–1930 (rys. A. Cervilla García)

Fig. 7. The three types of columns in Villa Tugendhat (photo by A. Cervilla García, December 2009)

Il. 7. Trzy rodzaje słupów w Villi Tugendhat (fot. A. Cervilla García, grudzień 2009)

Fig. 8. View of Villa Tugendhat from the garden
(photo by A. Cervilla García, December 2009)

Il. 8. Widok na Villę Tugendhat od strony ogrodu
(fot. A. Cervilla García, grudzień 2009)

with a change of shape. But it seems that Mies is not looking for strict compliance with structural logic in these columns. He is not looking for an efficient column. There is something else, which we discovered with our analysis of the three types of columns in Villa Tugendhat.

Mies treats each column differently depending on its location. On the outside terraces, the columns are clad in a black galvanized steel jacket. In the kitchen and service area they are uncoated, and the steel is painted white. In the large living area, the columns are covered with a chrome-plated, shiny, reflective steel casing (Fig. 7).

The black columns wish to disappear, to remain in the background in shadow. They are holding up a white ceiling and rise up from a white floor, in other words, they are columns in discontinuity with ceiling and floor. And they are inflated columns. The sleeve that covers them hides the authentic supporting elements. The white columns are used in the service spaces, the areas of least interest in the house. These columns do not have a rounded sleeve; their edges are sharper. They are tenser, more expressive of their function and their materiality. As the ceiling they support is white and the floor is also white, there is continuity here, at least in color, between ceiling, support and floor. These columns do not want to disappear. They do not hide the frame that shapes them. Finally, the columns with a chrome-plated steel casing are the most important. The cruciform section has a function similar to that of the grooves of the columns of classical Greece[9]. This inward and outward interplay brings about a certain dematerialization of the column. In addition, the fact that the edges of the cross are rounded, and that the casing material shines and reflects – not a perfect reflection like that of a burnished mirror, but a deformed reflection – further intensifies the dematerializing effect of the shape. Mies wants these columns to be tangible elements that participate in the play of reflections of the house, together with the steel tubes of the armchairs and chairs, the glass panes or the golden onyx. He wants to treat them with ostentation. In fact, the dematerializing effect used by the maestro does not lead to the concealment of the columns. When we are inside this room, we cannot ignore the magical presence of these shining columns. It is true that their formal appearance is confusing, but there they are, magnetic, unreal and luminous. They are part of the game of space. Only the intersection with the ceiling and the floor tells of their true cross-section. The same words used by Fritz Neumeyer when referring to the Barcelona Pavilion could be used here: *The (Villa Tugendhat) was a display structure that pointed to architecture itself as an artwork of space. Approaching and entering the (Villa Tugendhat) encourages spectator participation, physically, psychologically, and cognitively* [18, p. 105].

In the symmetrical dialogue between the white plaster ceiling and the white linoleum floor, the chromed steel pillars are a break in continuity. It seems that the slab does not rest on the cruciform pillars, but is suspended above them. White pillars would have emphasized the idea of supporting a slab that is also white, and its transition to the white floor. And in fact, when we look at the house from the outside, this is when we can best appreciate the effect of the roof floating on the columns (Fig. 8). The roof of the living room merges with the terrace and forms a powerful white lintel that flies 2.05 m upwards from the columns. Although from the outside we can see the brightness of these columns, their contact with the ceiling remains in shadow, it disappears. There is an intentional omission of the load transmission. On the one hand, Mies proposes his first visible grid structure, and uses it both to define space and as a decorative element. On the other hand, he tries to hide the tectonics of the structure and its load-bearing function. And he wants us to believe that the white roof plate of the living room is suspended in the air, like the slabs over the porches of the houses in Krefeld.

Here we have a clear case of structural poetics. Present and at the same time absent structure. A real, but illusory structure. And Mies wants so much to omit the idea of support and structure that he even denies the perception of the structural grid (Fig. 6). The history of Architecture provides us with examples of hypostyle rooms in which the perception of a gallery is very clear, such as the hypostyle room of the temple of Amun in Karnak or the mosque of Cordoba. In both cases the columns are visible, as are the beams and slabs. The basic cell of the structural grid, made up of four facing columns, two porticoes or beams, and the slab between the two beams is visible in these cases. In Villa Tugendhat, however, the beams are hidden by the false plaster ceiling, and obviously also by the slabs. Moreover, the partitions are arranged in such

[9] Viollet le Duc associates the origin of the grooves of the Greek column with a lighting effect: *To the Greek architect, the columns seem too flat when exposed to light, and too bland and indecisive in the shade. He cuts out straight grooves along the entire height of the shaft, and then hollows out these grooves and thus forms grooves deep enough to concentrate the oblique light on the edges, but not enough for these edges to become an obstacle and injure the people passing between the columns. The light of the sun, when it repeats a sequence of longitudinal lights and shadows on each shaft, gives them back the importance that they had lost when they were only conical* [17, pp. 47, 48].

a way that no four columns of the same gallery are freestanding. Here we do not have the sensation of a hypostyle room. The onyx screen and the wooden cylindrical screen prevent this from happening.

The column steps forward

In 1938, impelled by the political situation in Germany, Mies moves to Chicago to head up the School of Architecture at the Illinois Institute of Technology, IIT. And coinciding with his arrival in America, the column takes a step forward. In the IIT Minerals and Metals Research Building, his first construction in America, built between 1942 and 1943, the steel columns and beams that make up the structural porticoes are visible, complemented by a brick enclosure. And just three years later, Mies designs several buildings in which the columns are placed to the front of the facade enclosure and the slabs. This will be the case, for example, in the design of the Cantor Drive-in Restaurant, 1945–1946, the Cantor House, 1946–1947, and in the Promontory Apartments, built between 1946 and 1949 in Chicago, on the edge of Lake Michigan (Fig. 9). Here we again see a feature of structural rationalism in Mies, which we had not seen in either the Krefeld houses or in Villa Tugendhat. The columns are visible along the entire facade, like the edges of the floor slabs, and their section is staggered, becoming lighter as they ascend upwards, and more robust as they reach the earth. The shape of these columns does respond to the logic of Gravity. They are nothing more than the corollary of the increase in loads that the columns bear as they approach the base of the tower.

In the Caine house, designed in 1950, Mies again places the columns to the front of the slab. But it was in the Farnsworth house, designed and built between 1946 and 1951, that this solution attained its maximum expression. The Farnsworth house is conceived as a single, diaphanous space, without columns, between two horizontal planes. After many years of designing dwellings with free and asymmetrical compositions, Mies returns to the box; it is, however, no longer a classic box, but a modern box of steel and glass, visually in continuity with the landscape. A diaphanous space and an emphatic volume with the columns on the outside and clearly defined by the glass. A house supported by eight columns situated to the front of the slabs[10].

The interior of the house is organized around a nucleus of kitchen, bathroom and slightly off-center facilities, leaving the kitchen area narrower and the living area wider. Farnsworth is the house with floor-to-ceiling glass that Mies had been pursuing for so long, and this time the surroundings and the client allow him to radically implement his idea. The feeling of transparency in the house is almost total. The relationship with the landscape is absolute.

Fig. 9. Promontory Apartments
(photo by A. Cervilla García, September 2012)

Il. 9. Promontory Apartments
(fot. A. Cervilla García, wrzesień 2012)

Basically, the Farnsworth House structure consists of eight columns with an H-section[11], which support two horizontal slabs: the floor slab, located 1.6 m above ground level[12] and the roof plate, at 2.9 m above the floor (Fig. 10). The columns are arranged in two parallel gantries 8.8 m apart. And each portico is made up of four columns, separated by 6.7 m, and two overhangs of 1.7 m at the ends. The main beams are arranged in the longitudinal direction of the house, with a maximum span of

[10] Tegethoff links these external columns to the wooden supports of the porch of the Chamberlain Cottage, 1939, designed by Walter Gropius and Marcel Breuer, which are also placed to the front of the floor slab [19, p. 131]. Returning to Farnsworth, there are previous drawings by Mies in which the columns are recessed, although in the final version the columns step forward and are placed to the front of the slab.

[11] 8WF35 columns as per American classifications. 8.12-inch web, 8.027-inch flanges, weighing 35-pound/foot. Ground floor joists are 12WF58 profiles. 12.19-inch web, 10.014-inch flanges, weighing 58 pounds/ft. Roof deck joists are 12WF27 profiles. 11.96 inch web, 6.5 inch flanges, weighing 27 lbs/ft. Finally, the main joists, which are visible on the facades, are 15C50 profiles. 15-inch web, 3.716-inch flanges and 50 lb/ft [20, p. 44]. The mechanical and dimensional features of the profiles have been obtained from [21, pp. 10–21].

[12] According to Jean Louis Cohen, there were two versions, a house resting on the ground and the one finally chosen, which was elevated, not only to have better views, but also to avoid flooding from the river [22, p. 99].

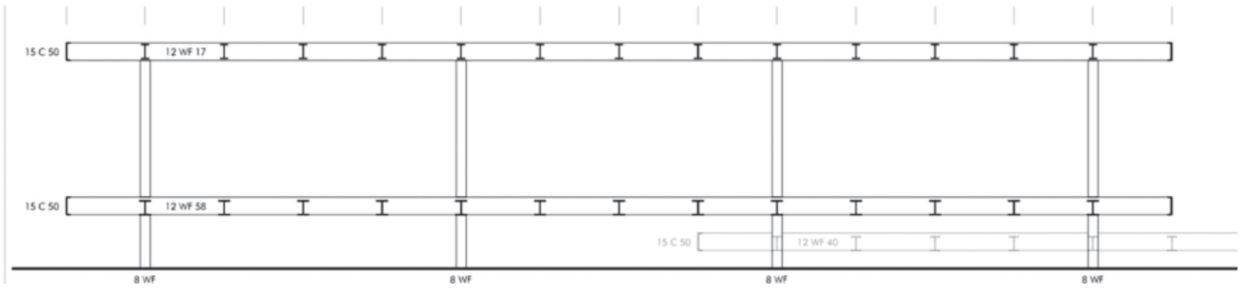

Fig. 10. Structure of Farnsworth House (drawing by Eduardo Mantovani [20, p. 44])

Il. 10. Konstrukcja Farnsworth House (rys. Eduardo Mantovani [20, s. 44])

6.7 m, and the slab in the transverse direction, with a span of 8.8 m[13]. It is strange that the span of the slab is greater than that of the portico but, as we shall see, it is not the only singularity of this structure. The main beams have a C-shaped section, with a depth of 15 in., and are welded tangentially to the interior flange of the columns, and the beams of the slab are H-shaped profiles with a depth of 12 in., arranged every 1.675 m.

One conclusion we can draw from analyzing the structure of the house is that the roof plate has a far lesser load than the ground floor slab. The roof joists are supporting the slab's own weight and snow overload. Ground floor joists are supporting the weight of the floor slab, flooring, partition walls, glass enclosure and service overload. That's why the 12WF58 ground floor joists have a stronger capacity than the 12WF27 roof joists. However, in both cases their web is very similar, approximately 12 inches. And this decision is crucial, because it allows Mies to visually match the two slabs.

In the Farnsworth House, abstraction rules over structural expression. The structural reality tells us that the roof slab bears less stress than the ground floor slab and, therefore, its thickness could be less than that of the ground floor slab. The structural reality requires two floors with unequal edges. And yet Mies has chosen the same thickness for his two slabs. The same visual weight. Two abstract planes independent of their different gravitational situation. Two visually interchangeable, and therefore universal, planes[14].

An analysis of the structure with Finite Element programming informs us that the position of the columns and beams is correct (Fig. 11). However, their resilient capacity is not pushed to the limit under any circumstances. And their deformations are well within what is admissible. Only the joists of the roof slab are well utilized, reaching 80% of their resistance capacity, and with deformations within the limit of what is acceptable[15]. We may well think that it is precisely these roof beams that determine the dimensions of the structure of the house. Their 12-inch web demands a 15-inch edge beam for concealment purposes, including the different layers that make up the slab and roof. And curiously, the columns that support these beams measure 8 inches, practically half the edge of the beams. Perhaps Mies was looking for a 1/2 relationship between the edge of the beams and the width of the pillars? Very probably, but we consider that this idea should be the subject of a more detailed study.

What we would like to focus on here is how the forward position of the pillars with respect to the beams affects the structure. And it is this structural detail that makes the transmission of the load between beams and columns eccentric. It introduces an additional effort onto the columns, a moment (Fig. 12). This is something that does not happen, for example, when the Gothic architect decides to move the buttresses of his cathedral forward. In that case, the forward buttress is in favor of the structure. It is brought forward precisely to favor its function as a support, next to the buttress, which sustains the horizontal thrust of the vaults. But Mies, with his forward column, disrupts the behavior of the structure. And he does it in favor of an idea. However small that eccentric moment may be, it is there.

The tangential intersection between the column and the beam (Fig. 13) is central to this house. Tangential welding. When Mies brings the columns forward, when he places them in front of the slabs, he is avoiding the idea of *sustaining*, whose Latin origin comes from *sustinere*, *"to have something above oneself"* [24, p. 534]. The column does not have the beam over it. It does not *sustain*

[13] The dimensions in inches are as follows: Ground floor level + 5 feet. Distance between columns 22 feet. Overhangs 5 ft 7 in. Roof deck width 28 ft 8 in. Distance between joists 5 ft 6 in.

[14] The gravitational loads of the roof slab include the actual weight of the beams, 0.4 kN/m; the actual weight of the beams, 0.73 kN/m; the beam filling; a compression layer of 5 cm of cement mortar; and the snow overload, which can be estimated at 1 kN/m^2. The gravitational loads of the ground floor slab include the actual weight of the beams, 0.85 kN/m; the actual weight of the beams, 0.73 kN/m; the beam filling; a 25 cm thick layer of light concrete; a 5 cm layer of cement mortar; the travertine marble pavement, 1 kN/m^2; and a service overload of 2 kN/m^2 in which the weight of the partition walls, furniture and enclosure could be included. The corresponding construction details on the composition of these elements can be consulted in [23]. Clearly, the gravitational loads of the ground floor slab are greater than those of the roof slab, hence the difference in inertia between the roof joists and the ground floor joists. The 12WF27 roof joists have an inertia of 8490.56 cm^4. Ground floor joists 12WF58 have an inertia of 19805.76 cm^4. In both cases, the web size is virtually the same, to constructively accommodate the 15-inch web of the edge beam.

[15] According to the structural calculation carried out by Pilar Sañudo Tinoco. The columns are operating at 43% of their capacity. The main girders at 43%. And the ground floor joists at 33%.

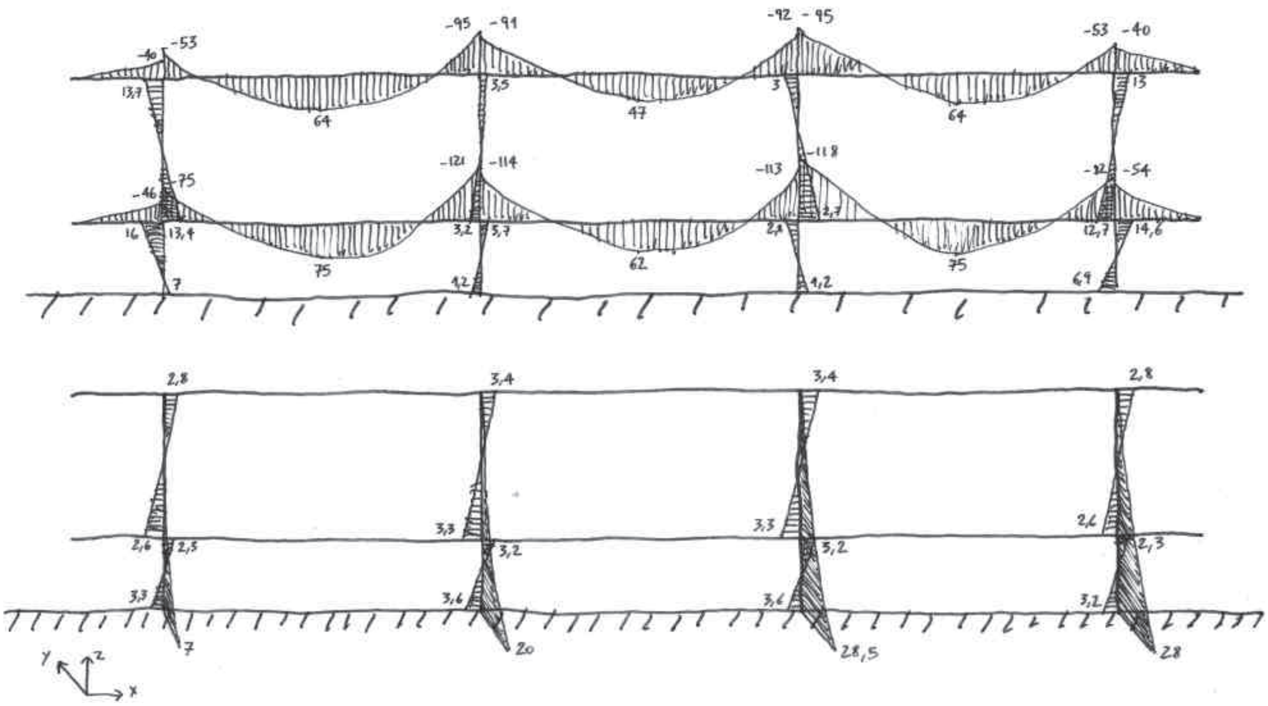

Fig. 11. Above: diagram of moments produced by the combination of gravitational loads in kN/m.
Below: diagram of moments produced by the wind load in both directions.
It can be seen how the most unfavorable moment for the columns is caused by the wind force in the Y direction
(drawing by Pilar Sañudo Tinoco)

Il. 11. Powyżej: wykres momentów zginających pochodzących od kombinacji obciążeń grawitacyjnych [w kN/m].
Poniżej: wykres momentów zginających pochodzących od obciążenia wiatrem w obu kierunkach.
Widoczne jest, że najniekorzystniejszy moment zginający w słupach wynika z działania wiatru w kierunku Y
(rys. Pilar Sañudo Tinoco)

it, at least not visually. Apparently the column only touches the beam. The flange of the H-profile is tangential to the web of the C-profile. The two faces are touching without intersecting. This is a subtle but very intense gesture of structural poetics.

This contact between column and steel beam is contrary to the contact between architrave and column in the Parthenon, which accounts for the transition of the load. The stone beam of the Parthenon rests on the column apparently without further ado[16]. The clarity with which the elements of this classical structure relate to each other vanishes in the Farnsworth, in the equivocal and tangential encounter between the column and the beam. We do not even see the C-shaped beam. The abstraction of this junction is total. There is neither support nor intersection: just tangency. An almost immaterial union. The result is that the column does not lose its integrity, but rises upwards in all its height. Without unions or intersections altering it, the column remains independent in its form. And behind the column the roof plate seems to float. This solution achieves its greatest effect when we are in the house, under the roof deck. It is from the inside, and not from the outside, that the plate seems to float the most: where the welding is not visible. Where we see the column on which the plate does not rest. Where the edges of the plate are cut away against the sky and against the forest. Although the situation of the columns is the opposite to that of the columns of Villa Tugendhat, the desired effect is the same: the suspension of the roof deck in the air. But if in Tugendhat the weightlessness effect was greater when we looked at the house from the outside, here the weightlessness effect is greater when we are inside the house.

What we see is Mies's acceptance that structural elements are more than just structure. They are beautiful in themselves, and so are their unions. And the criteria the German architect uses to define them go beyond strict structural mechanics. Unlike Villa Tugendhat, Mies no longer needs to case the structure in chrome-plated sheet steel. He no longer sees the need to clad his cruciform columns. That uncoated column that Mies used in the kitchen of Villa Tugendhat, that column that remained in the background in the service area, is now a cornerstone.

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16 As Viollet le Duc says: *The Greek architect wants to reveal to the whole world that the different parts of his monument fulfil a useful and necessary function. It is not enough for his monument to be solid; he wants it also to appear so* [17, p. 48]. Hegel endorses this idea when he tells us that what is peculiar to Greek architecture is that it emphasizes the act of *sustaining,* as such: *In Greek architecture what is characteristic and developed is the column and the architrave that horizontally rests on it. Here one has to speak in terms of rest and support* [25, p. 499]. In Farnsworth House, Mies ignores the narrative of the transition between beam and column. Not only is there no intermediary capital, but both beam and column appear independent, without any direct support of the beam on the column.

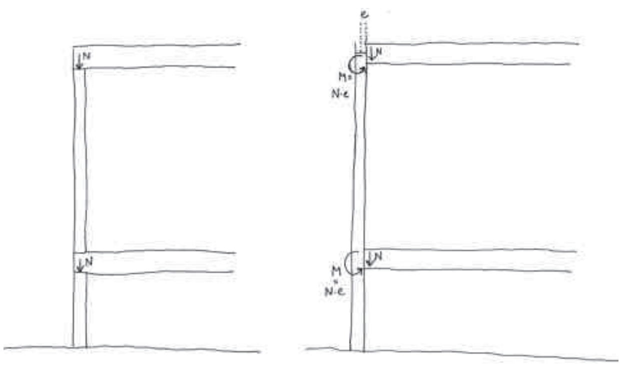

Fig. 12. Stress difference with centered load and with eccentric load (drawing by A. Cervilla García)

Il. 12. Różnica wartości naprężeń pochodzących od obciążenia osiowego i mimośrodowego (rys. A. Cervilla García)

The steel cage

From Farnsworth House onwards, Mies always places columns on the outside of his houses. He does this, for example, with his 50 × 50 feet house, which unfortunately he did not manage to build. And not content with the column, he decided to multiply it, and turn the structure of his houses into a real steel cage (Fig. 14). This was the last housing model Mies tried. From the prototype of steel prefabricated homes in a row, to the Lafayette Park homes in Detroit, through McCormick House, Morris Greenwald House and Herbert Greenwald House. A transportable steel cage manufactured in the workshop, derived from the enclosure system that Mies used in the Lake Shore Drive Apartments. H-section columns are welded to the flat roof and the floor slab without touching the ground. Can there be a better example of gravitational illusion than a column that appears not to reach its foundation? And as in Farnsworth, these columns do not take full advantage of their load-bearing capacity. Here the steel columns are arranged every 1.7 m, supporting a beam of with a span of 8.4 m. For every two columns, one beam.

Mies designed his last home in the late 1950s. More than fifty years had passed from the hidden structure of the Riehl House to the visible structural cage of the Lafayette Park townhouses.

Conclusion

Detlef Mertins acknowledges that Mies has become more complex and contradictory for us than he was for his early critics: *In retrospect, his trajectory was less inexorable and more contingent upon changing contexts, challenges, clients and collaborators* [26, prologue].

And I can only agree with that appraisal. Let's go back for a moment to Mies's first house, the Riehl house, with its embossed pilasters. The columns were already on the facade, but as a decoration. They were false columns. False brick embossed pilasters. And in the Farnsworth, the column returns to the facade, as in the Riehl, but in

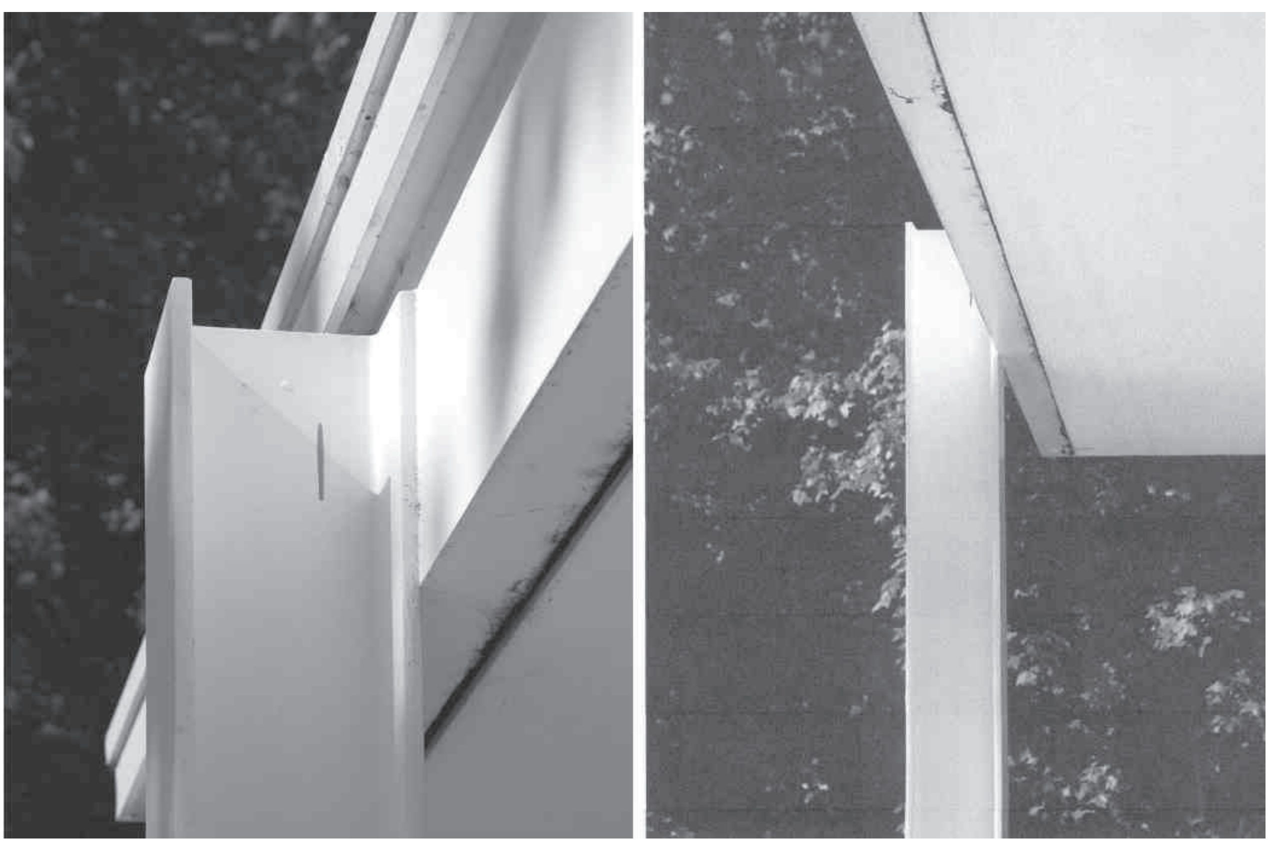

Fig. 13. The tangent union between column and beam in Farnsworth House (photo by A. Cervilla García, September 2012)

Il. 13. Styczne połączenie belki ze słupem w Farnsworth House (fot. A. Cervilla García, wrzesień 2012) a very different way. It is still a decorative element, but no longer in the classical or neoclassical style of the Riehl. It is a modern decorative element. Slightly shifted from its place, as we have already explained, the Farnsworth column becomes a sustaining element capable of producing an undeniable gravitational illusion. Mies no longer needs to paint or coat the column, as he did in Krefeld and Brno. A simple displacement turns the standard steel H-profile into an artistic element.

The mechanical capacity of the structure is not what most interests Mies. Mies is not a structural rationalist. Although he admired Berlage for the honesty of his construction, the truth is that he did not apply the same principles of constructive honesty to his houses. Although he worked for much of his career with structure as a guiding rule, the search for greater mechanical efficiency never figured among his ideals. This does not mean that Mies disdains the mechanical function of structure, but rather that he is interested above all in its illusory function. And if in Tugendhat he has to resort to cladding the column, or its inefficient cross-shape, in Farnsworth he presents us with a pure and hard column, mechanically efficient and without cladding of any kind. It is the most difficult yet. There are only two master tricks: its forward position in relation to the girder and its tangential connection to the beam. And in the McCormick house there is one more step. Here the column does not reach the ground. It is tangential not only to the beams and slabs, but also to the foundation, which it does not actually touch, only indirectly.

Only a master would dare to construct a gravitational illusion for all to see. And the journey that the structure underwent in Mies's houses, from its hidden to its forward position, lasted the necessary length of time for our German master to allow that idea to mature. The master of structures, according to Blake, uses structures as a decorative artifice, without losing their necessary supporting capacity. Mies shows us that one can be both rational and an artist. One can seek coherence and poetry at the same time. One can be contradictory (that is, human), and masterful[17].

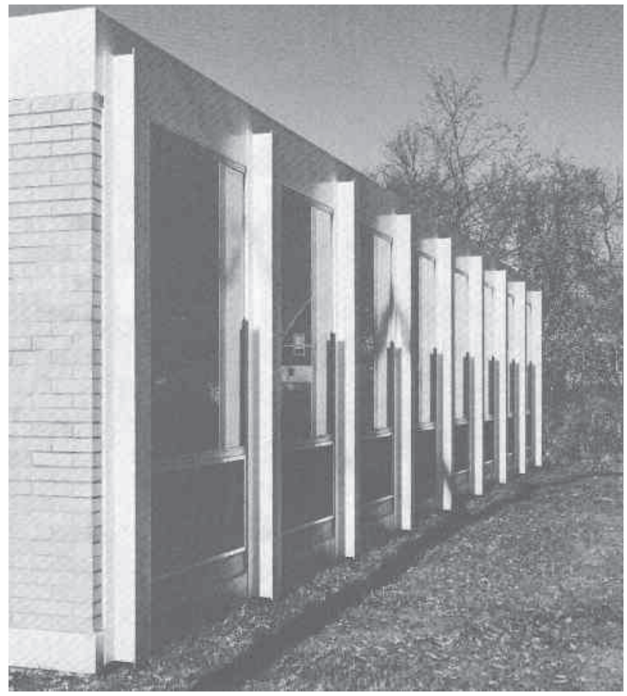

Fig. 14. Steel cage-type facade, in which Mies multiplies the number of columns (Hedrich-Blessing [10, p. 178])

Il. 14. Stalowa fasada typu klatkowego, w której Mies zwielokrotnia liczbę kolumn (Hedrich-Blessingg [10, s. 178])

[17] Translated from Spanish by Penelope Eades. Structure consultant: Pilar Sañudo Tinoco, architect.

References/Bibliografia

[1] Spaeth D., *Mies van der Rohe*, Rizzoli International Publications, New York 1985.
[2] Blake P., *The master builders*, W.W. Norton, New York 1976.
[3] Simonnet C., *Hormigón; Historia de un material*, Editorial Nerea, San Sebastian 2009, 54–62.
[4] Addis B., *3000 years of design engineering and construction*, Phaidon Press, London 2009.
[5] Summerson J., *El lenguaje clásico de la arquitectura*, Gustavo Gili, Barcelona, 1963, 25–49.
[6] Kostof S., *Historia de la Arquitectura*, Alianza, Madrid, 2007, 224.
[7] *Mies van der Rohe. Casas. 2G Revista internacional de arquitectura*, nº 48–49, Barcelona, August 2009.
[8] Schulze F., *Mies van der Rohe. A critical biography*, University of Chicago Press, Chicago 1985.
[9] Frampton K., *Historia crítica de la Arquitectura Moderna*, Editorial Gustavo Gili, Barcelona 1980.
[10] Johnson Ph., *Mies van der Rohe*, MoMA, New York 1947.
[11] Frampton K., *Estudios sobre cultura tectónica*, Ediciones Akal, Madrid 1995.
[12] Solá Morales I., Cirici C., Ramos C., *Mies van der Rohe. Barcelona Pavilion*, Gustavo Gili, Barcelona 2002.
[13] VVAA, *Mies van der Rohe-Barcelona 1929*, TENOV, Barcelona 2018.
[14] Norberg-Schulz Ch., *Los principios de la Arquitectura Moderna*, Editorial Reverté, Barcelona 2005.
[15] Vitaskova J., *Tugendhat Villa*, Tugendhat Villa Foundation, Brno 2009, 15.
[16] Campo Baeza A., *The Built Idea*, Fundación COAM, Madrid 1996.
[17] Viollet le Duc E.-E., *Conversaciones sobre la Arquitectura*, CGATE, Madrid 2007.
[18] Neumeyer F., *The secret life of columns*, [w:] *Mies van der Rohe Barcelona 1929*, TENOV, Barcelona 2018, 105.
[19] Tegethoff W., *Mies van der Rohe. The Villas and Country Houses*, MIT Press, Cambridge 1985.
[20] Mantovani E., *Mies' two-way span*. Ph.D. Thesis, Director: Cristina Gastón Guirao, UPC, Barcelona 2015.
[21] VVAA, *Hot rolled carbón steel structural shapes*, United States Steel, Chicago 1948.
[22] Cohen J.L., *Mies van der Rohe*, Akal Arquitectura, Madrid 1998.
[23] Vandenberg M., *Farnsworth house. Architecture in Detail*, Phaidon, New York 2003.
[24] Coromines J., *Diccionario Etimológico de la Lengua Castellana*, Editorial Gredos, Madrid 2012.
[25] Hegel G.W.F., *Lecciones sobre la Estética*, Ediciones Akal, Madrid 2007.
[26] Mertins D., *Mies*, Phaidon Press, London 2014.

Abstract

Mies van der Rohe is considered one of the great masters of the 20th century, both for the coherence of his work and for his ability to make modern architecture based on the importance of structure. This is recognized by the architect and architectural critic, Peter Blake, in the chapter he devoted to Mies van der Rohe, entitled *The Mastery of Structure*, in his "Masters of Architecture" series. In the present article we would like to analyze the evolution of the image of structure in the houses of Mies van der Rohe, from his very first dwelling, Riehl House, built in Berlin in 1907, to his last house, Morris Greenwald, built in Weston in 1953. We will see how structure underwent a radical transformation over this period progressing from the innermost hidden realm of Architecture outwards to its exterior, and how in this process, the German maestro managed to transcend the idea of structure and its load-bearing capability to convert it into the main artistic element of his architecture.

Key words: Mies van der Rohe, Riehl House, Mosler House, Esters House, Lange House, Weissenhofsiedlung, Wolf House, Tugendhat House, Farnsworth House, structure

Streszczenie

Mies van der Rohe uważany jest za jednego z wielkich mistrzów XX w., zarówno z powodu spójności jego pracy, jak i jego zdolności do tworzenia nowoczesnej architektury opartej na znaczeniu konstrukcji. Zostało to docenione w serii „Mistrzowie architektury" przez architekta i krytyka Petera Blake'a w rozdziale poświęconym Miesowi van der Rohe, zatytułowanym *Mistrzostwo konstrukcji*. W niniejszym artykule chcielibyśmy przeanalizować ewolucję wizerunku konstrukcji w domach Miesa van der Rohe od jego pierwszego miejsca zamieszkania, Domu Riehla, zbudowanego w Berlinie w 1907 r., aż do ostatniego domu, Morrisa Greenwalda, zbudowanego w Weston w 1953 r. Zobaczymy, w jaki sposób konstrukcja uległa radykalnej transformacji w tym okresie, przechodząc od najgłębszej ukrytej sfery architektury do sfery zewnętrznej, i jak w tym procesie udało się niemieckiemu mistrzowi przekroczyć ideę konstrukcji i jej nośności w celu przekształcenia w główny element artystyczny jego architektury.

Słowa kluczowe: Mies van der Rohe, Riehl House, Mosler House, Esters House, Lange House, Weissenhofsiedlung, Wolf House, Tugendhat House, Farnsworth House, konstrukcja