The Palau Güell

Eusebi Güell i Bacigalupi commissioned Antoni Gaudí to build the Palau Güell in 1885 when the Catalan architect was only 34 years of age [1]. It was his first major work, since the buildings that he had already built, several of them also for the Güell family, certainly reflected his strong personality but they had neither the volume nor the social importance of the projected Palau Güell residence.

Eusebi Güell formed part of the powerful, cultivated and enterprising bourgeoisie of the industrial Catalonia of the second half of the 19th century. Through the Güell Palace he sought to reaffirm his personality and position within the Barcelona bourgeoisie. Gaudí was six years younger. He hailed from a family of rural craftsmen and was at the outset of his career. According to Ràfols[2], Gaudí presented 25 different proposals for the Palau Güell façade and it was Eusebi Güell himself who, in his eagerness to achieve notoriety, chose the one most likely to cause the maximum visual impact at that time, which was, with certain minor variations, the one that was finally built.

The building permit was granted by the Barcelona City Council in November 1886 and the building was completed towards the end of 1890.

Regarding the Palace's value in the architectural context of the time, "it is important to point out the pioneering role played by that early renovative Catalan architecture, not only in relation to the earlier local Art Nouveau but in the context of European architecture in general. Let it suffice to mention the dates of some of the key works of European Art Nouveau: 1893, the building of the house of Paul Hankar in Brussels; 1894, the construction of the Vienna Metro by Otto Wagner; 1896, the Elvira House in Munich by August Endell; 1898, the Glasgow School of Art, by Mackintosh, and the Sezession Palace of Vienna, by Olbrich; 1900, the Paris Metro designed by Guimard. As can be seen, all these were built after the early work of Gaudí. [...] at that time, Gaudí was, without any doubt, a pioneer within European architecture."[3]

The building was to be the Güell residence until the 1940s, when it became the...
The Relationship between the Building's Function, Space and Load-Bearing Structure

As can be seen in the diagrams 1 to 10, the building consists of a total of seven floors from the basement up to the loft. The title assigned to each floor indicates the original uses for which it was destined. "The rooms of this peculiar urban palace – built in an area which was already beginning to be socially run down – are organised around a central space, almost turning its back, as it were, on the streets outside (the large bay window or tribune, more than a viewing point, is a continuation of the interior space). And in the block's inner courtyard, which was more run-down looking than the streets outside, the lattices of the back façade seem to be there to protect the occupants from undesirable views more than from the hostile sun. The large central space, markedly vertical in nature (its total surface space is 80 m² as opposed to a height of almost 20 m), takes on a singularly important role in the composition, assuming the functions of the traditional Mediterranean central patio. In addition, the spatial sequences and impressions it creates seem to multiply the relatively small-scale dimensions of the building, which occupies a site of scarcely 500 square metres" [6].

In its essential elements, the load-bearing structure consists of the perimeter walls and a complex interior combination of pillars, arches, vaults, beams and walls. The three exterior façades are of natural stone, whereas the party wall is made of brick. The interior is more complex: the three lower floors, (the basement, the ground floor and the mezzanine) are supported mainly by means of brick or stone pillars, and arches and vaults made of bricks or metal beams and girders. The upper floors are supported by load-bearing walls running parallel to the line of the street but in combination with the structure which supports the central space and originates from the piano nobile and closes with the elliptical parabolic dome on which the spire is supported.

The structure of the building is directly linked to the uses to which the different floors were intended to be put: the ground floor provided access to the building for carriages in the form of two spaces which are perpendicular to the façade and which are structured around
Fig. 1. General rear view of the Palau Güell

Fig. 2. Main façade
Fig. 3. The basement: the stables

Fig. 4. The ground floor: entrance for carriages, and offices

Fig. 5. The mezzanine: Güell’s library and offices.

Fig. 6. Piano noble: on the street side salons for social life, in the interior the grand salon and private rooms. Location for the load plans in figures 14-17.

Fig. 7. Interfloor area: extension of the grand salon, service quarters.

Fig. 8. Main bedrooms.
Fig. 9. Transversal section.

Fig. 10. Longitudinal section.
pillars, and walled off at the level of the mezzanine. The other uses reserved for these two floors (the ground floor and mezzanine), coach house and offices, respectively, also fit in with a structure built around pillars, as the pillars ensure flexibility as regards use of space. The brick pillars and arches and vaults employed in the basement are therefore a direct consequence of the conception of the other two floors, that is, the ground floor and the mezzanine, and their uses, and, of course, they did not clash with the use of the basement as a stable.

In contrast, the three upper floors, destined for domestic uses, have the more usual load-supporting mechanism of load-bearing walls, which also have to support the powerful central space. The entire system which provides structural support for the dome, the difficulty of which is heightened by the fact that its dimensions are smaller than those of the grand salon, is based on the walls parallel to the main façade (a standard solution for supporting the façade bay in Barcelona) and the shear walls, by means of large-scale metal beams. This arrangement also allows for the inclusion of a corridor around the central space providing access to the rooms, which was one of Gaudi’s preferred solutions, and it can also be seen in his La Casa de los Botines in León and in La Pedrera.

In its general conception, we can clearly see the building’s structure as the positive outcome of a dialogue between all three of these different spatial compositions, which are in turn the result of the different uses planned for the various floors and Gaudi’s precise architectural intentions.

Nevertheless, there is a general opinion, based on the analysis of both general and specific issues, which holds that the structure of this building is somewhat “confused”.

**Enigmatic and Puzzling Elements**

All the studies carried out on the Palau Güell, both structural and more general in nature, have coincided in pointing out the complexity of the building’s structure and the existence of a number of elements which are rather enigmatic viewed from the perspective of standard construction practice.

Thus for example, Bassegoda claims that one of the most outstanding features of the Palau Güell is its structural originality: “what were thought to be simply decorative or crafted ceilings turn out to be supporting structures” [7]. While this area is not the concern of the present paper, it is nevertheless an opportunity to point out that the ceiling panels of the piano nobile are a masterpiece of wooden structure-building [8].

Bassegoda goes on to claim: “In the mezzanine, where Güell had his library and office, there is a famous pillar which has often been the source of comments, for it does not correspond to any of those on the ground floor and is supported directly on the floor”

This is perhaps the most surprising feature of the structure. However it is not only the pillar mentioned by Bassegoda that is surprising; there are also a number of others: a pillar supported directly on the flooring is found over and again.

The study which deals in most depth with these enigmatic features, indeed these features which seem to defy logic, is that carried out by the Professors of Structure of the
School of Architecture of Barcelona, Joan Margarit and Carles Buxader that is mentioned above. This study also formed the basis for an article which was published in a number of journals of wide circulation [9].

Given the recognised authority of these professors and the fact that to date no studies unearthing new data have appeared, the conclusions presented in those articles can be taken as representing the current state of general opinion on the matter.

Let us now examine five controversial structural solutions in more detail, and then we will move on to consider the various assessments of them that have been made by the two authors mentioned above. Almost all of the features in question are situated in four of the different load transmission plans [10] which, we can call A, B, C, and D, as set out in the attached diagram (figs. 11, 12, 13, 14, and 6).

Firstly, analysis of all these features enables us to see that, despite the fact that the load being borne by the ceiling of the basement does not increase significantly, nevertheless the diameter of the basement pillars is much greater than that of the ground floor pillars. Furthermore, load plan A enables us to see the first surprising feature that the basement pillars receive considerable loads from the upper floors, but the two central basement pillars, the section measurements of which are very similar, do not receive any load whatsoever. In short, in the basement there exists a clear disproportion between the dimensions of the supporting sections of the pillars and the loads borne by them. This phenomenon is most strikingly reflected in the case of the two pillars which support no load.

Secondly, on the same load plan A, in the area marked on the diagram, there is another area which is problematic: the intersection of the system of upper floor walls and the system of lateral and perpendicular walls of the mezzanine. In this intersection of walls there is a concentration of loads which has contributed to causing certain disorders in the component materials of the lower wall.

A third point; observation of load plans B and C, shows us that there exist four pillars whose purpose is to transmit at least three-quarters of the load of the entire central space, along with that of the corresponding dome and spire, which are not supported on any other vertical element but rather on beams which are perpendicular to the plan in the case of load plan C, and on elements which are impossible to locate in load plan B. The point marked in load plan C, which can be seen in the photograph 15, is without any doubt one of the most puzzling features of the entire building. According to the above-mentioned study, this cantilever slipped and the consequent downward movement of the pillar which it supported opened up a void between it and the main beam, which it also served to support. This gap had to be filled in with platen (Fig. 16).

Now turning to a fourth example; load plan D illustrates the case of the pillar mentioned by Bassegoda, which can be clearly seen in the diagram 14. In fact, it does have a lower structural element supporting it and it is not the only pillar of this type, since its symmetrical partner and the two walls which are perpendicular to the plan and which enclose the central corridor are identical in this respect: they are all supported on the ends of the metal brackets which transmit their load to the three definitive pillars which, connected to those of the basement, stabilise the entire structure.

Finally, the study claims that several of the load-bearing brick walls, including that
Fig. 11. Load plan A. See floor location in figure 6

Fig. 12. Load plan B
Fig. 13. Load plan C

Fig. 14. Load plan D
Fig. 16
illustrated in plan C above the pillars we have just been discussing, support excessive stresses of the order of 20-30 kg/cm².

The first of the points that we have just discussed, the seemingly excessive section dimensions of the non-load bearing pillars in plan A, leads me to the opinion that Gaudí "is motivated by considerations of form but he disguises his intentions in a cloak of technology" [11].

The second point is considered to be due to "the excess of distortion or [...] not waiting for the beams to come under load before fitting the cladding" [12].

The third point, illustrated in load plans B and C, prompts the following question "why should an architect such as Gaudí, gifted with such a clear structural instinct and possessor of such formidable technical skills [...] be so careless as to fall into the trap of having to make these improvised arrangements? [...] Perhaps the answer lies in the overwhelming and multi-coloured nature of the Gaudí style, since it is not hard to imagine that the degree of improvisation employed when he gave rein to his decorative talents might have also extended to other areas of his work" [13].

The fourth point is explained as a "measure that seems to be more an attempt to limit the span" of the girders and "is certainly not a construction solution that is justified without powerful arguments" [14].

With regard to the stresses borne by the walls and the excessive load mentioned when discussing plan A, its can infer that "Gaudí’s sound structural judgement led him to pay less attention to the walls and beams than to the arches and pillars [...]. The result of this approach could have been that the confidence he deposited in the walls led to their being, paradoxically, the least stable of the structural elements in the Palau Güell.” [15]

In conclusion, these five features, taken together, along with a number of other elements of lesser importance, have led to the Palau Güell being judged as a somewhat "confused" building, and has aroused doubts as to how "this structural framework which we have just discussed could possibly be the skeleton for a masterpiece of architecture." These doubts "could well serve as the starting point for a revision of our present-day assessment of catalan Art Nouveau in general and Gaudí in particular” [16].

There are of course opposing opinions, though some of them coincide in part, such as that of Antoni González, who holds that "it is true that the overall framework of supporting structures in Palau Güell is somewhat confused, but it is quite another thing to sustain that the skeleton of an architectural masterpiece of the 19th century must necessarily fit the idea of structure we now accept in the light of the contributions of the Modern Movement in general [...]. It seems clear that for Gaudí, working out the elements which were to contribute to holding the building up in the Palau Güell was a secondary matter at the service of the truly fundamental issue in hand: the construction of a spatial idea.”” [17]

Reinforcing that rather instrumental vision of structure, Giorgio Croci, another expert in Palau Güell, declare:
"Gaudí also knew how to use structure solely as an indispensable support whose only purpose is to free every possible type of form, space, void and light, as in his Güell Palace."[18]
The Original Structure

One of my main objectives in the present paper is to draw attention to new data which will permit us to make some progress in our evaluation of the Palau Güell and of Gaudí’s ideas on the integration of the structural framework into his architecture. I hope to do this while bearing in mind the concluding recommendations of the two Professors, who urged us to “combine the dispassionate approach of the scientist in the interpretation of data and the enthusiasm of the devotee in the search for these data, so that none of our claims will suffer from a lack of foundation or justification.” [19]

Fortunately, we now have access to a document which may well contribute information that will enable us to reach new, solidly-based conclusions: this document is the set of plans that Gaudí signed and presented to the City Council in 1886 in order to obtain the building permit for the Palau Güell. However, before beginning to consider these plans, I would like to add some further comments concerning the “confused” features we have just discussed. Some of the following comments are based on careful observation and study of the building, while others are based on new assessments carried out on other works by Gaudí in the aftermath of the publication of the comments I quoted in the previous section of this paper.

The great diameter of the basement pillars may not seem so excessive when we consider that if the stone pillars of the ground floor had to bear tensions of 15 to 30 kg/cm² the basement pillars served to reduce these tensions to 5 to 15 kg/cm², which are not so low if we bear in mind that the material is brickwork [20]. If, in spite of this, we still think the pillar sections could have been narrower, we should not criticise Gaudí’s structural design skills, since it seems clear that these pillars will never cause structural problems, rather we should criticise his lack of a sense of economy. In any case these pillars seem to be in response to some kind of formal requirement but they do not pose any kind of conflict or threat to the building’s stability.

Evaluation of the load borne at the intersection of the walls in the mezzanine [21] confirms that the cracking on the outer surfaces is due to excessive load, but is not due to flexion of the girder since it is supported at that point.

Of the cases considered, the fourth one, set out in load plan D, is undoubtedly the easiest to understand and the comparison of the mezzanine and the ground floor does not lead to any confusion: the fact that the axes followed by the pillars do not correspond from one level to the next is obviously in response to a desire to facilitate the turning of carriages at the back of the ground floor, which made it necessary to separate the two pillars and have instead only one central pillar. It is an unusual solution, but nevertheless one that was not overly expensive and that has not led to any defect in the overall load plan. Furthermore, as will be seen shortly, it is one of a repertoire of architectural techniques which were genuine Gaudí trademarks.

Returning to the matter of Gaudí’s excessive confidence in the load-bearing capacity of the walls, I would like to offer the following consideration. The negative evaluation of the load-bearing walls was made on the basis of comparison of walls conceived in 1885 and those built in response to the demands of a modern standard established in 1972. But the 1972 standard (MV-201) came about as the result of the building boom of the sixties and was designed to avoid the disasters that were beginning to occur as a result of the decline of the
great building tradition, of which Antoni Gaudi was a part. Using the present-day NBE-FL-90 standard, (the new term for the MV-201) for evaluation purposes leads in general to a near catastrophic evaluation of practically all 19th century Catalan architecture and a good deal of the architecture of the early part of the present century, all of which is still standing. Further consideration of this can be found in some of my other papers [22] and also in the study of another of Gaudi’s buildings which is almost contemporary with the Palau Guell, the Casa de los Botines in León [23].

Other recent studies include information which provides insights into Gaudi’s structural intuition and also into the link between his architecture and his sense of structure [24].

However, returning to the central concern of the earlier part of this paper, the first three cases (those illustrated in load plans A, B, and C), do not have such a convenient or immediate explanation. Nevertheless, an explanation can be found if we study the original structure as set out in the administrative plans I mentioned earlier.

It was not until 1974 that these administrative plans, which Eusebi Güell presented in application for the municipal building permit, were discovered in the city’s municipal archives through the research efforts of the Gaudi Chair of Architecture of Universitat Politècnica de Catalunya. These plans were completely unknown before then [25]. The figures 17 to 21 include a simplified reproduction of the plans.

Being strictly administrative plans, they do not include any detail other than the definition of the form, volume and space of the building in those areas which were the concern of the City Council. Nevertheless, the plans do cast light on the exact ideas Gaudi set out with as regards the organisation of the structural framework of the building.

If we compare the data contained in these administrative plans with the plans we looked at earlier, we can see differences in some details, but the spatial intention is essentially the same, both in the lower and higher floors and also in the central space. The details reveal some differences in the final solution – load bearing in the mezzanine was achieved exclusively by the use of pillars, the piano nobile has two colonnades to the sides – the rest however, in general, is the same.

It is important to analyse the original plan in as much depth as the drawings will permit [26]. We will start at the lower level, and move as far upwards as it is possible to do. Like the actual building itself, we can see evidence of an interrelationship between different spaces, structures and uses, and it is the interface between all three which provides the key to understanding the structure of the building.

The relationship between the basement and the ground floor is the same, both are isotropic in form. The relationship between the ground floor and the mezzanine allows us to see that the lack of coincidence between the axes of the pillars which appeared in load plan D (Fig. 14) was also present in the original design, and was clearly due to the need to allow for the movement of carriages. This lack of coincidence between axes occurs in other locations and we will refer to it as an “arboriform” or Y-shape figure.

At mezzanine level, there is one notable difference between the original plan and the actual building, and it lies in the double-height wall of the back of the hall, one span further
Fig. 17. The basement

Fig. 18. The ground floor

Fig. 19. The mezzanine

Fig. 20. Piano nobile

Fig. 21. Bedrooms
back, in load plan D. It is resolved by means of four large rectangular buttress piers, between which there are eight pillars of smaller diameter. It must be pointed out that in the lines perpendicular to the façade there is no continuous wall but rather there are pillars of rectangular section which form a grid among which there are circular pillars of smaller diameter.

Continuing to move upwards, examination of the piano nobile shows us two important differences in addition to some minor differences affecting the right-hand side of the building: firstly: the main access stairway, situated to the left, and secondly, the two colonnades at the sides of the main salon.

The most difficult interface to resolve was that which interrelated the system of load-bearing pillars of the mezzanine with the system of walls and the central space of the grand salon or piano nobile. Superimposing one floor on the other allows us to see that the columns and their adjacent walls are symmetrically situated one on each side of the line of load transmission of the pillars of the mezzanine; observing it from above enables us to see that we are dealing with another case of an “arboriform” configuration, which leads to a doubling up of the pillar by means of two cantilevered elements on the wall and column, both - it must be presumed - supporting similar loads so as not to upset the overall balance (Fig. 22).

It is now time to consider a little further this “arboriform” or Y-shape figure which, as we have seen, is recurrent. It seems clear that it is not a usual technique, since the most common solution would be to make the axes of the pillars coincide from one level to another. But the fact that it is unusual does not mean it is flawed or mistaken or was excessively expensive to execute. In fact, it was the same technique Gaudí used in building the school “Las Teresianas”, which was one of the most economical buildings he built, and yet it was very rich in terms of space and conceptual rigour. That building’s design and construction was almost contemporary with that of the Palau Güell (Fig. 23).

The arboriform figure constitutes one of Gaudi’s permanent resources of composition and structure, and it reaches its high point in the Sagrada Familia, practically all of which is arboriform; it is also found in the partial building and the model for the church in the Colonia Güell. The origin of this element lies, of course, in the early work of the architect.

If we continue moving upwards through the building, the wall which closes off the bedrooms is supported not on the axis of the arboriform structure of column-wall but on the lateral walls, thus achieving - and perhaps this was its purpose - greater width for the perimeter corridor which provides access to the bedrooms (Fig. 22).

However, examination of the floor of bedrooms, which is the last one drawn in the plans, leads to a question about the supporting mechanism for the central dome which, as is clear from these plans, was basically similar in the original conception and the finished building: above the salon of the piano nobile the central space is reduced to a smaller square, which frees up space for the access corridor to the bedrooms and which, it seems reasonable to suppose, also served to support the spire. The solution to this problem is found on the walls of the piano nobile running parallel to the façade.

It seems reasonable to suppose that the pilasters marked with the letters m, n, p, and q (Fig. 24) would have supported two beams which would have been perpendicular to the façades, and tangential to the central space in a similar way to the actual ones but in a perpendicular direction (I and J in Fig. 22).
Fig. 22. Longitudinal section of the building

Fig. 23
Pilasters p and q were to be supported on four pillars at the mezzanine level (p1, p2, q1, q2, in Fig. 25), where once again an arboriform configuration was employed but upside-down. There was no option but for pilasters m and n to be supported on beams resting on the another mezzanine pillars (m1, m2, n1, n2, in Fig. 25), which led to another inverted arboriform figure of greater span which would have required a beam of larger dimensions. This solution is not at all frequent but it is in keeping with the freedom with which Gaudi worked - setting out from the basis of solid resolution of all the structural problems of the intersections, he related floors which were planned for different uses and which were structurally different by means of the arboriform figure, which was unquestionably effective, as demonstrated by his major works carried out later.

Superimposing the floors from an axonometric perspective (fig. 26) enables us to conclude that in the original design there was total coherence between use, space and structure, and that the structure could not by any means be termed "confused" or "confusing".

The next question is obvious: why did he change from a clear-cut structural framework to one which could be seen to be, at least in part, confusing?

We will now turn to this question.

Variations Introduced in the Design Once Work had Started

The almost absolute coincidence between the finished building and the original plan in so far as the basement is concerned allows us to reasonably suppose that all changes were made at a relatively advanced stage of the construction work. Let us imagine the situation in which the Palau Güell was built, and let us relate it to our personal experience. It was a situation in which the architect was young, the client older, and of course much more powerful, and given the complexity and lack of definition of the project in hand, the client probably did not understand the proposals put forward by the architect until the work was actually in progress.

Perhaps for this reason, and also having foreseen the inevitable difficulties which lay ahead, Gaudi built a ceiling for the basement which would be capable of accepting certain significant variations in the location of stress and thrust forces transmitted from the higher floors, almost as if it were a cement slab. Although this is only supposition, what cannot be denied is that the service stairway is supported on the vaults, as are a number of pillars.

If we compare the present-day plans with the original designs, we can see immediately the three fundamental changes: on the ground floor two of the pillars enclosing the central platform for the ascent and descent of carriages in connection with the main stairway disappeared. On the mezzanine level, we can see that the back enclosing wall was brought forward one span, as has been mentioned already. The third fundamental change is that in the piano nobile, there is a major change in the positioning of the main stairway. Unfortunately, there is no documentation which might help to explain the origin of these changes, although it seems reasonable to make the following hypotheses:

The disappearance of the pillars would seem to have been due to the fact that they got in the way of the carriages entering and leaving the building. Bearing in mind that the
carriages were horse-drawn, the position of the carriage door could not be adjusted very precisely and on occasion a carriage must have come to a halt with its door rather inconveniently blocked by one of the pillars. It seems reasonable to suggest that it could have been Gaudi himself who took the decision to remove the pillars before being told to do so by Eusebi Güell.

Bringing the mezzanine wall forward was justified by the fact that it led to better utilisation of the space, since it expanded the space available for Güell's office. In addition, if we consider how difficult it would have been to combine the original wall and the arboriform figure we have just identified in load plan D (Fig. 14), we can see that moving the wall forward was a logical step.

All the changes that took place in the piano nobile were basically the consequence of changing the location of the stairway. The reason underlying this particular change was simply that it provided for improved utilisation of available space since it gave rise to another room on the bedroom floor and a new surface for the piano nobile at medium height on the interfloor space. Another reason, by no means trivial, could have been that changing the stairway's position permitted the establishment of a direct connection between the rooms on the inner courtyard's façade, the stairway and the rooms on the street façade.

Whatever the reasons may have been, the new position of the stairway led to the disappearance of the left lateral colonnade, and of course, for the sake of symmetry, the one on the right had to go too.

To these reasons, based on the house's use, we must also add a number of other reasons which are more concerned with structural details: in effect, in the case of the stairway there was no option but to use arboriform figures to transmit its loads to the line of lower pillars in the same way as the arboriform figure of the colonnade it replaced. However, the stairway was wider and this led to further structural and, more importantly, spatial problems. The balustrade of the stairway was closer to the axis of symmetry of the salon than the earlier columns, and on the other symmetrical side, the disappearance of the colonnade led to the logical solution of maintaining the load distribution of the lower floor in the upper floors, which changed the spatial distribution radically, and the axis of the salon was moved to its present situation 40 cm or less to the right of the original position.

Without any doubt, this was a radical change which broke one of the key formal features of the building: the absolute continuity of a plane of symmetry from the basement to the spire which involved the coincidence of the axis of the helicoidal ramp with the axis of the central space and even with the axis of the weather vane. However, the lack of coincidence is difficult to notice because of the complexity of the interior, and lack of sufficient viewing perspective prevents it from being noticed from the outside, although it can be noticed from the inner platform of the piano nobile.

It would seem reasonable to imagine that Gaudi must have been deeply upset by these changes, though there is no record to the effect. In the plans presented in the 1910 Paris exhibition all the axes coincided. However, none of his disciples ever gave a written account of the matter.

The structural consequences of all these changes, which came about as the result of changing conceptions of the uses to which the house was to be put, were significant and
coincided in more than a few points.

The removal of the two pillars from load plan A required a supporting arch of voussoirs, which seem to be out of proportion for the task. This arch was combined with a lintel. The overall mechanical behaviour of these features is still difficult to understand. To reduce the span of this new arch-lintel the supporting pillars were brought closer together, with the result that they were no longer situated directly above the original pillars of the basement, so the latter had to be rebuilt with a greater section (Fig. 27).

It is reasonable to assume that Gaudi had his doubts as to whether this replacement for the original pillars was sufficient to assume the load transmitted to it from the central space, the dome and the spire, through the beams which were described earlier and the pilasters m and n of the piano nobile and m2 and n1 of the mezzanine level. For this reason, or perhaps for others difficult to discern at this distance, Gaudi seems to have decided on another major structural change: the original ceiling beams of the piano nobile were discarded for others parallel to the façade, i.e. perpendicular to the original ones (which we will refer to as B and C since these are the load plans in which they appear (Figs. 12 and 13)) and supported on elements which were not at all contemplated in the original design (Fig. 28). Beams I and J are maintained in the final solution but without the main load-bearing function because they bear on beams B and C.

The right-hand end of Beam B, which is the one nearest to the street, is supported on the wall which rests on the pillars of the ground floor and basement without any serious problem, However, the left support is rendered vulnerable by the new position of the stairway and now requires additional support from a camouflaged arboriform figure under the first landing which is supported by means of an metal distribution beam on the mezzanine wall (Fig. 12).

Beam C presented even more difficulties. The second change in use, the bringing forward of the back wall of the mezzanine floor, made the support of beam C more problematic. Due to the disappearance of a supporting wall as a consequence of the second change discussed earlier, the right-hand support of beam C requires the additional help of a beam situated in the floor of the piano nobile perpendicular to load plan C, which has already been mentioned in the discussion of figure 13.

This brings us to its left-hand support, where all the consequences of the three changes in use are concentrated: the changing of the position of the stairway, moving the mezzanine wall forward, and the new location of the beams resulting from the removal of the pillars which obstructed the carriages. This was too much for a single point to support but the solution to the problem (photograph 15) was in no way erroneous or confused, though it was strange. Let us see why.

If a Y-shaped structure six metres high bearing some 25 metric tons is supported by a single beam, it is difficult to prevent it being unstable in isolation. Gaudi took the decision to tie it to the neighbouring wall by means of braces situated half-way up the wall, one perpendicular and one rotated forming a double triangulation, so the assembly was totally immobilised. The equal loads bearing on the two ends of the Y and the more than sufficient width of the double projecting element prevented the left support from yielding at all. The supplements (platen) inserted in the support of the upper beam could be attributed to problems in the adjustment of the measurements of the stone elements, but were certainly not due to the distortion of one of the branches of the Y.
Fig. 27. Magnification of the section in figure 9

Fig. 28. Position of the new beams in the planta noble.
Conclusions

Without any doubt, we are dealing with a building in which, in itself, the task of understanding the observed structure is difficult. To try and understand it we must become familiar with the vicissitudes, changes, doubts and indecision that marked the design and construction of this structure.

Through this case once more it becomes clear that when we are faced with the task of restoring a historical building it is crucial to bear two basic principles in mind. Firstly, understanding structures from the past poses a wide range of problems for our 20th century mentality, and it is therefore necessary to search out all the means which may facilitate the task of understanding. Secondly, a knowledge of history is one of the most powerful tools in our effort to understand these buildings. Let this second principle serve as a posthumous homage to a great master who was a radical defender of the role of history in helping us to understand: Antonino Giuffré [27].

In our case, unless new documents come to light, all the suggestions I have made today must be taken as hypotheses, some of them very reasonable and almost certain, others less so, especially those concerning the intentions of the participants — which we will never be able to confirm. But one thing I hope is that these considerations may help us to achieve a fuller understanding of the building and its creator. At least in my case this has turned out to be so.

Without doubt, the two basement pillars in load plan A bear no load simply because the pillars on the ground floor were removed. The range of strange and unusual solutions in load plans B and C were decided by Gaudí in response to developments as construction work took place. The fact that they are hidden in no way detracts from the general perception of their appropriateness. The absence of distortion or cracking shows that they were correctly dimensioned. What more can one ask for?

All those who have ever been involved in building projects know the far-reaching effects and sometimes disastrous consequences that can come about as a result of changes during building work.

Indeed, it seems clear that there is no reason to doubt his extraordinary ability and unbending desire of Gaudí for rigour in the creative dialogue between his architecture as a container of changing uses, his architecture as a spatial adventure and his architecture as a defiance of the force of gravity.
NOTES


4. A. González, P. Carbó, *La azotea fantástica (La cubierta del Palau Güell)* in INFORMES DE LA CONSTRUCCIÓN 408, pp. 31-41

Directed by J. L. González: *Estudi detallat del descens de càrreques gravitatòries*, 1998(a) and *Comparació entre les estructures del projecte original i l'actual Palau Güell*, 1998(b).
Justo Hernanz, an Architectural Technologist and holder of a master's degree in Architectural Restoration, Ms Jesús Pérez, an Architectural Technologist, and Raquel González, a Civil Engineering student collaborated in the drawing up of the last two and in the present paper.


8. The previously mentioned study by E. Nuere amply demonstrates this.

We now have new data on the non-structural reasons why Gaudi designed his structural elements, thanks to the work (also funded by Barcelona County Council) carried out by “Audioscan Enginyeria del So”, *Estudi d'ailament acustic del Palau Güell*, July 1997. This study shows that the reason underlying the complexity of the flooring and ceiling arrangements separating the service bedrooms from the main bedrooms is their high level of acoustic insulation, which is good enough to comply with current French legislation.


10. Data and maps compiled from J. L. González (1998a)


15. J. Margarit and C. Buxadé (1990) p. 27

17. A. González, El Palau Güell de Barcelona. La construcción de una idea espacial, in INFORMES DE LA CONSTRUCCIÓN 408, pp. 17-22, p. 20


20. Data drawn from J. L. González (1998a)

21. Conclusion drawn from J. L. González (1998a)


26. The data and conclusion on the structure of the original plan and the variations made on site are taken from J. L. González (1998b).

27. Of course, Giuffrè is not the only one who defends this idea; the writings of many other authors, such as Giorgio Croci, also put forward this view. What was unusual however about the master, who left us last November, was the radical way in which he defended the idea, as reflected, for example, in his impassioned and unforgettable contribution to the first edition of this Seminar, which was published as, Proposal for the restoration of Marcus Aurelius' column, in P. Roca et al. (eds.), 1997.