Arch Bridges
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Restoration of the Pont Trencat (Broken Bridge). Barcelona, Spain. (ARCH'04)

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Abstract. *In 1811, during the Napoleonic Wars, the "Pont Trencat" bridge suffered the destruction of one of its two arches, the main one. At the beginning of 1999 we were commissioned to develop a bridge restoration project. We first carried out archaeological works and documentary research in order to obtain the information available about the history and the construction sequence of the bridge. Since the bridge was destroyed a long time ago, nobody knows what it really looked like before it collapsed. If we had tried to give the bridge its original shape back we would have had to invent all the information we lacked. Also, people was used to seeing its broken shape. Therefore we proposed to restore it in a way that reflects the contrast between the new work and the existing remains, using a modern material —steel, which is, along with concrete, the most representative structural material of our time— and contemporary constructions techniques. The work began in July 2000 and was divided in three phases: The first part consisted of reinforcing the old remains, made of stone, as well as building the new foundations in concrete. The second phase consisted of constructing the steel structure that was erected in four pieces. The arch was lifted in two pieces welded to each other in the crown. The beam was also lifted in two pieces. The third phase consisted of constructing the pavement and installing the street and monumental lighting. The bridge was opened to public in September 2003.*

1. WHAT THE WAR TOOK AWAY

"*Als vint y tres Febrer de mil vuit cents onse morí de edat... offegada en la Tordera per haver romput lo Pont per ordre del general de vanguardia Don Josep Obispo, sens reportarsen altra utilitat, ni ventaja que las desgràcias se han experimentat, i se esperan de necessitat*" (The 23rd of February 1811, a women drowned in the Tordera river after destroying the bridge, ordered by General Mr Josep Obispo. This action didn't bring benefits but the misfortune that has been experienced and that is expected). This note, written in old catalan, coming from the Deceases Book of the Parish File of Sant Celoni, reminds us the destruction of the Pont Trencat, over the Tordera river, ordered by the Spanish General Mr Josep Obispo, in order to obstruct the movements of the invading army during the Napoleonic War. Because of this action the woman responsible for the explosion that caused the destruction of the main arch of the Pont Trencat died. Actually this action wasn't useful at all according to the engraving made by one of the drafters, Michel Charles de Langlois, that joined the Napoleonic army. It shows how the invading army crossed the river despite the destruction of the bridge.

Figure 1 – Engraving of Michel Charles de Langlois

The efforts of the Sant Celoni authorities to reconstruct that bridge finally brought about the construction of a new bridge in 1866, down the river from the old bridge. The new bridge was named Queen's Bridge, because it was build under the reign of Queen Elisabeth II. After the construction of the new bridge, it was not necessary to repair the ancient bridge, and it was abandoned. Happily, because of the strength of its foundations and structure, the remains survived all the *Torderades*; this is how the floods of the river are called.

2. THE PONT ROMA 2000 ASSOCIATION: THE EFFORT TO RECOVER WHAT THE WAR TOOK AWAY

Despite its strength, it was necessary to protect it against deterioration. This was what some people from the two villages the bridge links —Sant Celoni and Santa Maria de Palautordera, fifty kilometres north-east of Barcelona— thought. In the fall of 1996 we decided to create the Pont Roma 2000 Association. At the beginning, our main goal was to get funds in order to recover the destroyed bridge, but we quickly realized that this was not enough. The reconstruction of the bridge was the first steep to improve the whole environment, both the

urban one in both banks and the natural one along the riverbed, that unfortunately were very degraded. This was an ambitious target, but its success was based on the idea that singular interventions have the power of functioning as a catalyst for improving dynamics. We believed that if we got the necessary funding to recover the bridge, other agents such as the City Councils or the neighbours would be motivated by this intervention to improve the surroundings.

Figure 2 – Two images of the bridge in 1997

3. WHAT WE FIRST DID

After we defined what the Association wanted to do; recover the broken bridge and improve the riverbed close to it, we first did a sketch design as well as an approximated budged in order to get the first funds for the preliminary work we need to do: the documentary research, the archaeological work, the topographic map of the site and the geothecnical studies. We happily receive funds from the Barcelona Province Council and the Vallès Oriental County Council that allowed us to carry out this first part of the work. Afterwards we also got money from the ERDF (European Regional Development Funds) of the European Union; the City Councils of Sant Celoni and Santa Maria de Palautordera; the Department of Culture and the Department of Environment, both belonging to the Generalitat de Catalunya, the regional government; and from several companies in that area.

We also carried out public relation work by organizing an exhibition about the history of the bridge and the new project that was shown in both cities, and we designed a web page that can be seen at http://www.terra.es/personal3/ponttrencat as well as a printed dossier.

The first archaeological work was done in three phases, in the summer 1998, in the fall of 1999 and in the spring of 2000. The information we obtained from these work was checked with the results of the documentary research. We also got the real geometry of the existing remains by means of photogrametric methods. The geothecnical studies gave us information

about the internal structure of the remains and the morphology of the underground. In the meantime, helped by the information we were getting from these preliminary works, we did the execution documents of the bridge restoration.

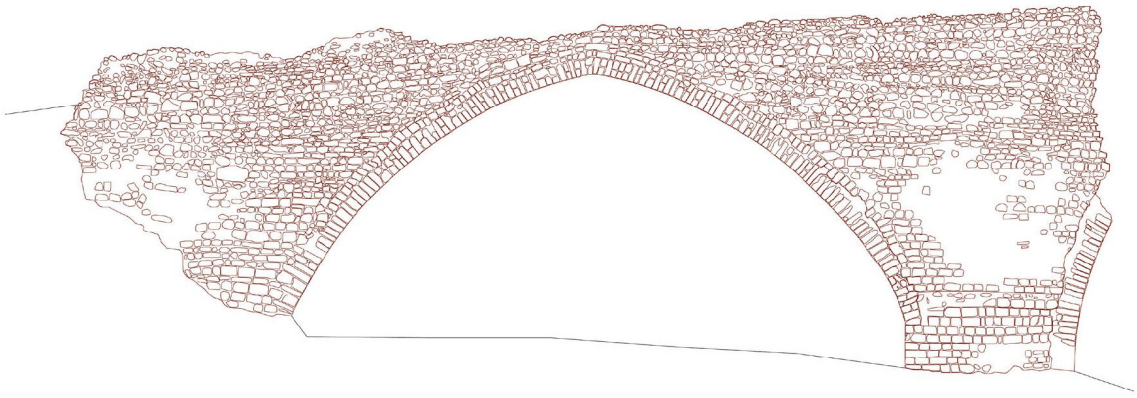

Figure 3 – Elevation drawing of the existing remains obtained from photogrametric processing

4. REBUILDING THE BRIDGE; BUT HOW?

The key question of the project was: How should the bridge be rebuilt? May be the word "rebuilding" is not the most accurate. To rebuild implies a certain way of doing things: to built the bridge again like it was before its collapse. Is it possible? If we had found all the needed information to restore the bridge to its original form, it would be. But after almost one hundred and ninety years, we don't know the missing geometry of the bridge. From the geometry of the remains, the archaeological findings on both banks, and the mentioned engraving from Michel Charles de Langlois, we made some deductions: we believe that the missing arch was bigger than the remaining one and the highest point of the pavement was placed over its crown. But we don't know its precise geometry. Even if it was a ogive arch or a semi-circular one. If we decided to rebuild it, in a strict way, we would have had to invent all the information we lacked. As we have said, we carried out archaeological work, geological studies to know the morphology of the internal structure of the remains, and did research in order to get all the remaining ancient documents related to the bridge, but the information we found didn't give us any approximate idea of what the missing part looked like. A drawing, even an accurate description from one of the many travellers that used to write about the places they visited, would have been very helpful.

On the other hand we had to take into account other things. The destroyed bridge was not just an architectural object; it could be considered a historical monument. Why? Because it had a set of special values as a document, as an architectural building, and as a symbolic object[i].

As a document it can evoke historical facts of which it has been witness to, and not only can it give us information about its history and the societies it was related with, but —from the material it is made of— it can give us information about the evolution of architectural styles and construction techniques.

According to the Vitruvian attributes of good architecture, architectural values are done by its capacity to satisfy the functional requirements (*utilitas*); by the aesthetical experience it can provide (*venustas*); and by the rationality of the material and techniques used in its construction (*firmitas*).

The symbolic aspect includes more subjective values related to emotional things; about what the monument means for the individuals and collectivities it is related with.

According to these values, any intervention in a historical monument must try to preserve all these aspects. Not always it is possible to achieve this goal. For example, in order to recover the function of the monument —architectural value— it can be necessary the destruction of some parts that may contain interesting information —documentary value— about the monument itself or its history. In these cases it is very important to find a desirable balance.

In our case there were three main possibilities. The first one was just to reinforce the remains without recovering its function; the second one was to rebuilt the bridge trying to give the shape we thing it has back; and the third one was to restore its function constructing the missing part in a totally different way, making clear the contrast between the old and the new part.

We rejected the first option because we considered it to be very important to recover its use, for three reasons. First of all, with this new link we were improving the connection between the Pont Trencat neighbourhood, on the right bank, and the city centre of Sant Celoni, on the other bank. Until now, pedestrians had to cross the river by a road bridge, a little bit up the river, with low lighting and narrow sidewalks. Second, by recovering its function —just for pedestrians— we were offering a new privileged point of observation of the environment, the improvement of which was one of our goals. Actually with this new point of view we could show its deterioration. Third, we share the idea that the best way of protecting an architectural object from deterioration is by giving it a use; if something has a function it becomes necessary and any lost of functional capacity must be fixed.

At the beginning, under the influence of the most recent reconstructions of bridges destroyed in the Spanish Civil War (1936-1939), we proposed to rebuilt the bridge trying to give it its old shape back. This was, for example, the case of the Pont del Diable, between Martorell and Castellbisbal, twenty kilometres west of Barcelona. These were the kinds of interventions defended by the French architect M. Viollet-le-Duc (1814-1879)[ii] against the postulates of the English thinker John Ruskin (1819-1900) and the English poet, craftsman, and politician William Morris (1834-1896), who defended a non-intervention policy, and thought that we don't have the right to intervene in a monument. If the monument is in danger of collapsing, to reinforce its structure in a non obvious way, is allowed. But our situation differed from these other ones in one important way: In those cases, since they had been recently destroyed, there was information enough about what they looked like before its destruction. On the contrary, as we have said before, in our case we didn't know what the bridge looked like before it collapsed, and the only image known was of its broken shape. Several people asked us if, after its reconstruction, we would change its name. This latest aspect may not seem so important, but we strongly think it must be taken into account. The bridge remained broken for almost one hundred and ninety years, and this is a period of time

long enough to be taken into consideration.

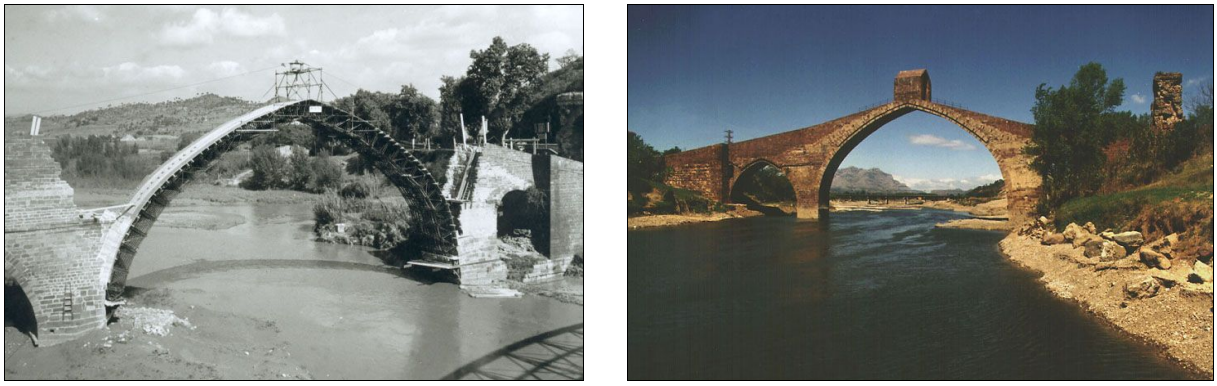

Figure 4 – The *Pont del Diable*: its reconstruction in 1961 and already completed

Moreover, the present project is part of the history of the bridge. It's an intervention that takes place in a certain age, with its own characteristic materials and construction techniques, quite different than the ones from other times. Trying to use the stone and its proper techniques would give future generations false information. This would damage the documentary value of the monument. The use of a technology not proper of our era would mislead the people who will observe and study the bridge in the future. In our case, we thought that trying to rebuilt the bridge giving it its old shape back, using materials and techniques not proper of our era, inventing the information we lacked about what the bridge looked like, would be an act against its symbolic and documentary values.

Figure 5 – Rendering of the final solution

Therefore, following the ideas of some famous restoration theoreticians, such as the Austrian art historian and jurist Alois Riegl (1858-1905)[ii,iii], and the Italian architect Camillo Boito (1835-1914)[ii], we finally decided to reinforce its stone remains and to restore its function using current materials and techniques; and steel, along with concrete, is the most representative structural material of our time. We chose corten steel because we thought it goes with granite stone. We proposed to re-erect the missing part in a way that reflected the

contrast between the new work and the existing remains, evoking the shape we think the complete bridge had, but not trying to make a mimetic reproduction. We wanted the new part to dialogue with the old one, without taken a leading role. For this reason we designed a light structure that emphasized the difference between the old and the new volume, throwing into relief the silhouette of the ancient part, that is the one which better symbolizes the image of the bridge.

5. WHAT WE FINALLY DESIGNED

Before we achieved the final design we tried different solutions. We worked with digital models by means of which the first ideas evolved until the final proposal. We first tried solutions that evoked the stone façades, but we realized early that it would be better to work with linear objects instead of flat ones, obtaining in this way a lighter structure. This helped us to reinforce the contrast between the new and the old volumes. And the structure we finally constructed consists of a two span box girder deck, 3.00 meters in depth, varying in width from 2.08 meters at the bottom to 3.36 meters at the top. This is supported by three pairs of bearings, two at both ends and the intermediate one placed over the crown of a hollow box ogive arch, spanning 24 meters, which width varies from 3.40 meters over the foundations to 5.12 meters at the crown. The arch depth also varies from 0.61 metres at the arch springing to 0.89 at the top. In order to bring out the old silhouette, the parapets of the deck are lengthened along the remaining structure. The top line of the new deck and the intrados of the steel arch follow the shape we think the old bridge had in order that the new structure tries to evoke the missing silhouette of the original bridge.

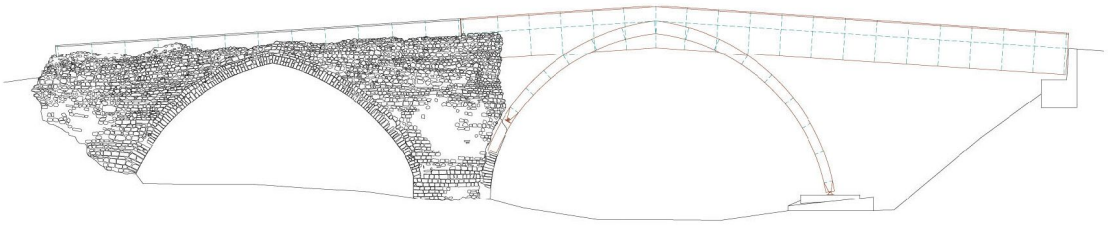

Figure 6 – Elevation drawing of the final proposal

The internal structure of the arch is composed by two hollow box arches connected to each other in the lowest part by means of St Andrew crosses hidden by steel plates, in order that in the upper part the deck passes through between the two arches. Every single arch is supported by to steel joints, one placed on the stone voussoirs of the springing of the missing arch, and the other over a new foundation placed on the riverbed, on the right bank. In order to protect the arch from objects that can be transported by river floods, we filled the first two meters of its bottom, on the right bank, with concrete. This mass of concrete also helps to increase the lateral stability of the structure in front of wind loads. We must take into account that the deck width, 3 meters, was not chosen for structural reasons but for aesthetic ones. From a structural

point of view it could have been more slender. But we needed to design a structure large enough to obtain a more balanced relationship between the massive old part and the new one. The huge deck width makes the structure quite sensitive to lateral wind loads and this situation is worsened by the fact that the arch reduces its width in its bottom part. In order to increase its weight, and therefore improving its stability, not only did we fill the lower part of the arch with concrete, but we also made two concrete slabs inside the box deck; one on its bottom plate and the other under the pavement.

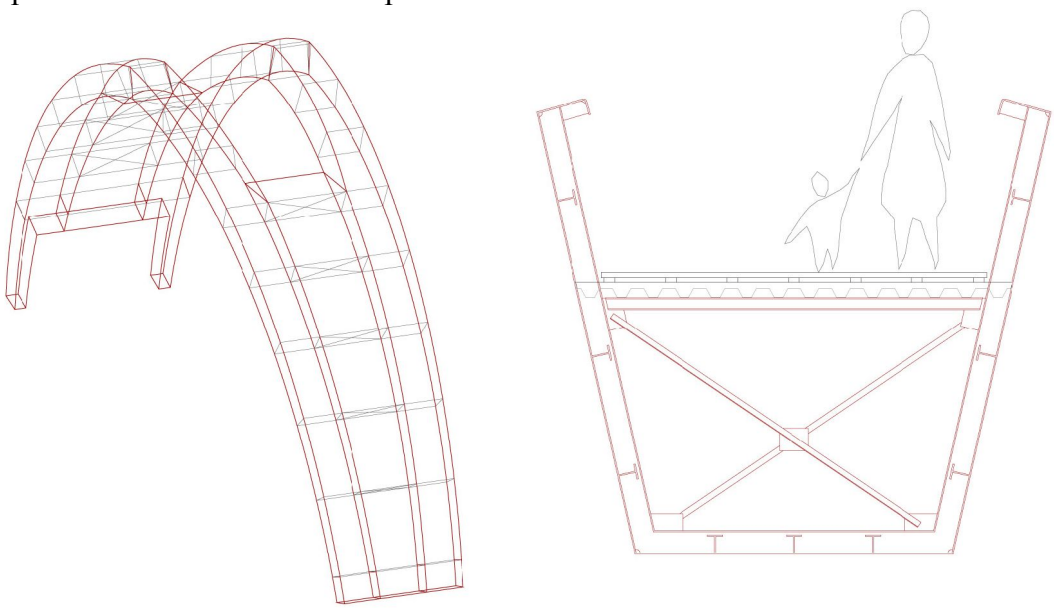

Figure 7 – Internal structure of the arch and cross section of the deck

6. THE CONSTRUCTION PROCESS

The work started in the year 2000. Alfa Polaris did the concept development, the preliminary design, the execution studies as well as the construction supervision; SAPIC was the principal contractor; and TAMANSA the steel fabricator. The construction was done in three phases: The first one consisted of reinforcing the old part, made of stone, as well as the construction of the new foundations; the second phase consisted of the construction of the steel structure; and in the third phase we constructed the pavement and we installed the street and the monumental lighting.

In the first phase, we tried to follow a non-interventional attitude. We just proceeded to consolidate and repair what we thought was in bad condition. We tried to avoid anything that could change its traditional appearance and, when it wasn't possible, for example when we had to reinforce the lowest part of the lateral walls because of some underminings, we underlined our intervention using a completely different material, in our case, concrete. Since the central pile was founded over a layer of sandy gravels instead of a hard substrate, we installed a cage of 28 micro piles Ischebeck-Titan 73/53 around its foundation, five meters in depth, in order to protect it from undermining that could be provoked by river floods. We also reinforced the existing arch my means of six stainless steel transversal bars, 32 mm in

diameter, in order to stop some longitudinal cracks it had.

The new foundation of the arch, on the right bank, is made of a grid of 4x5 micro piles, 12 meters deep, the ones of the perimeter are Ischebeck-Titan 73/53 and the interior ones are 40/16 in size.

In the second phase the abutments of the deck were made; one on the existing remains, and the other one on the right bank. The steel structure was constructed in Gava, in the Tamansa's workshop, seventy kilometres away from the work side, and was transported in five pieces; three for the deck and two for the arch. We first lifted the two parts of the arch which were welded to each other in the crown. For the deck, before it was erected, we welded two of its parts and then we installed it in two pieces welded to each other on site.

Figure 8 – Erection of the arch and lifting of the deck

In the third phase the pavement were made. Over the bridge we choose a timber pavement in order to provide pedestrians a warmer and more tactile material in contrast with the coldness of the steel. On both ends the pavement was a combination made of roseate granite stone, named *poriño*, and washed concrete pieces. The street lighting over the bridge was placed in the parapets of the deck. On the ends, on each side, we installed some modern lampposts. The monumental lighting was placed on the lateral slopes, over the maximum flood level.

On the 27th of September 2003 the bridge was opened to the public.

7. CONCLUSION

We think this is an original use of steel, which was chosen, not for economical or structural reasons, but for its aesthetic purposes in combining the old use of granite stone with the modern use of steel.

The restoration of the bridge has induced improvements of the surroundings; and we recovered the bridge's use, but, in some way, the bridge keeps on being broken.

Figure 9 – General view of the bridge and pavement and street lighting over the old part

REFERENCES

[i] A. González. *La restauració objectiva. (Mètode SCCM de restauració monumental). Memòria SPAL 1993-1998,* Diputació de Barcelona, Barcelona, 1999, pp 30-38.

[ii] F. Choay. *L'allégorie du patrimoine*. Éditions su Seuil. Paris, 1992, pp 114-129.

[iii] A. Riegl. *Der Moderne Denkmalkultus*, Wien, 1903. Spanish translation by Pérez López, Ana, *El culto moderno a los monumentos*, Visor. Dis., Madrid, 1987, pp 71-99.