ENGLISH VERSION

Joaquin Arnau Mó

Of Screens and Masks

In olden times, screens were considered erotic. Gorgeous actresses hid behind them partly to reveal and partly to conceal their curves. The screen was the threshold where a certain amount of modesty and a certain amount of brazenness came together. Intimacy added a little to the show: a game where what you see roases your imagination as regards what you don’t. Such a game has been brilliantly played by the architects at the Head Office of the Caja de Castilla-La Mancha in Albacete, where Tesifonte Gallego street ends and Abelaño Sánchez park majestuously begins.

A typical ordinance, questionable like them all, obliged the architects to preserve the facade of the old building, a perfectly dignified work designed by the architect Ramón de la Masq in 1920, with a concave central part that gives shape to Gabriel Lodares square. And the architects complied with this ordinance, while mocking it at the same time. Well done.

The new architects have broken no rules. They have just made fun of the preservation order in obeying it: this is indeed an elegant, intelligent way to make fun of something. Because there’s no fun in sarcastic laughter. Not in the least. Laughter that attacks the rules, however witty they may be, is easy laughter in bad taste. Any fool can do that.

On the other hand, subtle, not too obvious irony is a sign of an architect of consequence. Irony that impeccably assumes the order (which is what an ordinance happens to be) in such a way that it shows how absurd it actually is just by observing it. In this case, the old facade is still in place. If not intact, yet it is partly improved by the compulsory restoration. But what was seen as a face, which is what facade actually means, is now seen as a piece of furniture (fig. 2).

It’s a kind of screen. Now then, the beauty of the screen has nothing to do with what it is or what it looks like, but with what and how much it covers and uncovers: what it reveals and what it conceals. And it doesn’t reveal but suggests.

The beauty of the screen has to do with what is hidden behind it (fig. 3). The beauty, in this case, of the old (and here we see the cleverness of the current architects) is in fact the new. The seduction of what was is replaced by what has been turned into a transit area from the old to the new building to the old city. Because a classical facade is in itself an urban fact. The building makes a contribution through it to the city with an air of courtesy as a token of its gallant nature.

We know, on the other hand, that there is inevitably a certain amount of hypocrisy underneath the courtesy. ‘How are you?’ ‘Fine, thanks. And you.’ Let us analyse the number of untruths involved in this short exchange. Because neither you nor I are well, and much less fine. Neither are we very interested in each other’s health. And we don’t feel too grateful, either. But we are very happy in whatever we may think of each other, we keep it under our hat. Thus the facade of a classical building, or even of just an old building, is hypocritical. It doesn’t tell us what is going on inside; it doesn’t show the irregular layout of its secret functions, some of which are rather coarse. It limits itself to telling us a story of harmonious masses, balanced volumes and regular bays, all designed with delicate composition and an airy rhythm.

What a facade tells us about times gone by is not true: at least if it is not true in relation with the building it corresponds to and to whose intimate secrets and weaknesses it shelters or covers up. But it makes the street more beautiful. Or the square. Placea S. Paulli privatiss aedibus ornata it says at the foot of an old square in Venice. The facade of the old building is not part of the house but of the street. It is not a household, but an urban issue. It is not honest: it is hypocritical. It is not sincere: it is polite. No doubt this Head Office of the CCM could have made use of these antiquated pleasantries and kept the old facade urban and hypocritical, so that it would appear to be what it is not: the same as ever. It could have done so. But it didn’t. On the contrary, it froze its handsome and distinguished gesture and turned it into a ridiculous piece of nonsense. It turned courtesy into irony. It turned the hypocritical but original face into a parapet as pretty as it was unnecessary. Because it is a feature of screens that they can be carted around without any shame: a screen is a portable artefact. The architects skillfully turned the original building into a piece of furniture so that the old wall is where it is but could just as easily be somewhere else. It is there just by accident. But since it is there we might as well make the best of it. The essential part of the old building has become an accessory of the new one.

And that is why we consider the ordinance that obliged them to conserve this accessory as an arbitrary whim of a banal city planning system. The innocent passer-by may ask himself: What is that facade doing on that building? Nothing at all. But does it bother you? Not in the least. That’s funny. Why? Because it is uncalled-for: like the ordinance that made it necessary. Besides, it has a role to play. Indeed it does: it softens the opulence of the new fabric which might have been too rich and magnificent without this paravent to screen it.

The veil is a help.

It does not always work this way. We have another very different example in the same city. In its day (1925), it was a modest little pistacho-green mansion, near the City Hall, just behind it, and opposite the church. In the corner of a street dedicated to another architect: Martínez Villena (fig. 6). It was designed by yet another: Ortiz e Iribas. With its pilasters, pediment and other academic ornaments, its most outstanding feature was its tiles, reminiscent of more humud rustic lands, rather inappropriate in this dry, airy place. A sample of neither splendid nor typical architecture, but discreet, slightly beautified over the years by age and, on the other hand, the monstrosities built on either side of it. But one fine day the popes of urbanism singled out this secular building and declared it of certain merit. And out of respect both of its age and of good taste they put a preservation order on it.

We know that a fleshless body like that of the flayed martyr Saint Bartholomew in Michelangelo’s Last Judgement is in fact a mummy. So, in the course of this cleaning operation, the face of the building lost its entity to become a mask. (fig. 7) Thus what the city planners, like guardian angels of the city, were actually doing with their conservative ordinance was to save the screen. Or the mask. In this way they were reducing the building to a mere stage setting, because they thought it was majestic and well designed.

Of course they failed to notice the errors in its composition. And I say errors, because the role of the facade as decoration. Like one of grammar or spelling, are very straightforward. You either know them or you don’t. It is obvious that the architect Ortiz was only half familiar with Vignola and his followers, and he only half used them in the building.

Where a good solid entablature should have been raised, he contented himself with a mere projecting cornice. In this way, he put in the adjective, the crowning cornice, and left out the noun: the entablature, with its firm architrave and its strong frieze.

But in spite of everything, the little palace, set against the skyline like a post-modern cut-out, stayed standing. And thank God, it still is. The badly-designed facade masks the building: and they are both happy to relinquish the category of Architecture, which cannot conceive the former without the latter or the latter without the former.

The local association of architects has chosen this masked building as its headquarters: although it is narrow and sandwiched between characterless modernities, it is indeed picturesque beneath its mask of ancient eclectic bourgeois airs and graces. Its scant space, even counting the attics and lofts added on with the consent of the ordinance, half-concealed from the passers-by that they won’t offend its supposed architectonic sensibility (but do they?), would have been large enough, at most, to house the studio of a single architect as they used to be in olden times. But we all know space is scarce. That is why we have so much to say about it: we mash and grind it up, as though it were an expensive drug.

What happens when a blanket is not infinite and an infinite number of people are pulling at it? It gets torn to bits. So be it: if others tighten their belts, so to speak, we architects should tighten our walls. Well now, as they were at it, once they had decided to keep and restore the old facade, mask, stage setting or whatever, couldn’t they just as easily have restored its dignity by putting right what was wrong with it, leaving it looking better than it had originally?

What an opportunity for a group of people who call themselves architects to deliver a lesson in architecture by means of the facade of their modest but decorous head offices. It can’t get out of the job of a restorer, when he is an architect and not an archaeologist, notary public or historian, is to put things right: he corrects the error where possible; he does not perpetuate it. Rehabilitation involves correction (fig. 8).
As things are, the current state of the rehabilitated, and introverted, building recognizes the rather grotesque appearance of the mask that masks it. A mask is supposed to be worn wherever one wants to wear it: on the nape of one’s neck, for instance. Considering what the building is to be used for, this may be an involuntary emblem of a profession used in the mad fantastic things and to turning the city into a perpetual carnival.

No doubt the emptying out of such delightful containers as some outstanding buildings of our past have been, to fill them up with new contents leads us to useless coverers such as screen or mask. The facade is, after all, the front, or rather the face of a building. And a face cannot be put on and taken off like a mask. So said the different manifestos of modern architecture when the century that is now on its way out had just begun. We should see outside, these manifestos proclaim, neither more nor less than what is inside, which seems logical enough. Modern architecture prides itself on being honest and sincere above all else. And as a result, it abhors the hypocrisy that was the mask of the bourgeoisie, who built their houses carefully so that they would seem to be what they were not.

We may agree with the Modern Movement or not. If a model building was to be, as Palladio would have it, a temple for the soul, it doesn’t seem right for its face to ignore the rest of the body. However, Palladio’s reasoning, applied by the moderns in their own way, cannot be applied to 19th century architecture, justifiably called eclectic, because of the free adornment of their facades, turning their backs on their insides. Theatrical, not to say histrionic, as it is, this show-model architecture gives us one view on stage and conceals another in the wings. It is like the costumes of the period: the visible figure, or the figure plate, disfigures and distorts to its heart’s content the invisible figure, that is to say, the real body it covers. The figure plate contradicts the figure.

As far as women are concerned, for example, the fashion of the period flattered like a board whatever bosom God might have endowed them with; to make up for this, it furnished them with a false derrére, a bustle, that was absolutely unnatural. It was appropriate for a hypocritical and pretentious society to have hypocritical architecture to keep the public happy.

The new 19th century bourgeoisie, a direct or indirect descendant of the French Revolution, recovered the philosophy of the last throes of feudalism at the end of the Middle Ages in the 14th century. This is the way of thinking expressed by Sempronio in La Celestina when he says: "Do what I say right and not what I do wrong". Whatever it may be that happens inside bourgeois houses, whether good or bad, we cannot tell by looking at their facades. These, discreetly composed and exquisitely adorned, always "say right". They are elegant and stately. And in turn they make up and adorn with exquisite courtyards streets and squares, regular and well laid out, the pride and joy of any enterprising and opulent Pasaje de Lodares in Albacete (fig. 9), is, for example, a perfect example of this glorious bourgeois hypocrisy.

This arcade (1925), the work of Buenaventura Ferrando Castells, a contemporary of the above-mentioned Pre-Renaissance Casas Massó and Miguel Ortiz e Iribas and the same distance from them both in the city, delivers its haughty speech like a great actor while concealing its many secret interlinings and its lack of space and its poor layout.

So applying modern criteria of sincerity, occasionally tinged with cynicism, on architectures of the past, conceived on false pretences is nothing but a piece of nonsense. Because in this sort of architecture the facade is not the epilogue of the building, as Modernity sustains, but the prologue of the city. What Lodares is not conditioned by the dwellings inside, but by the arcade itself, which can perfectly well be adapted to different uses. A beautiful mask is a treasure, whoever may be wearing it. People come and go; the mask remains.

It is no good, then, trying to give to the bourgeois architecture that is still standing integrity it never claimed to have. From our point of view, it is an atrocity to detach the facade from the rest of the building. From its own point of view, however, separating one from the other is the most natural thing in the world. In fact, if we look at what was called a project in those days, we often find gorgeous, autonomous facades delightfully drawn, and little else.

The ground plans are either conspicuous for their absence or are no more than what in our Golden Age were called scratches, little more than simple sketches. It is clear that in designing facades, and only facades, the architects of that period put all their eggs in the one basket. They designed them with great care, and they are in fact the most valuable part of some of these bourgeois buildings. Ignoring completely the buildings behind them, these old façades make up city fronts with great dignity. It is only right that the city should save them, then. Because if they are safe and of course restored and, where necessary, perfected, we may well say we have lost nothing, or hardly anything.

ILLUSTRATIONS

1. The modern and the old part of the building sharing the cornice at the left hand side, giving on to Tesifonte Gállego street.
2. Detail of the facade of the Caja de Castilla-La Mancha, by Ramón Casas, giving on to Gabriel Lodares square.
3. Foreshortened view of the gap in the same building between the old restored facade and the new.
4. Restored facade hiding the new head office of the Castilla La Mancha Architects Association, Albacete branch.
5. Details of the old facade and the new added body.
6. Restored facade that hides the building of Caja de Castilla-La Mancha, Albacete branch.
7. Details of the same facade seen from inside the newly built part.
8. Drawing of the remodelled facade: the space opened up between the capitals of the pilasters and the cornice restores the proper proportion to the entablature.
9. Interior facade of the Pasaje de Lodares.

Libero Cechini
Restoration of the Abbey and Cloister of San Zeno in Verona

History

This monastery, like most suburban monasteries, was built in a large open space outside the walls of the city and on an important route: the Via Gallica, leading to Brescia and Milan. In spite of being on the outskirts of the city, it was a very important site in Roman times because it held the largest necropolis in the city. We cannot set very precise dates, but we can say that San Zeno church was first built between the 8th and 9th centuries, although its fabrics conserve very little indeed of the building in existence before its re-construction during the Romanesque period after the earthquake in 1117.

In the buildings of the monastery, later called abbey, the 13th century towers still survives, standing beside the entrance, and the cloister. The latter, built according to the fashion of the late 13th century, is strongly evocative of the old spirit colour of the monastery.

Great constructive activity started on part of the monastery at the end of the 12th century and went on until a great crisis arose in the 14th century, after which it fell into a state of mere survival. The abbey struggled along until 1747, when it was closed down, and in 1797 the abbey property was handed over to Verona council until the buildings were sold at the beginning of the 19th century to private owners who demobilized the monastery to obtain construction material.

Intervention

In 1982 a great restoration programme for the whole abbey of San Zeno Maggiore was initiated under the patronage of the Banca Popolare di Verona. To draw up the project for the recuperation and restoration of the whole complex of buildings, a detailed historic and bibliographic study and a painstaking graphic survey were carried out on all the buildings, together with a careful analysis of the fabrics of the walls, the materials and the tools used, completed with a campaign of archaeological excavations.

On the basis of the data found, a plan was drawn up with a hypothesis about the historic evolution of the fabrics of the walls with a view to documenting decisions in a future project (fig. 3). These fabrics are the fruit of different construction stages and a series of transformations not always easy to read at first sight. The doubts and mysteries involved in their building history are many, and mingle with other more general and complex issues.

As we said above, since these buildings were erected on a Paleo-Christian cemetery, the oldest elements found were the Paleo-Christian tombs that were discovered during the archaeological excavations, and which date back to the 3rd and 5th centuries. The oldest object is the sepulchral chapel of Saint Benedict, which scholars believe was originally a hypogeous or burial chamber for members of well-to-do families of the pagan Roman period. In archive sources data has been found to indicate that work was performed on the hypogeous during the 10th century, when the south wall was reinforced to be used partly as a lateral facade of the San Zeno church standing at that time. The two naves and four panels found in 1990 during the archaeological campaign have also been dated in the 10th century; the documents describe these remains as the palatium vetus room, built before the space leading into the cloister, probably the old entrance to the monastery and the cloister, built in the 11th century.

These two buildings, the access and the staircase, were constructed at different times, as we can see from the different fabrics used in their walls and the west corridor of the cloister. As far as the building of the monastic manor is concerned, with the dimensions of the first Romanesque church were the same width as the current ones and about three quarters of their length, so that the main facade was set further back than the present one, in line with the eastern side of the way into the cloister.
The first two floors of the tower must date from the same period as the church, which must have acted as a corner of the fortress flanked by the walls surrounding the monastery orchards.

However, the expansion and reconstruction of the basilica, whose longitudinal walls were prolonged almost 26 metres and whose new facade housed the portico of the Romanesque church, were started in the 13th century.

The last important intervention on the basilica took place in the late 14th century and consisted of the reconstruction of the large Gothic apse and the timber soffit with the vault.

On the basis of this data an overall project was drawn up for the whole complex and has been carried out in stages according to the urgency in the preservation and recuperation of the different parts.

In 1994, the intervention was awarded a medal ad honorem by the cultural organization Europa Nostra, promoting works and projects all over Europe, “for the methodology used and the quality of the work performed”. The following tasks have been carried out to date:

- Restoration of the church of San Protocolo (6th, 8th and 18th centuries)
- Restoration of the tower and the abbot’s palace (13th and 14th centuries)
- Covering of the archaeological excavations with the spatial restitution of the monastery’s library and the form and volume of the connection between the abbey tower and the cloister
- Restoration of the buildings attached to the east side of the cloister (from 1996, currently under way)
- Project for the recuperation of San Zeno square

**Restoration of San Zeno Basilica**

Of the splendid abbey erected in honour of Saint Zeno, the city’s patron saint, all that remained was the late-Romanesque cloister with some of the buildings that formed part of it and the tower. The cloister was the central point of the abbey because all its parts gave on to it, organized in the form of a self-sufficient little town. It was a monastic complex not only for the monks to live in but also to take in passing guests.

The large cloister is surrounded on its four sides by a low wall bearing twin columns of red marble, many of which were rescued from the old Romanesque cloister.

The arches between these columns are built of brick and round on the south and north sides and pointed on the other two. The present cloister was built between 1296, when the Romanesque cloister is known to have existed, and 1313.

On the north side there is a little cloister in the middle of which there used to be, according to 18th century plans, a little fountain that is no longer there, where the monks would wash their hands before entering the refectory.

The archaeological excavation on the area around the cloister was performed as much to investigate the perimeter of the old abbey as to consolidate the original walls on the north and west sides.

In the first place, static surveys were performed on the fabric of the walls and later the roof. The heads of the beams were completely pulverized, to such an extent that many of them had to be replaced. The large cloister was in a very poor state of repair, and the renovation would have been impossible.

As a consequence of the necessary repairs, the bases of the columns were cracked and so water and ice got in and caused large fragments to break off (fig. 4). That is why most of the work concentrated on the stone and the verification of the proper static functioning of

practically all the inner east wall.

Apart from the works on the structure, the inner walls were cleaned and restored along with gravestones, sarcophagi and arches, situated in a disorderly way along the corridors, brought from other centres in order to set up the Christian museum that was intended for this place.

**The Covering of the Archaeological Excavations**

This was an important part, as it was conceived as partial restitution of the old abbey and of the form and volume of the church. The documentation in the files shows that a lot of building went on at the abbey, especially the abbot’s palace.

The archaeological excavation started in 1983 was intended not only to preserve and consolidate the original walls on the north and west sides of the cloister, to which the remains found during the 19th century demolition were attached, but also to discover the perimeter of the old abbey.

The cellar beneath the refectory with its 14th century entrance, its stairs, ventilation cents and remains of the impost of the vault was discovered on the north side (fig. 8).

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**Cleaning**

The following steps were taken to clean the different elements:

- Removal of surface pollutants with a jet of water, rubbing with a soft brush and treatment with sprayed water
- Isolated application of poultices of a dissolving mixture of basic Ph in a solution of carboxymethylcellulose
- Microjet precision treatment with aluminium oxide powder in grooves and less accessible areas in the bases and capitals

**Protection**

None of the stone elements in the cloister require chemical consolidation. It was therefore decided not to use resins for insulation and much less for waterproofing. A study carried out in collaboration with Florence CNR (National Research Council) recommended the use of another type of product: perfluropolymers.

**Frescoes**

The overall intervention on the cloister included the recuperation of the fresco surfaces, also affected by damp in the form of alarming blistering on the plaster. The work was initiated on the lunettes at the entrance (14th and 16th centuries) and completed with the large fresco by Paolo Ligozzi (early 17th century), which covers
Besides, separate from this structure, a flat framework was set up with ceramic paving at the height of the first floor of the monastery, a plane that was also found in the other rooms attached to the east of the cloister (fig. 16). This solution respects absolutely the reading of all the archaeological structures, which in the new reconstructed space are not affected by the new elements planned.

The connection between the abbey tower and the cloister constituted another spatial reconstruction work. Originally it must have consisted of only a wall to which a two-storey building was attached in the 12th century, when the abbó’s palace was built (fig. 18). This hypothesis is confirmed both by some traces found on the impost of the large ogival arch of the tower and by the fact that the height of the hall with the large fresco in the tower is on the first floor of the building over the entrance into the cloister, which originally must have been the second defence tower of the monastery.

Once the original bays of these two buildings had been built, it was determined to connect them not only on the ground floor but also on the upper floor by means of a timber catwalk hanging over the entrance for people to follow the different routes between the different exhibition areas of the tower and the parish services. The fact that there were no elements for the reconstruction of the ground floor suggested building the catwalk out of a large reticular beam of laminated wood about 22 m long, which succeeded in recuperating the old architectonic space (figs. 17).

PICTURES
1. Aerial view of San Zeno abbey
2. Ground plan of San Zeno monastery in a drawing dated 27th June 1810
3. Hypothesis of the historic evolution by means of an analysis of the wall structure
4. View of the cloister after the restoration works with the little fountain where the monks used to wash their hands
5. One of the bases of the twin columns during restoration
6. Control of the integrity and the spreading of possible cracks in some of the columns by means of ultrasonic auscultation
7. Plasticine mould for the replacement of a missing iron rod
8. Moment during the process of transference of the data from the plaster cast to the marble piece
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10. The entrance to the cloister of the abbey opened up during the recent works
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13. The large central room with two naves and three panels discovered during excavation
14. View of the courtyard with the internal staircase reconstructed
15. Internal view of the large room through the cloister
16. Detail of the timber vaults
17. The new facade of the abbey wall, made with tufa masonry
18. The connection between the reconstructed hall and the abbey tower after restoration
19. The reticular beam of laminated timber during assembly
20. View of the wooden catwalk connecting the two volumes

Libero Cecchini
Reconstruction of an architectonic space for the recuperation of a large medieval fresco in San Zeno Abbey in Verona

This work addresses the refashioning of a space in order to recuperate the fresco called Tribute to Frederick II from the peoples of the land, situated on the external south wall of the tower at the Abbey of San Zeno Maggiore in Verona (fig. 1). This fresco is certainly one of the most important and significant samples of 13th century painting in the North of Italy, both in its representational quality and for the originality of the theme (fig. 2). The large painted scene is divided into three bands: at the top there is a magnificent frieze with double scrolls attached to masks and monsters; in the central zone, we find the main scene, with a long procession of figures moving towards a many-towered city to pay homage to Frederick II sitting on his throne; the lower band depicts the elaborate scene of a boar hunt.

Unfortunately the reading of this large wall (30 m2 approximately) has always been limited, not only because of the difficulty of the wall itself but particularly because of the presence of a framework that conceals important parts of the painted surface.

There are records of the existence of the tower since 1169, and two constructive phases can be clearly distinguished: the first in the 12th century, with the original two frameworks, and the other in the late 13th and early 14th century, corresponding to the expansion of the abbey to its current size (fig. 3). This more recent top part of the tower can be distinguished from the lower part because the walls are less thick, the type of brick used is lighter in colour and the arches of the windows are made of bricks instead of blocks of tuff.

The tower was initially free-standing, but shortly afterwards a building consisting of two large spaces was attached to it on one side, a loggia on the first floor and a room above. In this large loggia open towards the inside of the monastery the large fresco of the procession was made. Later, in the time of Abbot Giuseppe della Scala, this porticoed structure was transformed into a real space, much larger than the present building, as can be seen in the traces of the stone ashlar present in the west wall of Abadia lane and the remains of the ceiling still visible in the north wall of the tower (fig. 4). The tower and the structure, partly destroyed in the early years of the 19th century, manipulated by the insertion of various frameworks among the original framework and with a new staircase and new bodies attached to the old structure, were quite unrecognizable at the start of the works.

The reading of the monastery was very complex at the beginning. It is built on the foundations of a dwelling dating back to Roman times, some of whose remains were rescued during the archaeological excavation. The oldest fragment of fabric that has survived until today is the west wall, specifically the part over the entrance arch, undoubtedly built immediately after the first construction stage of the tower, since it is attached to it. In fact these two walls present a very clear line of evidence.

As we pointed out above, this wall was almost twice as long as the current one. The wall perpendicular to it is still exists in the interior, dating from around the 14th century; it is attached to it and covers a fresco depicting a yellow coat of arms with an imperial eagle. From the same period also is the east wall attached in turn to the large wall bearing the fresco, partly concealing it. These two walls are the works that didlogging into the two closed rooms.

This facade boasts a large ogival arch on the ground floor and a gothic window on the first, both of which were closed up in the 19th century and opened again during this intervention (figs. 10 y 11). Another operation in the project consisted of eliminating the only existing staircase (reinforced concrete on the ground floor and timber on the upper stories) that leaned on the fresco, ruining its unity (fig. 13). As a result, the most complex problem lay in where to situate the staircase and the lift, both essential to reach the room with the fresco and the tower. Two possible solutions were contemplated:

The first possibility was to construct a volume separate from the context both as regards position and form: the intention was to respect the monument by not manipulating it again, but putting up a separate modern vertical block in contrast with the old building. The second option, which was the one put into practice in the end, arose both out of the need to raise the ceiling of the second floor to leave the fresco entirely visible and because of the discovery, during the archaeological excavation, of the foundation of the inner facade demolished in the 19th century.

Therefore the new staircase was placed in a volume attached to the abbey in line with the facade wall separating the new works from the old remains by slightly setting back the fabric of the west facade and making a split in the east facade. A material similar to the old one was used for this intervention: handmade bricks, fired in timber-heated kilns, with the same dimensions as the original ones (27 x 13 x 6 cm). This decision sought to make these new works fit in with the existing building, since it was considered that the necessary differentiation between old and new was achieved in a formal sense (fig. 11).

Another problem consisted of restoring the original spatiality to the ‘Emperor’s Hall’ by raising the roof as far as possible to reproduce the point of union between the 14th century tower (boarded up), without reaching the height of the original roof, and attempting to provide a feeling of temporariness in the new one, lightly resting on the fabric by means of a horizontal groove (figs. 5, 6, 7, 8 & 9). All the initial spaces of the tower have been recuperated in this restoration, with the exception of the one on the first floor, divided in two by a framework decorated with an 18th century egg & leaf vault, which could not be demolished because of its great historic and artistic merits. So, in order to connect this first 18th century level of the tower with the new staircase, a timber gallery was made around the three sides of the abbey in order to keep clear the view of the ogival arch right up to the top (fig. 12). During the works, metallic elements were avoided and modern timber and bricks were used because they were considered to blend in better with the architecture of the monastery.

Research and Restoration Methodology
As described above, the tower and the abbot’s palace are complex structures that form part of a larger civic building. Before starting restoration, different studies were carried out, of geophyric and architectural nature. The methodology used to begin the intervention consisted of forming a team of researchers and specialists, and thanks to their contributions, constant on the spot verifications and project
decisions could be made. The following tasks were performed: Historic research into both written texts and plans, drawings and elevations by art historians, whose study can offer a view of the development of the building in time with indications concerning changes of use, dimensions of the different rooms, the addition of new rooms, etc. - Architectural, altimetric and archaeological surveys carried out by several specialists to coordinate the project. - Double study of the frescoes: performed by an art history specialist for the investigation into the ornamental typologies and their corresponding graphic plans in order to date them by comparison with other ornamented areas; and an experienced restorer to study the fresco from a strictly technical point of view in order to decide on the most suitable processes for its restoration, both at a technical level and to safeguard the monumental impact of the work. - Geological study of the land where the foundations of the tower and the abbey are imbedded, since the fabric presented a history full of repairs. The aim was to elaborate a stratigraphic succession of the subsoil in the intervention area, define its lithological and geotechnical characteristics and analyse its hydrogeological conditions of exploitation. - Cognitive research into the fabrics of the walls with a view to consolidating them. This research consisted of determining the degree of compressive tension present near the base of the tower and examining the mechanical features, apart from extracting a few test tubes at different levels to determine the morphology and the constitution of the structures. - Chemical analysis of samples of mortar taken from the walls of the facade, both to confirm its construction at different stages of the tower and to find out what kind of adhesive would be most compatible with the sample extracted to carry out the possible consolidation works. - Archaeological excavations performed by experts in this field closely monitored by the corresponding technicians from the administration, useful in deciding on the approach to use and in collaborating in the architectonic decisions about the project.

The 13th Century Frescoes in the Abbot’s Palace

We have already explained that this great fresco, dated between the late 12th and the mid 13th century, is divided into three bands: the central part represents a moving cortège of various people – characterized by different types of physiognomies, costumes and hats; the upper frieze bears a scroll motif where a swan, a warrior and an ephesius can be seen; and the lower strip shows a hunting scene; and the lower strip shows a hunting scene.

The interpretative hypotheses proposed by the art historians and scholars of medieval iconography for the total recovery of the fresco brought to mind a historic-artistic debate that has been going on since the nineteenth twenties. The issue concerns the subject of the great “cortege fresco”: some scholars believe the scene is “historic” and that the emperor sitting on the throne is Frederick II with the peoples of the earth paying homage to him (Professor Fulvio Zuliani). Other researchers see it as a scene from the meeting of King Solomon and the Queen of Sheba. At the beginning of the restoration process, art historian Federico Zeri agreed with the first thesis and affirmed that the fresco must be read with precise iconographic attention. He believed that the unusual thing about this painting is its theme, one of the most peculiar examples of Romanesque painting on a secular topic in an archaizing style. Professor Victor H. Elbin of Berlin University was of the same opinion, and comparing the type of iconography and the form of this fresco with mural paintings in the Alto Adige (apse of the church of San Giovanni in Grigno), he believed there were common elements of Venetian-Byzantine influence combined with a Scandinavian-type ornamental taste. This fresco is currently still under study and the debate remains open.

Restoration of the Frescoes in the Emperor’s Hall

The problems in the “reading” of the complex wall decoration in the Emperor’s Hall were not only pictorial in nature but above all technical, consisting of a general state of deterioration and severe mutilations, apart from the restoration works performed in the course of its history (1926). The following intervention stages have been contemplated:

- Demolition of the cement mortars and elimination of the patches in the plaster
- Cleaning of the whole surface of the cortège painting by biocides and the three walls decorated with false ashlars by applying putties of paper paste and ammonium carbonate
- Definitive adhesion of the film of paint by applying lime water
- Filling of the gaps with inorganic materials: from cocciopesto to lime, including powdered marble and sand and excluding resins
- Restoration of the painting and varnish by using fresco pigments with acrylic in an easily soluble watery emulsion

Consolidation of the Framework in the Fresco Room

It is a framework whose main beams are 2.20 m long and made of fir wood, with 2.2 m between axes, and whose joists are also made timber of lesser scantling, covering a 6.50 m span with 80 cm between axes. In the fresco room the framework that was statically weak and in no condition to bear great stress was also consolidated. The consolidation works consisted of applying a concrete floor reinforced with electrically welded netting connected to the beams and joists by steel connectors inserted into the timber structure with special timber epoxy resins. The flooring was applied to reach the upper edge of the beams so that the connectors could work to absorb the stress and have a larger section of concrete to support them (figs. 17 y 18).

Stratigraphy of the Subsoil and Geo-Technical Features

The lithostratigraphy of the subsoil was performed on the esplanade in front of San Zeno Basilica, at about one metre from the tower. The lithologies present in the depth of the subsoil examined are made up exclusively of more or less coarse gravel in sand, muddy-sand and at times clay. Only the superficial layer, approximately 1.5 m thick, is made up of muds and clays with the presence of materials from the demolition of earlier buildings. During the surveys the Standard Penetration Tests were also carried out at a depth of between 3 and 3.45 m in the gravel layer in a sand and mud mixture, and at a depth of between 6 and 6.45 m in the layer of gravel in clay. The values of these tests compared to experimental curves facilitated the determination of the main geo-technical features of the soils studied in order to establish their mechanical behaviour induced by the tension caused by the weight of the tower. It was found that the loadbearing capacity of the foundation area of the abbey tower is relatively high: although the exact geometrical characteristics of the foundations are not known and presuming a safety coefficient of 3, a value of 4 – 5 kg/cm2 was estimated.

Furthermore, given the composition mainly made up of gravels in the subsoil of the area tested, we can affirm that the settlement of the foundation of the tower, always limited, took place in a short period of time during or after the application of loads arising from the construction of the tower itself.

Analysis of the Behaviour and the Structural State of Consistency

The research consisted primarily of the experimental and theoretical determination of the tensile stress at the base of the tower. To this end, a non-destructive test technique was used. This technique is based on the variation of the tensile stress at a given point in the structure provoked by a flat slit of reduced dimensions made perpendicularly to the surface of the fabric at the height of a layer of mortar. Inside this little slit, a special flat jack of variable dimensions (400 x 200 mm or 240 x 120 mm) and 100 mm thick, made up of soldered thin steel plates is inserted, and its internal pressure is gradually increased until it eliminates the deformation measured when the slit was made (figs. 19, 20).

In these conditions, the pressure inside the jack is equal to the tension existing in the fabric of the wall perpendicular to the plane of the jack, affected by an empirical coefficient that takes into consideration the relationship between the jack area and the slit area and the intrinsic rigidity of each particular jack, which can be recovered after the test and used again. Once the jack has been removed, the slit is filled with mortar to restore the fabric to its original state.

With this system the resistance and deformability of the walls is determined. A couple of flat jacks determined what part of the wall should be tested, and a compression load was applied to measure the deformations. The elasticity of the wall and its resistance were determined from the corresponding load/deformation curves (fig. 21, 22).

Another important analysis was the mechanical extraction of horizontal cylindrical test tubes to determine the materials that constitute the structural elements of the construction, revealing, in the case of two-faced walls with interior filling, the thickness of the outer walls and the internal nucleus. These extractions were performed by means of a hand-drill with a diamond-crowned bit and thin walls. The refrigeration fluid and the dimensions of the crown vary depending on the type of wall. With the samples thus obtained, mechanical tests and especially physicochemical laboratory tests can be performed.

The holes made in these extractions are inspected with a colour television microprobe (external diameter 10.3 mm) in order to increase the information already obtained by means of the description of the material extracted in the perforation, specifically as regards the identification and dimensioning of possible hollows and gaps in the internal mass of the wall.

Besides all these tests, many other numerical analyses have been carried out using an elastic linear model with eight-knot finite solid elements,
where the materials were assigned the values of deformability obtained in the double flat jack tests. Although the hypothesis of linearity for a material like masonry is obviously rather limiting, it does not seem to be very pragmatic to use complex non-linear models, particularly taking into account the practical difficulty involved in characterizing the material analytically.

For that reason the usefulness of a linear model was not to be underestimated: in fact it makes it possible to discover the effects of the lack of homogeneity (for example between the different surfaces of an uneven wall) and the geometrical discontinuity even in cases of macroscopic cracks. This analysis also facilitates the application of an interesting calculation procedure, based on tests of a dynamic type, which make it possible to carry out an overall control of the actual structure. The procedure is based on the comparison of parameters of the dynamic response obtained from accelerometer data and the corresponding values found by the numeric model. The results of the research carried out show that the inner layers of the wall are seriously deformed and present many hollows, which naturally causes a relative excess of tension in the outer surfaces of the wall. Consequently, it was considered advisable to perform injections, although only in the lower part of the tower, using materials that would involve the least possible risk from a physicochemical viewpoint.

There were also found to be structural deficiencies in the zone of the north wall (where the greatest tension existed) because of the poor state of repair of the fabric and the separation between the internal filling and the external surface. Numerous individual pieces in the fabric of the masonry were therefore replaced.

Chemical Analyses of the Mortar Samples and Cognitive Research into the Structure of the Fabric in the Tower

The probes carried out by the engineer Modena revealed two different situations. The fabric of the upper part of the tower (13th-14th century) was in a quite a compact state with cracks on the outside exclusively; the lower part, dating from the 12th century, on the other hand, revealed a more precarious situation with internal hollows and deep cracks.

As a result of these discoveries, it was deemed necessary to proceed with injections of adhesive materials to fill in the internal hollows and seal the surface cracks. In order to determine what kind of mortar would be compatible with the existing one, samples were taken from the fabrics and sent to Milan Polytechnic for chemical tests. In view of the fabric and the separation between the existing one and a clearly visible on the four sides (fig. 24).

The four walls display polychrome geometrical motifs with palmettes, three-leaved forms and checkerboard forms forming different ornamental patterns. From the incision of a graffito (a heraldic emblem of Mastino II della Scala) on the frescoed surface, these decorations can be dated around the first twenty years of the 14th century. For a more in-depth study, graphic mapping was performed for a geometrical survey of the decorative structure, as in the case of the palmette or three-leaved designs, clearly made by means of a series of superimposed circles (fig. 25).

Relating these tests with the studies performed previously on medieval textile decorations ("Le stoffe di Cangrande"), the "clothing" of this wall, based on three-leaved shapes, can be said to combine the classical spirit with the Byzantine. These frescoes, when compared also to other ornamentation conserved in other heritage interiors in Verona, show a common lexicon in their origin. In San Zeno, specifically, these geometrical rhythms allow us to visualize the correspondence that exists between the architectonic and the ornamental space according to the canons of a culture akin to Giotto’s circle. In fact this painter was a guest of the Scaligers’ and carried out works on their palace, which naturally had an influence on the cultural sphere of the city.

PICTURES

1. View of San Zeno church, the tower and the abbot’s palace.
2. Fresco Room: the cortege scene after restoration.
3. View of the tower and part of the abbot’s palace before the works.
4. View of the north wall of the tower displaying traces of the skirts of the abbey at its greatest height; on the circle of walls the remains of ashlar show the size of the palace.
5. View of the closing of the ogival arch and the reinforced concrete elements attached to the abbot’s palace before and after restoration works.
6. View of the doorway and the 19th century staircase inserted into the north frescoed wall of the tower.
7. Historic reading of the structures: plan of the ground floor and project.
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11. Cortege fresco on the north external wall of the tower.
12. Detail of the frieze of volutes over the cortege of dignitaries.
13. Detail of the hunting scene in the lower band of the fresco after restoration.
14. Transversal section of the master beam of the fresco room framework with the scheme of the static consolidation intervention.
15. Numeric model with the distribution of the tensions caused by permanent loads.
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17. Diagrams of the compressive deformations obtained by using flat double jacks on the external wall.
18. Cortege room, north wall. Graphic map of the burn-etched drawings representing the emblems of the Scaligeri family.
19. Internal view of the 14th century wall of the abbey tower before restoration.
20. Abbey tower: graphic and chromatic map of the south wall (4th and 5th floors) with the three-leaved believed to be the original.

Lynda S. Waggoner
Fallingwater: Preserving an American Icon

Fallingwater is a building that is known and loved the world over. Clearly, it is a great work of architecture and in many ways it has come to represent both the technological and design aspirations of the 20th century. It is an icon of the modern movement – a building so famous, in fact, that it doesn’t need to be identified. One is simply expected to know it.

Fallingwater was designed by Frank Lloyd Wright in 1935 for the Pittsburgh department store magnate Edgar Kaufmann Sr. The building came at a time in Wright’s career when he had designed nothing of any real significance for more than 10 years, and was generally thought to have nothing more to offer. He was 65 years old and had written his autobiography. Internationally, he was viewed much like the Biblical prophet Moses – a man who had led the way to the promised land but never quite made it there himself.

Out of favor, and with little money, Wright retreated to the country estate he called Taliesin nestled in the rolling hills of Wisconsin. In an effort to keep his ideas alive and his expenses met, he and his wife Olgivanna focused their efforts on a school for young architects they called the Taliesin Fellowship. The Kaufmanns, on the other hand, were a wealthy, and respected Pittsburgh family and the owners of one of the country’s leading department stores. They had only one child, named Edgar Jr., after his father. In 1929 at age 19 he left Pittsburgh to study painting in Europe. But, with the outset of the Great Depression he came home. However, very soon he found that American life, particularly in Pittsburgh, which was then a dirty industrial
city, was too provincial and lacked the intellectual stimulation he had come to know in Europe. Then a friend gave him a copy of Wright's autobiography and he said reading it was "Like water entering dry land." He found Wright's ideas stimulating and wanted to learn more. Wright was contacted and soon Edgar found himself at Taliesin as a member of The Taliesin Fellowship.

Now, Frank Lloyd Wright, like any architect worth his salt, had the keen ability to smell a prospective client from miles away. So it was fairly soon in 1934 that Mr. and Mrs. Kaufmann were invited to Taliesin to visit their son and the Wrights. The Kaufmanns and the Wrights became fast friends finding in each other a love of the natural world and longing for beauty in their lives. They invited Wright to come out to southwestern Pennsylvania to see their land at Bear Run and to discuss the possibility of a new weekend home. Construction for the new house began in 1936. By 1938 the main house was complete and Frank Lloyd Wright was propelled to fame once again. But there were problems almost immediately. Over 17 leaks appeared at various locations in the house, the concrete dirtied easily and was difficult to keep clean, but most troubling of all - two major cracks appeared on the master terrace as soon as the formwork and scaffolding were removed. The roofs were continuous – extending beneath the stone curtain walls suggested several inches.

Nevertheless these and other problems never diminished the Kaufmanns' enjoyment of Fallingwater. Mrs. Kaufmann wrote in a letter to Wright, "Fallingwater has been an education for us.

"After the death of both Mr. and Mrs. Kaufmann their son Edgar Jr. inherited the house. However, by the mid 1950s he was living and working in New York as the Curator of Design at the Museum of Modern Art and as time went on he found it increasingly difficult to get to Fallingwater, nearly 400 miles away, for weekend visits. Finally, in 1963 he decided to donate the house, the collections, and over 1,500 acres of land surrounding the house to the Western Pennsylvania Conservancy, a private non-profit land conservation organization he and his father had long supported.

In the deed of the gift he stated that the Western PA Conservancy was to maintain the buildings and grounds in their current state. The new structures visible from Fallingwater, and open the house for visitation. At the dedication Edgar Kaufmann stated that he gave the house to the Conservancy because, "I believe the Conservancy will give nature, the source, full due and art, the response to nature, full respect."

Over the years there have been a number of restoration projects at Fallingwater. But most of them have been focused on addressing specific problems such as when a tree fell on the main floor terraces beam in the late 70s or a flood damaged the stairs to the stream. However, today we are in the midst of the first major restoration of Fallingwater. Now nearly 65 years after it was built - it is the same three problems that the Kaufmanns complained of earlier on, that continuing were removed and the concrete floors and walls, an inability to keep the exterior concrete finishes from cracking and soiling and the continued deflection or sagging of the cantilevers.

In order to begin to plan for the restoration, we felt it important to develop a written preservation philosophy. The intention of the preservation philosophy is to guide all maintenance, preservation and restoration work at Fallingwater, whether conducted by professionals or the Western Pennsylvania Conservancy maintenance staff. The conservation philosophy is based, in part, on the United States Secretary of the Interior’s Standards for the Treatment of Historic Properties and the Burra Charter adopted by the Australian ICONOS in 1979. The following is a general statement from the philosophy: A primary goal of all preservation efforts at Fallingwater is for Frank Lloyd Wright's original artistic intent. Every effort will be made to make all conservation of the building as noninvasive as possible, but all interventions must be measured against the impact on Wright's original vision and the Western Pennsylvania Conservancy's goal to preserve the building for future generations. No effort shall be made to revise or improve upon the original design for aesthetic purposes. However, changes to original building systems can be made if such changes contribute significantly to the long-term preservation of the building. We know that one characteristic of modernist architects like Frank Lloyd Wright is that they stretched both technology and design to their limits as they explored new forms and materials. The centuries of preserving Fowks that man had gained in vernacular construction was very often forfeited in favor of aesthetic aspirations. Consequently, in our philosophy of restoration we allow for some flexibility because we believe that a strict adherence to the original design does not allow us to use improved technology or materials may ultimately threaten the long term survival of the building itself. Our goal is to seek a balance.

Fallingwater has several problematic design features. The roofs are famous. However in our region of the United States ones never finds flat roofs in traditional construction mainly because of the climate. Southwestern Pennsylvania is known as a place where if it is not raining, it is probably because its snowing. Likewise, the stonework at Fallingwater is beautiful but not always practical. The stone at Fallingwater was all quarried on the site only a few hundred feet downstream. It was laid up in an uneven horizontal fashion specified by Wright and designed to suggest the sandstone cliffs that surround Fallingwater. But as beautiful as walls are, the little ledges that are created a result of this masonry technique create a unique problem. When it snows, the snow lays on the ledge-like projections and as it melts the water does not shed as it would in traditional construction. The water drainage through the mortar joints creating leaks like those seen in the slide on the right.

The roofs at Fallingwater have always been a challenge. Not only are they flat but also they have multiple functions. For example, here on Edgar Kaufmann Sr.'s terrace we have not only the obvious -a terrace- but also a functional roof over the sitting room below. Thus it must be able to perform as a terrace that thousands of people walk on each year, but protect the space below from the weather. When the Kaufmanns first acquired Fallingwater they complained of there being 17 leaks. We have improved on that statistic significantly, but the roof remains one of the most problematic parts of the building and one we are addressing this year. The asphalt roofs at Fallingwater were asphalt or built up roofs. They were continuous – extending beneath the stone pavers on the terraces, under the thresholds of the terrace doors from the exterior terraces into the house itself. The mesh of the asphalt roofs, which had been replaced several times, were removed and a rubber membrane roof installed.

The roofing system is an IRMA system, which stands for inverted roofing membrane assembly system. The system is based on Bituthene 400, manufactured by W.R. Grace. Deck Prep (a low viscosity, two-component asphalt-modified urethane coating) was applied over the Hardibacker. Two plies of Bituthene 4,000 were then installed over the Deck Prep; the edges were sealed with Bituthene Mastic, a rubberized asphalt-based mastic. Copper flashing was seated in a regret in the concrete parapet. A hydraulic drainage system was then installed. The mat acts both as a protection board for the membrane and the means to direct moisture towards the new drains. The drains are J.R. Smith drains with perforated collars to collect subsurface water. The drain lines were then laid in coarse sand and a cement mortar is placed between the stones. The mortar mix is the same mixture as the original 1 - 3 (cement: sand).

Another great challenge has been the restoration of the concrete to its original look. The smooth, almost pristine surfaces are essential to a proper understanding and appreciation of the machine age aesthetic of modernism. But maintaining the concrete surfaces has always been troublesome at Fallingwater, often streaked and dirty. Regardless of the reason, because the early paint system, a cementitious coating, was not easily cleaned, a practice of frequent repainting was established. Eventually, after years of layering paint upon paint, more and more cracks as well as peeling began to appear. The thinking in the mid 70s was that to address the problem one should remove all the existing paint and replace it with a waterproof system, which the Conservancy as well as many other historic properties did by sandblasting. Of course, we have since come to understand that this practice does not address the real problem rather it accelerates it. Regardless of what preventative measures are undertaken, water will inevitably find its way into concrete. The real problem occurs when it is unable to get out. In a 1970's water proofing effort a product called THOROSEAL was applied to Fallingwater and it literally encapsulated the building by creating such strong barrier that water vapor could not escape the concrete. Of course, when water becomes trapped in materials like concrete, brick or stone, in cold climates like ours where it freezes, it will expand causing the material to crack and spal. And this is what we faced in 1990 when we began a study of the concrete. We engaged Norman Weiss, an architectural materials conservator from Columbia University, and Stephen Gottlieb, a preservation architect. Fortunately their study showed that generally the concrete was in good condition, except on the parapet rolls, around drains and on some corner soffits as we saw earlier in the roofing slide.

It seems that at Fallingwater, a project for a very wealthy client, Wright did not cut corners as he often did in other jobs, usually to compensate for being over budget. Instead, he specified a very high quality of concrete - one with more than the usual amount of Portland cement.

In addition, the quality of the pre World War 2 steel used for the reinforcing bars was excellent because the quality iron ore was much higher than what we have today. The resulting concrete is one that corrodes. Nevertheless, through the construction photographs we have been able to understand that the reinforcement rods imbedded in the concrete were not laid properly. In some cases, they were not tied at all or not tied close enough to allow the continuity between de reinforcement rods of the beams and the parapet was not observed, thus reducing structural integrity.

As we studied to concrete more and more we discovered that most of the problems were more
cosmetic than structural. The majority of the deterioration was occurring within the parge or plaster coat of the concrete - that thin cementitious coating that is applied to create a smooth look to the concrete which otherwise would show the impression of the wooden forms into which it was poured. We found what we needed was to develop a method of filling surface cracks and finding a better coating or painting system.

We explored and abandoned some methods of repair, including this experiment in epoxy injection, which was extraordinary to look at but turned out to be an overkill because typically the cracks are not very deep and when the syringes were removed they left a kind of puck mark impression that was very hard to repair. Ultimately, Norman Weiss developed a method of filling the cracks with stucco-like fillers that incorporates a ceramic micro balloon material rather than sand. The micro balloon mix is used for the conservation of outdoor sculpture, but it works beautifully in our application because unlike sand stucco it does not burnish when you try to smooth the surface that matches the undamaged surrounding surface. The other problem we found in patching was finding someone to do the work that could make the surfaces as smooth as we needed them to be. Usually, welders we found most are not accustomed to working with the tolerances we require to achieve the desired smooth modernist surface. We finally turned to the husband of our bookkeeper. Trained in auto body repair, he was able to do the work perfectly, and subsequently taught our men this technique.

Most of the patching and repainting of Fallingwater is now complete. However, it took us over three years to remove the old Thoroseal paint coating. In some locations we found as many as 12 layers of paint. Today the building is coated with a new silicone emulsion paint system manufactured by PRO SO CO of Kansas City. It is water resistant, but also allows for the transmission of vapor. In addition, it incorporates a biocide that helps to reduce biological soiling in densely foliated, high humidity locations like ours, and it is easily washed so we will not have to repaint it as frequently. We are also pleased to report that the color of Fallingwater was still close to the original specified by Wright. Prior to beginning the repainting program, we performed a color analysis to determine more precisely the original color of the concrete and the steel sash. By taking samples of old paint that had never been removed, most of which we found up under the piers beneath the house or behind switch plates and in locations like the furnace room and then examining them in section under a microscope, we were able to establish a history of every color the house had ever been painted from the first coat, which was a pale ochre to an almost white color in the fifties, to a very warm and dark apricot in the seventies, and finally, back to the pale ochre color of the original. Each color was compared to a computer color notation system which identifies colors numerically thus enabling any good paint company to mix future batches fairly exactly.

But in 1996 a new problem surfaced - the structural integrity of the cantilevers themselves was in question. Shortly after Fallingwater was constructed, the Pittsburgh engineering firm of Metzer and Richardson, who were supplying the steel, reported structural cracks in the beams and joists of the 1st and 2nd floor cantilevers as well as the parapet around the stairway that goes down into the stream. It was also noted that all of the major cantilevers had deflected or begin to sag. Edgar Kaufmann Jr. wrote in his book Fallingwater: A Frank Lloyd Wright Country House that "the cracks worried my father throughout his life". To allay his fears, his father had careful measurements taken every year until his death in 1955. Edgar Jr. accepted Frank Lloyd Wright’s explanation that the cantilevers should have been canted up about 8 degrees to allow for settling and that although they were sagging, they had stabilized. After his father’s death, Edgar Jr. discontinued the monitoring, except for the rather low-tech approach shown here that involved placing a stick between the top of the 1st floor parapet and the base of the trellis above. Since there seemed to be no change in the distance between the two he believed everything to be sound.

However, in 1995 an engineering student from the University of Virginia undertook a mathematical analysis of the master terrace from available information and employing some limited computer modeling. He concluded that the master terrace was not as had been previously thought, a self-supporting cantilever and was indeed transferring its load via the window sills. We had stabilized. After his father’s death, Edgar Jr. discontinued the monitoring, except for the rather low-tech approach shown here that involved placing a stick between the top of the 1st floor parapet and the base of the trellis above. Since there seemed to be no change in the distance between the two he believed everything to be sound. At the same time, we undertook a program of non-destructive testing using 3 principal methods: Impulse Radar, Ultrasonic Pulse Velocity and High Resolution Metal Detectors. Non-destructive testing enabled us to analyze the conditions within the building without destroying the historic fabric of the building in the process. Each method we used - Impulse Radar, Ultrasonic Pulse Velocity and High Resolution Metal Detecting - provided us with different types of information and together they afforded us a good picture of the internal structure of the area. Therefore, using the method used, the equipment identified cracks, voids and poor consolidation in concrete as well as determining more precisely where the reinforcing steel is located and what its condition is. With this detailed information we were able to more accurately determine the compressive strength of the concrete and its general condition. The compressive strength of the undamaged concrete was, as we expected given the previous Columbia University study, very high. The tests found approximately 40% of the concrete undamaged, 47% had minor weaknesses, primarily micro cracking of the parge coat but still acceptable in terms of strength - and 13% was found to be in poor condition. The high resolution radar was used to examine the steel placement and this was found to be generally in accordance with Wright’s and his engineer’s specifications. There was also little evidence of corrosion of the reinforcing bars. With knowledge of where the steel was placed in the concrete, the next step was to gain a better understanding of how the building works structurally. Fallingwater has always impressed visitors with its soaring cantilevers that seem to defy gravity. But how the cantilevers actually work has always presented a number of questions. Here we see both the east and west elevations of the living room and master terrace cantilevers. Historically we had assumed that the parapets, i.e. the low walls around the terraces, contribute structurally to the stiffening of the cantilever. And as mentioned earlier, we also thought that the living room cantilever of the master terrace generally were self-supporting, that is, worked independently from one another. But Silman’s analysis showed otherwise. We knew that the window mullions, which are T supports, did provide some central support for the master terrace cantilever directly above; however, until the report we did not know the living room cantilever was carrying the full weight of the master terrace. This is how it works:

Within the master terrace the beams are placed east to west, in line with the parapets. Joists are located on 4 ft. centers between the beams. Within the larger first floor cantilever there are four reinforced concrete beams located parallel to one another going north to south on approximately 16-foot centers. These large reinforced concrete beams rather than, say, steel "I" beams, provide the strength and thus support for the primary cantilevers in the main house. Therefore, we have identified the placement of the reinforcing steel in the case of the beam of the master terrace, which have continuous steel in the bottom and discontinuous on the top, we know this was not intended to be a self-supporting cantilever as there is extending out from the supporting masonry piers of the living room below, as it should have been. The consequence of this omission is the vertical cracking that appears in the parapets of the master terrace, because the concrete alone is unable to handle the tension that would normally be taken by the steel reinforcing. Using this and other information, Silman then developed a computer model and projected several scenarios finally settling on the one that portrays the master terrace as a non self-supporting cantilever which is transferring its load via the stone piers and window mullions to the cantilever below. He also determined that the deflections are continuing although at a greatly reduced rate.

You may have heard the story that Edgar Kaufmann Sr., worried that there was not enough steel reinforcing, engaged outside engineers to review Wright’s plans. This enraged Wright and there was an exchange of angry letters between the two. Wright cried out: "I don’t know what kind of architect you are familiar with but it apparently isn’t the kind I think I am. You seem not to know how to treat a decent one. I have put so much more into this than you or any other client has a right to expect
that if I haven’t your confidence -to hell with the whole thing.” Kaufmann quickly responded with a letter which was a parody of the one Wright had written him, and in which he says, “I don’t know what kind of client you are familiar with but it apparently isn’t the kind I think I am. You seem not to know how to treat a decent one. I have put so much into this building and they conspired on this whole project in my limited way, to help the fulfillment of your efforts that I haven’t your confidence -to hell with the whole thing.” Kaufmann then added a postscript in which he suggests long letters and get on with the project. Wright endeavored to keep the house light in weight because he felt that placing too much steel in the structure would cause the house to sag under its own mass. However, in a recently uncovered taped interview of Wright’s apprentices on the project (Wes Peters, Bob Mosher and Edgar Tafel), we find them discussing the problem with the steel reinforcing 45 years later. Their conversation suggests that they too thought there was too little steel reinforcement in Wright’s design and they conspired with the contractor to double the amount of steel. In studying the plans and data, it appears that without the additional steel put in the first floor cantilever at the time of construction Fallingwater would likely not be standing today. This is how we are addressing the problem. First, we realized that the deflections could not go unchecked. Therefore, the first measure taken when we realized the extent of the problem was to install temporary shoring to prevent any further sagging. Initially the shoring was not carrying any load, but was simply snugged up under the building. However, a recent examination indicates that the cantilever has continued to deflect and therefore the cantilevered portion of the building is now resting on the shoring. The shoring will also be used during the repair to take the load off of the living room beams as we go about strengthening them. The geometry of the strands’ placement is carefully calculated to ensure that the large post-tensioning forces will always oppose the inner stresses now present in the beams. The strands will then be threaded through the face of the south living room parapet and a post-tensioning jack will be used to tension each group of strands on either side of the beam until the required 200,000 pound or 100 ton force is reached, which places 400,000 pounds or 200 tons of tension on each beam. The jack will then be removed and the strands will be cut off inside the parapet. R. Silman Associates is still in the process of investigating the ability to adjust the strands, in case more tensioning is required in the future. The exterior concrete where the cables terminate will then be patched. In order to achieve proper transfer of forces from the living room to the master terrace, the concrete joist directly above the four steel “T” millions will be reinforced by bolting a steel channel to each side. With this external post-tensioning proposal, the concrete condition at the top of the beam will not interfere with the design or limit the potential for reinforcement. However, to minimize the potential uplift of the main cantilever when post-tensioning is introduced, existing cracks in the top concrete beam will require injection with an epoxy adhesive. If the cracks are not filled, they could compress causing the main cantilever to lift slightly upwards. This upward movement would further shift the steel-framed windows and potentially break out existing glass. The proposal allows for the reinforcement to remain in the existing floor cavity with minimum disturbance to the original concrete fabric. However, in order to access the beams, a significant portion of the living room floor will have to be removed. When the floor is lifted to access the beams for the repair behind the master Lloyd Wright built-in furniture will be removed. Removal of the library desk and the south and west couches will allow for much needed wood conservation, which cannot take place in-situ. The removal of the floor will also enable us to conduct a thorough examination of the mechanical systems located there both electrical and plumbing. If repair is needed, it will performed at this time. Once the work is complete, the furniture will be re-installed. The east and west terraces will also be lifted during the post tensioning, so this work will be combined with necessary waterproofing (described below). The only historic fabric that will be lost is the flagstones’ cement bedding and joints. Every effort will be made to reuse the original redwood sub-floor. Once the living room cantilever is strengthened, the shoring underneath the building will be removed, allowing the cantilever, once again, to project over the waterfall as Wright intended. There are components that will require strengthening as well. Since Edgar Kaufmann Sr.’s terrace cantilever is not as overstressed as those of the living room, epoxying carbon fiber to the beams and joists that provide its structural support will adequately reinforce it. There is also a long horizontal crack at the juncture where the canopy over the walkway connects the main house to the guesthouse. This crack has been repeatedly patched and filled, but continues to re-open and widen. Robert Silman Associates identified the crack as a stress crack. They propose taking a conservative approach and installing an expansion joint along the crack. If this does not relieve enough of the stress, a strengthening method will be employed. The steel sash windows will receive a programmed and prioritized intervention. In each location, once paint stripping is completed, an assessment of individual components will be made with an emphasis on retaining as much original material as possible. Any repair, the corrosion and repair as much of the hardware as possible. Hopes of Jamestown, New York, the original fabricators of the steel windows and doors, will produce all replacement components. All windows, doors and hardware were custom made for Fallingwater and Hopes is still in possession of some of the original shop drawings. This will not be the first window replacement. Several years ago all of the glass in the house was replaced with UV filtered glass to prevent ultraviolet damage to the woodworking. However, all perimeter seals will need to be replaced and a program of monitoring will then be implemented. The replacement of the sealant requires the complete removal of the existing sealant and cleaning of the metal surfaces. A drip channel will be cut at the head of the windows and doors in the main house. This detail will be made to match the original drip edge currently on the windows and doors in the guesthouse, without addition will be of enormous importance to the preservation of the steel sash as well as the interior finishes at or near the windows. The preservation of the building is not our only issue at Fallingwater. In recent years we have become increasingly concerned about the impact of our large visitation on the landscape. The parking lot has been expanded, maintenance facilities have grown and sometimes visitors themselves damage the site by trampling over hillsides in their eagerness to get the perfect photograph or a better view resulting in an ongoing battle with erosion caused by photographers climbing the hills. As our visitors have increased we have begun to notice paths are becoming wider, signage is increasing, edges are being lost. We have also suffered from the impact of gypsy moth infestation and have lost many large trees. We have also begun to notice that there is little succession, no small trees seems to be coming up. And in a very general way, we have noticed an increasingly unkempt quality to areas that were intended to be more manicured. We sought professional guidance to develop a management and preservation plan for the Fallingwater landscape eventually, choosing Andropogon, a Philadelphia firm known for bringing an ecological perspective to the traditional area of landscape architecture. Andropogon recognizes Fallingwater as a subtle and complex work of art that cannot be separated from the land around it. Each element in the landscape is part of a larger whole and if one element is unraveled, the integrity of the whole experience is compromised. We have completed Phase 1 of the management plan. The focus of this portion has been on developing an overall philosophy for and interpretation of the landscape. In the study there are specific recommendations as well as guidelines to approach the various component parts of the site. Actual design and implementation will come in phase 2. Briefly, we have outlined a stewardship philosophy that meets both the conservation and artistic goals of the Western Pennsylvania Conservancy in its role as trustee of Fallingwater. The 5,000 Bear Run Preserve will be managed for the scientific goal of eco-system health and biodiversity. At Fallingwater this scientific goal for the forest will be integrated with an artistic goal—the recovery of the drama, beauty and visual richness of the old growth forest. We anticipate the programs for the restoration and management of the landscape and the Forest to become an important component of our interpretive program, and will dovetail with the restoration of the house and its interpretation. As part of the Landscape Interpretation Plan our landscape team identified several landscapes within the larger Fallingwater property. They are: 1) the approach landscape or, what is called the overture;2) the estate landscape with its sense of arrival and invitation; 3) the visitor landscape, which should provide orientation and a sense of anticipation; 4) the cultural landscape with its references to the site’s history and past uses; 5) the forest setting with the first glimpses of the house and its quality of revelation what we also call the “ ah ha” moment; and 6) The forest garden within which one makes connection with the art of the house itself. And there are other subsets of the primary landscapes. Each part of the site will be managed with regard of building on its individual characteristics as I’ve described them. We plan to restore the pathway edges, add more natural plantings, develop a more discreet signage program, tighten pathways, and select and place the institutional elements with greater care. The
In public baths, which usually had double installations so that they could be used by men and women at the same time, there was a palaestra at the end of the baths to do physical exercises.

The Sant Boi baths
The Sant Boi baths originally, at the beginning of the 3rd century, followed the classical model of thermal baths in a linear format, made up of seven rooms divided into two blocks (the heated room and the cold ones). As we pointed out above, they were private. The settlement it belonged to and the baths themselves were much used during the 5th century and also probably during the Visigothic period, up to the 8th century. We do not know when the farm and the surrounding buildings eventually stopped being used, but we know that a large part of the bath installations were still in good condition in the 17th century, although they were unused. Around that time a house was built on top of the ruins, and some of the buildings underneath were used as a basement for the new house.

The memory of the Roman settlement and the baths was lost in the annals of history. Even so, until well into the 19th century there was a place named to them (possibly no longer decipherable), derived from the old custom of identifying ancient times with our Muslim past: the street beside the place the old baths had originally been and totally buried at the time was known as "Mosque Street". This name, which had been a reference to this historic monument, was lost in the middle of the 20th century.

In 1955, Carles Martí Vila, a scholar of Sant Boi, noticed that an 1829 document referred to the fact that there were "traces of a mosque" in that part of the town. The document also mentioned the existence of tile paving buried below "twelve or thirteen palms" of soil. These data together with the no longer used name made Carles Martí think that there might be old remains with tiles in that place. His friend and co-investigator, Ramon Mas Campderrós, and another few amateur archaeologists immediately set about excavating the area financed by the Council, and were not long uncovering the frigidarium mosaic, the best and largest of those conserved, so they were able to state that the remains hidden in that place for so many centuries were of Roman origin.

Between 1954 and 1959 the research was taken to a more scientific level and this was decided as the works went on, and even changed several times during the works (conditioned by an amplification of the original site), which were by no means linear or simple. The solutions to the three aims depended very much upon one another and none of them had a clear starting point: the options as to how to restore the remains (whether simply to consolidate them, rebuild them on the basis of scientific data, eliminate the additions of earlier restoration works, etc.) depended on how these remains were to be displayed and vice versa (whether the spectator should be able to walk around to understand the original space or look at them from the outside, directly as they were or virtually reconstructed by technological contrivances, etc.); and in both cases, these decisions in turn depended on how to protect both the remains and the visitors (by means of an air-conditioned building, a mere roof, an annex attached to a museum or a museum with an independent programme, etc.). The character of the building...
did not only depend on conceptual reasons either, but on organizational, technical and administrative factors alien to it (since the museum or whatever it turned out to be depended on the town council, which changed its mind and its employees several times during the process).

The final set of criteria adopted, the result of successive decisions (all conditioned, as we said above, by all kinds of events), was as follows: in the first place, to preserve the remains of the baths (after cleaning, consolidating and repairing them generally), in the form and volume they had reached us without removing or adding anything (although, of course, "augmented", since parts previously not on view would be uncovered); as regards visits, to establish a route around the outside of the remains to avoid damaging them, and use traditional educational procedures to explain their history and architecture; and finally, as regards protection, to erect a single space building to make it possible to preserve the remains and visit them more easily; this building would not be conceived as a museum, but as a monographic room of a larger installation (as far as content and installations were concerned) and, as a result, with an exclusive programme for visits, without any other type of service or activity, so that it could be considered a semi-open, non-commercial enclosure. These programme criteria included other less explicit and more conceptual ideas: the historic architecture to be protected and displayed (the real monument, the remains of the baths) and the new architecture (the sheltering building) should be different from each other and respect each other without ambiguity. The monument must not be spoil in any way by the new building (obviously subsidiary to it) and the new building must not be aesthetically limited by the monument. And the spectator must notice this difference and respect and feel (at the same time but separately) the emotions produced in him by the historic remains as such (as an heirloom, as a document) and, on the other hand, the new architecture (with its possible spatial, formal and functional values).

Restoration of the ruins

In spite of the vicissitudes undergone by its fabric, Sant Boi is a preserved Roman baths in Catalonia (the height of the walls in places, for example, is 4.8 m above the lower hypocaust paving, a very unusual case). Furthermore, six of its seven rooms containing some very significant elements have lasted until our days. The apodyterium conserves remains of the mosaic flooring decorated with a border of flowers and a fret edging, with a black and white geometric design; the frigidarium and the tepidarium, the caldarium and the sudatorium and the drains of the two latter.

When the intervention on the remains started in 1989, a definitive criterion about how to carry it out still had not been drawn up, although the possibility of an ideal reconstruction was contemplated and studies were being performed in that direction. Nevertheless, as the conservation steps were taken (several walls of the apodyterium, sudatorium and caldarium were reinforced, the base of the east wall of the tepidarium was immobilized and some old pavements were braced). Some of these steps could not be made without removing or adding anything (although, of course, "augmented", since parts previously not on view would be uncovered) as regards visits, to establish a route around the outside of the remains to avoid damaging them, and use traditional educational procedures to explain their history and architecture; and finally, as regards protection, to erect a single space building to make it possible to preserve the remains and visit them more easily; this building would not be conceived as a museum, but as a monographic room of a larger installation (as far as content and installations were concerned) and, as a result, with an exclusive programme for visits, without any other type of service or activity, so that it could be considered a semi-open, non-commercial enclosure. These programme criteria included other less explicit and more conceptual ideas: the historic architecture to be protected and displayed (the real monument, the remains of the baths) and the new architecture (the sheltering building) should be different from each other and respect each other without ambiguity. The monument must not be spoil in any way by the new building (obviously subsidiary to it) and the new building must not be aesthetically limited by the monument. And the spectator must notice this difference and respect and feel (at the same time but separately) the emotions produced in him by the historic remains as such (as an heirloom, as a document) and, on the other hand, the new architecture (with its possible spatial, formal and functional values).

Restoration of mosaics

The mosaics were very badly damaged; many tessereae were missing and there were different chamfers and filling in with cement (Portland, fast setting cement, was used in the sixties). The first step was to remove the superimposed elements and many tessereae were found to have come loose from the substratum. Polyvinyl acetate dissolved in 50% distilled water was injected to consolidate them. At the same time the borders of the mosaic were set with a bevel of slaked lime mortar and washed silicon sand (two types of grain: one finer and the other thicker) in a 1:3 proportion. Once the bevel had been applied to the pavements, a shower of sand was applied to the finish to facilitate integration and uniformity of colour. Mechanical cleaning was then performed with vacuum cleaners, brushes, a dentist’s drill and a scalpel to eliminate the mortar stains. Next a chemical cleaning process was applied, with distilled water and neutral soap. This intervention was sufficient on all the mosaic except the door into the tepidarium. Here cleaning with a solution of sepiolite (hydrophilic clay and detergent) and 5% trietolamine (soap), mixed with distilled water was used. As regards gaps, in accordance with the general intervention criteria on the remains, the tessereae were not replaced but the gaps were filled in with lime mortar.

The new protection building

It was decided that the general features of the building that was to house the remains and facilitate visits to their features (without undergoing serious variations throughout the reflection and project process) would be as follows: it was to consist of a semi-open hall, spatially diaphanous (to allow as much natural daylight illumination as possible), cover the historic remains with politics of sepiolite (hydrophilic clay and detergent) and 5% trietolamine (soap), mixed with distilled water was used. As regards gaps, in accordance with the general intervention criteria on the remains, the tessereae were not replaced but the gaps were filled in with lime mortar.
metal bolted mouldings) letting in natural light and making it possible to see the Roman baths from the outside. The surfaces of the side facades are made of white yellowish brick and those of the main facade of hand-made red Catalan-style brick. These walls, resting on the retaining walls forming a continuous unit, stick out from the crowning line of the roofs like a pediment. The partition wall with the block of apartments (much higher than our building) is sloped to provide greater protection from the elements. On the external surface of the new wall, a stucco finish and geometrical patterns and frets reproduces a detail of the conserved Roman mosaic pavement and acts as an identifying publicity element in the section, which can be seen from many places. There are three direct ways in: the main one, situated where the two streets meet beside the glass door presents a higher wall that the other sides, finished in Arni-Viola type marble slabs in shades of pink. The second (which is also an emergency exit) is at the south-west end, and the third, situated beside the partition wall of the public gardens, is adapted for the entry of people with physical impediments.

The roof

The construction has a floor plan of about 550 m² and a maximum height with respect to road level of approximately 5.5 m. The archaeological remains occupy approximately 175 m², they are an average of almost three metres high and are some four metres below street level. The inside of the building is a single continuous space permitting a constant, itinerant, panoramic view of the bath remains. The roof is developed in three sections. The first is a set of opaque panels with a copper finish, spread out like a fan and layered at different levels to facilitate the ventilation of the space. It is supported by seven beams that rest on some walls and are anchored laterally to others by the stem. The second section, corresponding to the central part of the building, is a sloping plane, mostly translucent, of plaques of alveolar polycarbonate, permitting natural daylight and artificial night illumination of the ruins. In the zones covering parts of the visit itinerary, the panels are opaque, self-supporting, made of aluminium sheets that can be walked on, from some of which rise static cast iron fans to increase the ventilation of the interior space. The structure is made up of two beams (like louver beams with rectangular tubes), which stand out from the roof, from which hang the purlins, also made of steel tubes, made rigid and stable by crossed stainless steel tensors. The third section of the roof, with only one pitch, but in the opposite direction to the second, is resolved with opaque panels covered with copper sheeting. This section and the second rest on beams that hide the gutters for collecting rainwater.

Access and itineraries

Through the main entrance one arrives at the hall and, then, to a wall with the panelled doors to the ruins, from which the latter can be contemplated from different angles. The vertical surfaces of the steps are covered with slabs of classical Travertino marble with a jagged finish, decorated with horizontal grooves. The same as in all the other spaces, is unpolished Travertino marble. The steps of the stairs are made of prefabricated concrete. The free spaces between the ruins and the new building are paved with a carpet of fine, round gravel. At the opposite end to the entrance, beside the partition wall, there is a rectangular room giving on to the remains, so as to be able to see them from a medium height. At the south-west corner of this room there is a small triangular balcony from which that part of the baths can be seen better. The lateral itinerary goes between the lower part of the stairs, almost on the same level as the ruins, and the intermediate room. It starts with a metal staircase leading to a balcony overlooking the ruins, with a horizontal catwalk connecting it to the western room. From this level of the balcony, handicapped visitors can get in and out by means of a mobile platform and continue their visit along the catwalk. The structure of the catwalk and the balcony of the visitors’ route is made up handrails of 240 x 40 mm and stiffeners of 70 x 20 mm. The pavement is self-supporting steel plate with a relief pattern, with enamel paint, the same as the staircase. The banisters and protections are steel handrails and mullions and laminated glass and butyral sheet panels. The handrails are square section tubes with one of the diagonals in vertical. There are semi-cylindrical armrests, and the intermediate room. It starts where there is a very expressive or suggestive view of the ruins to induce the spectator to stop and look.

Presentation and museum aspect

As regards the presentation of the thermal baths, it was deemed essential that the ruins themselves be the greatest attraction for the visitors without other objects or mechanisms distracting their attention; for that reason, we decided to do without sophisticated audio-visual aids or virtual reality or any other kind of apparatus or games, which are so much in fashion nowadays in this type of installation. (There is a risk that these artefacts may lose their didactic function to become an end in themselves, used for propaganda purposes or as consumer attractions, which is why they are so popular among many cultural promoters, who use them as banners of modernity, a fallacy followed by a large number of professionals.)

The museum programme was resolved, therefore, by means of informative panels, glass cases with materials and two models. As for the itinerary, the idea of the visitors walking through the ruins was discarded (to avoid greater deterioration and because the usual apparatus designed to let visitors in, apart from expensive and complicated to adapt, end up complicating the ruins they are meant to simplify). The perceptive emotive route was structured as follows: in the first place, right from the entrance the visitors can see, to their surprise and delight, a full view of the ruins. At that moment they receive a minimum amount of information on panels. They then start to approach the remains slowly, going down the stairs, where they can see different angles from the vantage points at the four levels. Depending on the type of visit, they will stop and be given oral information on this staircase or not. When they reach the bottom, before they go on if they wish they can get more detailed information in the form of a model and three panels. They then go up to the balcony, along the catwalk (enjoying new perspectives, some of which are suggested by means of armrests, and finding additional information on bookstands) to the west hall, where more information is provided (a second model, audio-visuals, and from where they have a close-up view of the ruins). The following approach was applied to the information: the panels situated at the entrance, titled Sant Boi antes de Sant Boi (Sant Boi before Sant Boi) and La investigación y la restauración (Research and restoration), explain the appearance and formation of the urban nucleus of Sant Boi de Llobregat and the history of the excavation and restoration of the ruins with written texts and illustrations. The first model shows an idealized reconstruction of the landscape at Sant Boi in Roman times, with the villa and the baths, the building being situated with exactly the same orientation as the ruins so that the spectators can compare and understand the transformation undergone. Of the panels placed underneath the balcony, the first one speaks about the origin, evolution and character of the baths, the second about the functions and customs of Roman baths and the third explains the architecture. The two glass cases contain fragments of architectonic and archaeological remains (mosaic, cornice, ceramics, etc.) and objects of daily use. From up on the balcony, looking downwards to where the model is, the visitors can see still better what the territory was like at the time the baths were built, and they can situate them on the model thanks to a red spot marked “You are here” on the glass cases. Throughout the route that follows, two bookstands hold different views of the baths (with the same orientation so as not to confuse the spectators), indicating the different rooms. In the second model, the bath building is shown as it was used, sectioned so that the visitors can understand how the different rooms worked. At the end of the itinerary, a panel talks about the activity of the amphora-making centre that existed on the spot before the baths were built, and it is accompanied by a glass case with fragments of amphorae and an explanation of marks the potters used, and an amphora recuperated and restored in the sixties hanging from the wall over one of the panels. The artificial lighting of the ruins is provided by an exterior element that illuminates them through the skylight as though it were natural light. Inside, lights built into the floor underline the volumetric shape and the design of the steps of stairs. The west hall has no specific lighting of its own, since the lighting of the ruins is sufficient.

TECHNICAL DATA

Location Sant Boi de Llobregat (Baix Llobregat area, Barcelona province)

Intervention Promoted by the City Council and carried out by SPAL from Barcelona Provincial Council (1989-1998)


Total investment 238,000,000. (Treatment of remains: 53 m. [archaeological excavation, 17.5; restoration, 24.5; surveys and studies: 11.])

Protection building: 185 m. [works: 165; studies: 20]
At the end of the 16th century there was a proposal to build a masonry structure in Valladolid, although the existing documents do not make it clear whether this project was actually put into practice. Part of this aqueduct went on being a construction of large timber conduits taking water from the sources south-east of Valladolid to the centre of the city. This aqueduct was modified, repaired and perfected on many occasions throughout the 18th century. The current masonry structure probably dates mainly from the 18th century. Juárez speaks about it as follows: "The 18th century put a definitive stamp on the material fabric and the architectonic style of Valladolid. The height of each of the wooden pieces were replaced at that time by stone so as to solve forever more the scarcity of water caused by the constant collapsing of the older structure. The first stone section was completed between 1728 and 1730 and followed by an underground pipeline to transport the water to different fountains and convents in the city. This stonework construction was the prolongation of a timber structure that brought the water from its sources to the outskirts of the city, so that the two construction systems were thus joined together. However, in 1784 the "collapse of over 30 varas of piping and 20 arces" was reported. From this moment on, the reconstruction of the aqueduct became a priority for the inhabitants of the Valladolid.

The edict for the reconstruction of the aqueduct was issued 21st October 1785 with the participation of Fray Antonio de San Miguel, a fervent supporter of this work. The document states that the works had two aims: to supply the city with water and to provide work for the unemployed. The foreman of the works was Isidro Huarte and the chief architect, Diego Durán. Some arches were completely rebuilt and buttresses were added to the existing structure in places. From the historic documents it was not possible to determine exactly what parts were rebuilt, so detailed research was carried out during the restoration to permit the detection of different construction stages in the aqueduct. This aqueduct went on serving the people of Valladolid-Morelia until 1910, when it was replaced by a new system of water supply. Once it fell into disuse, the construction began to deteriorate, and at the same time it became a more and more emblematic identity mark for the inhabitants of Morelia.

The aqueduct was preserved starts at a reservoir to the west of Morelia city. According to oral tradition, the monument had 253 arches, although changes in paving levels have left some arches buried under ground. At about 700 m there is a second reservoir, which was probably to monitor the levels and avoid overflowing before the aqueduct entered what was then the city. The total length of the monument is 2,010 metres from the first reservoir to the end, near Villalongin square.

**Restoration and Research**

Restoration of the monument began in September 1996 on the basis of a project promoted by a civil association: the Foundation for the Restoration of Morelia Aqueduct. This association worked with both federal, state and municipal government departments to have the project implemented. The main deterioration undergone by the aqueduct consisted in the loss of the protective layer in the aqueduct and the loss of mortar in the joints between the ashlar. When the restoration began, rainwater began to seep in, bringing salts and mortar components with it and leaving stains on the intradoses of the arches. In some areas ashlers showed scaling or pulverization, micro- and macroflora and the monument was generally used to house all kinds of installations: electricity and telephone wires. Although there were cracks and some ashlars were broken, the monument was not in any danger of collapsing; it merely looked dirty and neglected. Before starting to replace the mortars of the monument, samples of the existing mortar were laboratory tested. 74% of the original mortar was silica sand, with smaller proportions of calcium and iron oxide and traces of magnesium carbonate. Sheep’s wool was detected in the mortar matrix under the microscope. It is worth mentioning that although we are not sure that this type of fibre was used in the whole aqueduct, we do know that it was used for the construction of the underground pipeline. Thus the work contract signed between Valladolid Town Hall and the architect Nicolás López Quijano (1731) specifies: Es condición ser de quenta es novíllima ciudad el darle a dicho maestro la manteña, pelos de chivos, y col, para hacer el aula que ha de gastar en guarinaciones de las caveñas de los caños, como así mismo todos los lazos, hilo de campeche y mirilhauque, para remeter en los hingeridos de dichas caveñas.

The works performed throughout the intervention consisted of washing the stonework with non-ionic soaps, replacing missing mortars and re-covering the aqueduct. To carry out restoration works in Mexico, there is still a great deal of skilled craft labour. So the stone could be hand washed, using brushes and natural fibres and the mortars were made with lime slaked on site. The levelling of the conduit was restored by applying a thin coat of mixture (made with slaked lime and silica sand enriched with an adhesive additive) with a small metal spoon and later polishing the surface covered, pressing it in place by hand through a rubber glove. The film is very fine and follows the natural shape of the stone. As the cleaning of the stone in the surfaces went on, the marks left by the builders on the stone, both engraved and painted, could be seen, and each one was carefully examined. Taking advantage of the scaffolding, each arch was measured and its particular features examined. There are three types of mark on the monument: painted marks, marks engraved in bas-relief (stonecutters’ initials) and marks engraved in high relief, of all of which the latter are the fewest in number. Most of the painted marks are simply red dots or circles which seem to indicate position. Some stoncutters have this type of marks superimposed on marks engraved in the stone. The engraved marks probably correspond to stoncutters’ signatures and are very similar to examples provided by Gimpel for the case of medieval churches. In this way they would have been used to qualify the work or progress of each stoncutter, and the symbols used would have been handed down from father to son. However, it is not always clear whether these marks represent signatures or indicate position. In some stretches, for example, there are arrows fashioned in the keystone of each arch, which could either mean the same stoncutter made them all or that the arrows indicate their position.

**Results**

As a result of the examination of the marks and measures and the careful observation of changes of quality, hardness, colour and cutting of the stone, several different stretches of the aqueduct could be defined. Besides, research into the hydraulic functioning of the monument carried out at the same time led to the discovery of sections of the channel in cut stone several kilometres away from the aqueduct inside the city. In this way it was possible to determine the total length...
of the aqueduct when it was in use. From the springs, the aqueduct measured twice the length of the aqueduct that can be seen today, i.e., 2,010 metres.

The marks (stoncutters’ signatures and position) permitted the distinction of several different sections. The first, between the two reservoirs, stands out for having hardly any engraved marks, but more variety in its painted marks than the rest of the aqueduct. These marks are mostly on the row of stones corresponding to the level of the water channel or in the row corresponding to the water level over which it was just above it.

After the second reservoir, in Vicente Suárez street, there is a great variety of marks, mostly engraved. The painted marks usually appear on the ashlars of the water channel and consist of red dots or circles. There are engraved marks both on the surfaces and on the voussoirs of the arches, mostly initials or signs easy to identify with some letter of the alphabet. The reservoir has a large number of painted marks that correspond to rows, which probably means that they were position marks. Follows on for having hardly any engraved marks. Apart from the different impact that the earthquakes have on the masonry and on the stones, a hypothesis is based on the fact that they differ from the rest of the monument because of the lack of marks engraved in the stone and because of the type of stone used. Besides, an adjustment can be seen in the measurements of the last arch in the area of the second reservoir to adapt to the space available, since the reservoir was already there.

On the other hand, the oldest part of the masonry structure is between Ventura Puente street and Villalongín square, since this section can be seen in a lithograph of M. Murguía dated 1753. Besides there is also an adjustment in the level of the aqueduct west of Villalongín square and another one, barely visible, two arches to the east of Ventura Puente street. However, this 4-arch section can be clearly distinguished from the rest because of the stonecutting.

The field work carried out has led us to question the history of the monument, and an interdisciplinary investigation is currently under way, with the participation of historians, engineers and architects, in the hope of learning to decipher the evolution of this monument. The surveys and detailed examinations constitute a corpus of information that will be analysed in greater detail and compared with the documentary testimonies which, without this research, would have continued to classify this monument as a work built between 1785 and 1790 on the initiative of Fray Antonio de San Miguel. In the words of Carlos Chacón: “The testimonial, documentary, meaningful message of a monument, ciphered in keys of the past, contains more enigmas the older it is. Its interpretation, therefore, can rarely be complete and final”.

Giorgio Croci
The restoration of the Basilica of St Francis of Assisi

History, Damage and Collapse

In its history many earthquakes have affected the Basilica of St Francis, which was built in the 13th century. Important earthquakes occurred in 1279, 1328, 1703, 1747, 1781, 1799, 1832, 1859, 1917, 1979, and yet another of more serious damage as great as that which hit central Italy during the night of September 26, 1999, and the second one, which struck the Basilica at 11:42 a.m. The result was the destruction of the vaults close to the facade, those close to the transept, a portion of the left transept and the production of large cracks and permanent deformation in all the vaults of the Basilica, leaving them in a very precarious and dangerous condition. Apart from the different impact that the earthquakes of different characteristics, which have succeeded each other over the centuries, may have produced on the Basilica, other factors have increased the vulnerability with respect to the past.

As regards the tympanum, made up of a hollow wall with two faces and an inner fill, the cause of the partial collapse was the decay of the mortar which connects the stones of the external face with the inner fill (fig. 2) (the first damage was produced on September 26, but it was the earthquake of October 7 which created a large hole in the wall). The reduced cohesion and bonding could not prevent single stone blocks from becoming progressively detached from each other and falling.

As regards the vaults (fig. 3), the collapse was produced by a large volume of fill which was made up mainly of broken tiles and other loose materials accumulated over centuries of roof repairs in the springer zones. During seismic activity, this fill without any cohesion alternatively acted only on one side, whilst on the other side the fill was detached. What is more, the loose fill followed the movement of the vaults, opposing their recovery and facilitating more and more permanent deformations.

When the earthquake of September 26 hit the Basilica, it is very likely that permanent deformation, reducing the curvature and therefore the bearing capacity, was already present, having been progressively produced and increased during the previous earthquakes. The failure mechanism of the vaults (fig. 3) close to the facade, filmed by Umbria Television, resulted from the progressive loss of curvature of the ribs, then a hingel was produced in the middle and finally the rib collapsed, drawing the vault down with it. A similar mechanism occurred in the zone close to the transept, where the second vault collapsed.

The collapses were concentrated in these specific zones because, as the direction of the seismic force was mainly perpendicular to the nave axis, the system of the vaults behaved globally like a beam, where a kind of restraint at the ends was provided by the stiffness of the facade and the transept. This behaviour is clearly shown by the global mathematical model that will be presented below.

Urgent Measures

Urgent measures were required immediately after the earthquake so as to prevent the total collapse of the tympanum and of the vaults.

- The Vaults

The surviving vaults were all affected by large cracks distributed both on the intrados and the extrados; curvature, as mentioned above, was lost in several areas. The danger that the vaults might collapse, and the consequent risk to human life, precluded the possibility of supporting the vaults from the ground level. Rather, a platform was suspended from the roof above the vaults with the double function of inspecting and providing a base for working over the vaults. The urgent measures taken in the first month after the main earthquake can be synthesized as follows: removing the huge load represented by the fill in the springer zones of the vaults, filling the cracks with a salt-free mortar to limit possible damage to the frescoes, first taking the precaution of inserting a strip of polyurethane in the larger cracks to prevent the mortar from flowing out, applying bands of synthetic fibres over the cracks of the extrados, suspending the vaults from the roof with a system of tie bars, having first inserted two springs to maintain the force at the design value, independent of thermal effects and minor vibrations, suspending the ribs from the roof with a system similar to the previous one after having placed a kind of steel cradle filled with soft rubber underneath in order not to damage the frescoes.

- The Tympanum

The risk was that if the tympanum were to collapse it would have destroyed the roof of the chapel below, causing the loss of frescoes and works of art of artistic and historical value. After a long reflection, it was decided to use a huge crane, 50 m high. But such a large crane could not get through the narrow gate into the inner yard. This problem was solved by using two cranes; one placed outside the Basilica complex lifted the second one over the roof of...
the building and deposited it in the inner courtyard. Organising this operation involved anchoring two cantilever steel trusses on the two walls of the transept. The trusses were designed to support a 4.5 ton steel frame structure in the shape of the tympanum, a triangle 8-m high and 17 m at the base. In the period of time between the 10th and the 14th October the reinforcements were completed. The steel structures were built; two cranes arrived on the square in front of the Basilica; the first crane lifted the second one into the courtyard; the two cantilever steel trusses were lifted over the roof of the transept and were anchored to the lateral walls, ready to receive the fill.

After some attempts hindered by heavy rain and wind, the crane succeeded in lifting the steel tympanum over the brackets. The following day the empty spaces and larger holes were filled with polyurethane foam to stabilize the masonry provisionally.

**Seismic Forces and Mathematical Models**

**- Seismic Forces**

The acceleration measured on Sept. 26 1997 on the ground close was about 0.16g in the direction of the longitudinal axis and about 0.18g in the perpendicular direction. Considering a reasonable amplification factor for the vertical structures, it is likely that the top of the structure reached a transversal acceleration, of around 0.36g. The earthquake of September 26 1997 however, was not as strong as expected of major earthquakes in the Assisi area, which are at least 1.5 times stronger than that.

Moreover, the Basilica and the Monastery are located on a hill facing in a E-W direction and very high and narrow in N-S direction, which is orthogonal to the Basilica’s axis. In the event of N-S seismic forces, this leadsto local amplifications and acceleration larger than that in the centre of the city of Assisi.

These considerations bring us to take into account a possible maximum ground acceleration of around 0.30±0.35 g. in the perpendicular direction with respect to the Basilica’s longitudinal axis. The measures taken (by ISMES) on the occasion of the numerous seismic events occurred through 1998 show transversal acceleration at the top of the vaults from 3 to 8 times larger than those on the ground. These amplifications are much larger than that evaluated for the September 26 1997 event, but two considerations are necessary: 1) during stronger earthquakes, when parts of the structure exceed the elastic limit, there is major energy dispersion and therefore the amplification is reduced; 2) the removal of the fill increases the local amplification of the vaults.

On the basis of the previous points, also considering the present damaged state of the vaults, it has appeared prudent to take into account dynamic amplification (from the ground up to the top of the vaults) in the order of 4 times, and therefore to take as a basis for the design of the reinforcements a horizontal transversal acceleration, at the level of the vaults, of around 1.2-1.4 g.

**- Structural Analysis**

Different mathematical models have been prepared to study the structural behaviour under the effect of seismic forces perpendicular to the axis of the Basilica (which is the worst possibility); essentially they are discussed below:

- General Model of the Basilica

This shows that the vaults close to the facade and the transept (fig. 1) take, in addition to the local effects due to the fill, supplementary stress due to the restraint produced by the facade and the transept. A model of a central module of the nave with the fill (situation before Sept. 26 1997) was clearly shown that high tensile stress is produced in the ribs and the curvature is reduced even in static conditions under the effect of dead loads. A preliminary step-by-step analysis with horizontal statically equivalent forces shows that the severe seismic forces reach around 0.16g at the base, and cracks and permanent deformation is produced, and that with forces between 0.25′0.3g the vault may collapse (fig. 6). These values of the seismic forces are comparable with the values induced by the earthquakes of September 1997 and explain the great damage everywhere and the collapse of the vaults near the facade and near the transept, which received the additional stress. Model of a central module of the nave, without the fill. The model represents the deformed shape of the vaults as surveyed; however, it neglects the stress accumulated as a consequence of deformations; this approximation is partially justified by the presence of the cracks, and it would not have been possible to evaluate this stress reliably. A first elastic analysis shows that stresses are significantly reduced after the removal of the fill. A second step-by-step analysis with horizontal statically equivalent forces, shows that great deformation is developed when the horizontal seismic force reaches, on the vaults, around 0.4g (with the presence of the fill the value was 0.18 g) and collapsing occurs between 0.6607g (instead of 0.25′0.3 g considering the fill) (fig. 7); this improvement however, is not sufficient to deal with the maximum expected earthquake.

**- Model of the reinforced vault**

Taking into account the reinforcement ribs that have been connected with the extrados of the vaults during the restoration works, a step-by-step analysis shows that reduction is greatly and the vaults’ behaviour is largely improved. When the horizontal statically equivalent force reaches 1.2g (the value considered in the design), the stress in the reinforcements reaches half of the strength. The mathematical model also shows that great deformation of the vaults occurs only when horizontal acceleration reaches 1.6 g. The diagram of Fig. 5 synthesizes the various situations.

**Research and Tests to Strengthen the Vaults**

The problem of the definitive restoration and consolidation of the Basilica, especially as regards the vaults, immediately appeared to be very delicate because, due to the presence of the frescoes, it was impossible to reduce the deformation and thus to re-establish adequate curvature and autonomous bearing capacity. Different studies, research and structural analyses have been carried out to decide what solution would have been the best to strengthen the vaults and secure their stability over time, without producing risk which might damage the frescoes and without compromising the historical value of the original vault structure. The hypothesis of building a reinforced concrete shell or reinforced concrete ribs on the extrados, was rejected a priori as being too heavy because of the difficulty in following the deformed shape of the vaults as surveyed; however, it was necessary to reduce their section to a minimum. The strength of the ribs was increased by inserting unidirectional aramid fibre bars in the intrados and unidirectional glass fibre bars in the extrados, as glass fibres have higher performance under compression stress.

The decision to utilise a central nucleus was taken because in this way it could be built more quickly, as well as the fact that this guaranteed higher resistance and energy dissipation. In addition, the central nucleus would prevent any buckling phenomena in the thin webs of aramidic fabric.

Several different materials were tested for the nucleus such as rigid foams, different types of wood, compositions of wood plus foam and, finally the mahogany nautical plywood was chosen, placing several layers of plywood over each other. The use of plywood, instead of layers of simple wood, reduces the transversal core expansion under load action. Very homogeneous mahogany wood guarantees high resistance and stiffness to compression while the nautical treatment, given according to the strictest seafaring standards, results in an imputrescible wood of high durability. The wooden layers, glued on site, allow the deformed shape of the vaults to be easily followed. Some pull tests were performed to verify the adhesive capacity between composite elements and masonry both in the case of direct gluing and through aramid fibre pivots (fig. 15). Some cyclical tests have shown good wood conservation of bearing capacity after the yielding point, with good ductile behaviour as well.

**Reinforcements of the Vaults**

The strengthening of the vaults consists of five main parts: the new ribs connected at the extrados; the anchorage of the ribs to the roof; the grouting of the cracks; the connection of the arches which support the roof to the perimetral walls; the steel beam placed in the nave over the cornice of the walls.

**- The Ribs**

The rib pattern is shown in Fig. 10: A couple of ribs, (section 22x10 cm) are placed in correspondence to the transversal arches, which are the weakest and most important in the event of seismic activity because of their reduced or missing curvature. A series of ribs (section 30x12 cm) is placed just over the diagonal arches. Some smaller ribs (section 20x5 cm) are placed over the webs. Longitudinal ribs are placed on the vault crowns (section 18x12 cm) half-way up the vaults (section 12x5 cm). The ribs are directly created in situ as the result of
the stratification of various materials. These are the phases of construction:

On the vault extrados surface, after adequate cleaning, the first four-directional (0°, ±45°, 90° angle ply) tissue of aramid fibre of 230gr/m2 is glued with epoxy resin.

Over this first layer, the polyurethane flat aramid fibre bars are glued which are covered by a second tissue of aramid fibres equal to the first. Then begins the phase of placing subsequent strata of mahogany plywood layers to create the rib core.

The wooden core is then covered by a third four-directional aramid fibre tissue 360gr/m2, heavier than the previous ones, as it is expected to be part of the stratification of the composite ribs lateral walls. At this point, the polyurethane flat fibre bars are glued. Finally, everything is covered with another four-directional aramid fibre tissue of 360gr/m2.

The design of the ribs was carried out ignoring the cooperation with the vaults and the contribution of the timber core.

b) The Ties Bars to Anchor the Ribs

The ties are connected to a system of tie bars, which are anchored to the roof. Each tie bar includes a spring, similar to the solution adopted for urgent measures (fig. 14). This reinforcement aims to reduce deformability under seismic forces.

c) The Grooving of the Vaults

The reinforcement of the vaults' cracked structure, where continuity was compromised, was created by using a mortar capable of withstanding very specific and severe unusual conditions. This mortar, chosen from the most up-to-date technologies at the time, was used (fig. 17).

d) Belts to Anchor the Main Arches

The masonry arches which support the roof simply stand on little vaults, which are situated over the springers of the main vaults without any structural connection and with a certain eccentricity with respect to the main pillars. Therefore, it was decided to anchor the base of the arches to the walls and the towers behind them, which in this very peculiar Italian Gothic structure, have a function of abutments. The anchoring was performed with a steel bolt and prestressed horizontal bars (fig. 13);

e) The Trussed Beam

Over the centuries, the frescoes on the walls have frequently suffered damage and cracking due to the deformation produced by earthquakes, even though, fortunately, the walls resisted and never collapsed. To limit this phenomenon, a horizontal steel trussed beam was placed over the cornice of the walls inside the Basilica (immediately below the stained glass windows) to stiffen and strengthen the walls covered with Giotto's frescoes. The connection between this beam, which runs along the perimeter and the walls was created with special viscous devices which allow relative displacements due to thermal effects, but become rigid under dynamic forces and provide full strength in the event of earthquakes (shock transmitter).

Reconstruction

a) The Vaults

The construction of the collapsed vaults constituted another major problem. Fortunately, after painstaking research, several frescoed bricks that could be reused to rebuild the vaults were identified. The operation was particularly successful as regards the pieces of ribs, which in spite of having fallen 25 metres, had maintained a good bend between the bricks. It was therefore possible to assemble, the broken parts of the ribs in the laboratory in such a way as to create a sort of vousoir about 40 - 60 cm long. These vousoirs were then placed on a provisional centring to rebuild the ribs (fig. 16). It was not possible, on the other hand, to recover significant elements of the webs, so that new bricks, especially made to have the same substance and similar characteristics as the original ones, were used (fig. 17).

The reconstruction of the vaults took into account the problem of re-establishing not only structural but also stress continuity between the new and the original portions of the vaults; a system of jacks was foreseen for this purpose and placed in a provisional joint on the crown of the new vaults to compensate deformation, including shrinkage of the mortar, and to calibrate stress distribution.

b) The Tympanums

The restoration of the Basilica was completed with the reconstruction of the collapsed portion of the left tympanum (fig. 18) and the removal of the deformation that both the transept tympanums suffered. Stones from the same original quarry were used.

To reduce seismic forces transmitted to these tympanums, which although consolidated are still delicate structures, the connection between them and the roof was created by interposing special steel devices, composed of a shape-memory alloy, capable of dissipating a certain amount of energy, (fig. 19).

Conclusions

The operations carried out, firstly to save and then to consolidate and restore the Basilica of St Francis of Assisi, all followed the same philosophy: to place the most up-to-date techniques and technologies at the service of culture in order to respect the historic value of the ancient building and to obtain adequate safety levels whilst changing the original conception as little as possible. Some of these technologies, never applied before in the field of restoration, were studied specifically for this occasion, offering new and interesting possibilities for the safeguarding of our architectural heritage. These are some of the most interesting: the use of special equipment in the creation of the works, such as for example the two huge cranes for lifting a stone block to reconstruct the collapsing tympanum, first over the walls of the Convent and then at tympanum level, the use of polyurethane foam, never before used, to block the deteriorated masonry of the tympanum; the use of steel-bars together with springs to suspend the cracked and deformed vaults provisionally from the roof; the use of composite material with aramidic fibres to create a series of ribs on the extrados of the vaults to strengthen the structure definitively; the creation of a special connection (using a shape memory alloy) between the damaged tympanum and the roof to allow partial dissipation of energy; the steel trussed beam, over the inner intermediate cornice, connected with the walls by means of shock transmitters. As already mentioned these innovative technologies not only gave us the possibility of saving the Basilica in a historical and architectural sense, but have also opened up new prospects for designers and companies involved in restoration work.

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Luis Valdén & Rosa Mª Esbert
Facade of San Isidoro Church in Oviedo. Follow-up on the conservation of the stone

Background

Before proceeding to repair the stone of the main facade of San Isidoro Church in Oviedo, a survey was performed to determine the petrophysical characteristics of the stone, its degree of deterioration, the factors that had caused it and the phases and methods that would be most recommendable to alleviate the damage. Part of this survey and the methodology used was published in the third issue of Loggia (Esbert et al., 1996). When the refurbishment work was carried out (January-September 1997), the same alteration group from Oviedo University performed a follow-up of it. The principal aspects of this survey are described in this article.

Refurbishment Follow-up

The follow-up of the refurbishment contemplates aspects of the stone in relation both to the fabric of the building and its use as constructive material. Its contents could be divided into two parts, which have been given the following titles in this text: Intervention Stages and Preliminary Tests and Analyses.

Intervention Stages

In chronological order, the different stages consisted of: cleaning, conditioning and repair of the stone fabric, consolidation and surface protection (waterproofing).

a) Cleaning and Desalinization

Most of the facade of the church was cleaned by using wet micro-particle mechanical impact methods and dry methods on the carved areas on the lower part. Other ornamented areas were cleaned with laser, specifically the central frieze and the capitals of the four columns on the first floor. In Fig. 2 the digital cartography of the facade can be seen, showing the areas where each of the above-mentioned methods was used. During the intervention modifications were made to the methods recommended in the preliminary survey, based on the availability of tools, the suitability of alternative methods tried out in situ and financial limitations. After cleaning, soluble salts were removed from the zones where their presence was detected. Fundamentally, they were mostly found under cornices and projecting areas. Before desalinization, salts were extracted not only from the surface but also from deep inside the stone and analysed. Figs. 3 a and b show one of the extraction zones and the appearance of the stone in the same zone after desalinization.

b) Conditioning and Repair of the Stone Fabric

This section deals with the interventions performed when the poor state of several zones of the facade required special solutions. Specifically, the following items were performed:

- Joint Consolidation

All the joints between ashlers from which the original mortar was missing or in a poor state of repair were compacted. A new mortar was prepared. After several
essays, one made up of sand, lime and white cement was chosen, in doses of 8:4:1 parts.

- **Adherence between Separated Ashlars**
  Many joints between ashlars were open showing gaps more than 4 cm wide, probably caused by differential shifting which no longer takes place. These gaps were observed in vertical surfaces and horizontal zones, cornices and balconies, and also between several ashlars in the spire (fig. 4 a). A commercial brand of mortar was chosen because of its good adherence properties, adequate tisotropicism and low retraction. The definitive finish of this type of joint (except in horizontal zones) was performed with the joining mortar described above (fig. 4 b).

- **Reintegration of Volumes and Conditioning of Horizontal Elements with Mortar**
  The criteria for the reintegration of missing or very badly damaged volumes were as follows: Intervention on all the areas that channel rainwater to a greater or a lesser degree, for example, cornices, impostes, balcony floors, etc. Within these areas, in the ones that had greater water impact (cornices and floors), reintegration was performed on several layers, and the waterproofed surface was lined with stone material to make it look like natural stone (fig. 5). In areas where water had a lesser importance (e.g. the central impost), the missing volumes were replaced directly with mortar specially chosen for that purpose (fig. 6). In all cases, the old horizontal areas were sloped in order to evacuate the water more easily.

- **Reintegration and Replacement with Natural Stone**
  Some stone elements at the top of the spire and some of the balusters of the tower, among others, had to be replaced because of the physical danger of actual crumbling. Because of their extreme thinness, it was decided to replace these volumes with natural stone. As it was not possible to obtain the original stone, a stone known as Vinaixa was used to build these pieces. This is a very homogeneous dolomitic stone, coherent, with great durability and suitable for carving.

  The central part of the cornice of the western side of the tower was replaced with Cantabrian sandstone. Finally, some steps of the staircase at the top of the spire was replaced with Cantabrian sandstone. This fact together with the slowness and cost of the method were the reasons that it was used in very few areas (fig. 12).

- **Regarding Humidity Control**
  Since the application of consolidating and protecting agents must be done with a low degree of humidity, it is necessary to schedule the time that must elapse between the end of the humid cleaning and the application of products. The control of the drying was done by taking systematic measurements using a wall humidity meter. This showed that between 6 and 8 days should go by for the stone to reach the ideal degree of humidity. To calibrate the measurement of the humidity meter on this rock on the job, the data about hydric properties previously obtained in a laboratory was used (Alonso et al, 1999).

- **Regarding the Presence of Soluble Salts**
  The application of certain conservation products is not compatible with the presence of soluble salts inside the stone. After the cleaning process had been completed, the type and amount of soluble salts on the surface and the interior of some ashlars were analysed. There turned out to be a very small amount of soluble salts inside the ashlars. However, there was a large amount of salts, mainly sulphates, on the surface even after cleaning (fig. 11). As a result desalinization was recommended, preferably in those areas that were to be consolidated as well as protected.

- **Regarding the Choice and Dosage of the Mortars**
  Different types of mortars were prepared depending on the function they were to fulfill and paying attention to the following aspects:
  - Joining mortars: composition and dosage necessary to obtain minimum retraction on hardening.
  - Volume replacing mortars: measurement of physical and hydric properties, which must be similar to those of the stone on which they were to be used.
  - Mass replacement mortars: verification of the degree of adherence, retraction and tisotropicism.

- **Regarding the Replacement Stones**
  A petrographical survey was carried out and the elementary physical properties of several lithologies suitable, in principle, for replacement, were determined (Valdeón et al, 1992). The most suitable of those with the most favourable parameters were chosen on the basis of their homogeneity, colour and durability.

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  - The company MC Conservación, which carried out the works.

**PICTURES**

Fig. 1.- View of the stone on the facade of San Isidoro church in Oviedo before and after the intervention. The photograph on the left was taken in January 1997 and the one on the right in September of the same year.

Fig. 2.- Elevation of the facade of San Isidoro marking the areas where the different cleaning methods have been applied.

Fig. 3 a & b. - a) Detail of one of the zones of the building where the stone has been desalinized with cellulose compresses. B) General view of the same zone, after desalinization.

Fig. 4 a & b. - a) Joints opened up due to horizontal subsidence localized at the top of the central window, b) View of the same zone after repairs and sealing with mortars.

Fig. 5.- Final appearance of the restoration of the surface of the upper mould of one of the balconies.

Fig. 6.- Reintegration of part of the cornice with mortar, which also facilitates the proper evacuation of water.

Fig. 7.- View of the balusters replaced with Vinaixa stone in the tower balustrade.

**Different Mortars**

*Fig. 8 a & b.- Cleaning essays on broken substratum with the method of the application of mechanical impact dry (left) and wet (right). a) Above: results obtained with powdered glass mixture. b) Below: view of other ashlars after using microsphere mixture. The best results were obtained with wet application and powdered glass mixture.*

*Fig. 10.- Elevation of the facade of San Isidoro showing the consolidated areas.*

*Figs. 11.- Comparative graph showing the ions found in the chemical analyses of the salts extracted from the stones at San Isidoro, after cleaning. In the samples analysed, as the graph shows, the presence of an amount of anions higher than 1,500 µg / gr. of stone was found on the outside of some ashlars.*

*Fig. 12.- Partial view of the central frieze during*
laser cleaning. This method eliminates dirt without damaging the material of the substratum.