

PEDESTRIAN ARCH FOOTBRIDGES

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Abstract. *The article presents two pedestrian footbridges solved through arches cable-stayed by the deck itself (Bowstring type). At the Monistrol footbridge the bearing structure consists of two tubular arches subtly lying towards the inside of the deck and its design was strongly conditioned to the presence of J. Manterola's Centenario Bridge. At the Torelló footbridge the square section arch is unique: a "bow tie" plan deck hangs from it by means of suspension cables, crossing the arch the deck's "directrix" with a slight skew. Lastly, the article presents a footbridge proposal over the motorway at the Castellbisbal service area, which was prepared for a competition.*

1 MONISTROL FOOTBRIDGE

1.1 Background and motivation

The town of Monistrol de Montserrat, with approximately 2.500 inhabitants, is placed at the bottom of the Montserrat Mountain. Throughout its municipal district crosses the road C-55 linking Manresa to Barcelona. The construction of a new junction between the town and this road forces the substitution of the present 1.5 m-wide footbridge crossing over the road and communicating Monistrol's city centre with a school and a residential area placed on the other side of the road.

On the other hand, one of the historic entry ways to the Sanctuary of Montserrat has been the Rack Railway, starting at Monistrol. This line was opened in 1892 and closed in 1957 due to a serious accident that took place in 1953. From 1995 on, with the setting up of the Association of Friends of the Montserrat Rack Railway, necessary steps have been taken in order to reopen the line, including new works like the building of the new station "Monistrol Vila" linked to the station "Monistrol de Montserrat" by the Bridge Puente del Centenario, by J. Manterola, which saves the River Llobregat.

On April 2002 the project of the new footbridge over the Road C-55 was commissioned to us, with 27 meter span, 3 m wide, and an explicit suggestion by the City Council: a tube bridge as well because it was to be located near this wonderful bridge.



Picture 1: Bridge Puente del Centenario in Monistrol (Javier Manterola)

1.2 Work description

The body and the environment were inviting us to use a wood structure, material that we have already used. But after various designs and proposals we ended up opting for a steel structure of tubular sections on its exposed elements, keeping that way a consistence with the new railway bridge.

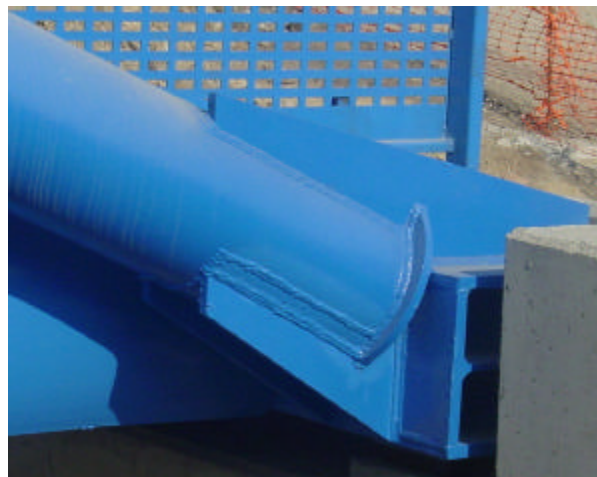
After considering various proposals of lattice or a single arch, we finally chose a structure made of two circumference arches (tubes $\phi 323.9 \times 8$) slightly inclined (9.59°) in relation to the vertical, the two supports are placed outside the deck (0.5 m from the axis of the lower suspenders) and the vertex on the vertical of the lower suspender's axis ($425 \times 350 \times 8$). The arches and the lower suspenders are kept together through struts and uprights, which are segments of the arches radius and therefore are not vertical (tubes $\phi 70 \times 4$). The deck consists of a concrete slab of 8 cm on a corrugated sheet metal supported by the IPE180 rib every 1.5 m that keep together the two lower suspenders.



Picture 2: View of the Footbridge

The connection arch-suspender is not made directly but by means of a cross element of certain power (a turned HEB 450), which transfers the strain between them.

The two arches have been braced in the central area by means of three tubes $\phi 100 \times 6$ mm thick in order to avoid their buckling.



Pictures 3 and 4: Connection suspension cable-deck and arch-deck

The connection between struts/uprights and the arch have been made directly, without any ancillary element, whereas the dimensional relationship of the elements with the lower suspenders does not allow the direct connection. Additional sheet metals are required, welded to the suspender vertical webs that overhang as eyelashes to this end.

The lower suspenders have been designed with rectangular section (with the eyelashes for the connections with struts and uprights) in order to facilitate the connection with cross ribs.



Picture 5: Inside before the launching



Picture 6: Side after launching

In order to homogenize the structure, curved imposts have been designed to cover the suspenders.

As for the treatment of the entry ways, we have to state our failure. The only element we could control completely was the deck, not the abutments or the environment.

1.3 Work credits (Monistrol Footbridge)

Engineering:	Manuel Reventós Rovira Josep Maria Prió Peralba
Work Direction:	SAEM
Construction Company:	COPCISA
Promoter:	GISA

2 FOOTBRIDGE OVER THE RIVER GES IN TORELLÓ

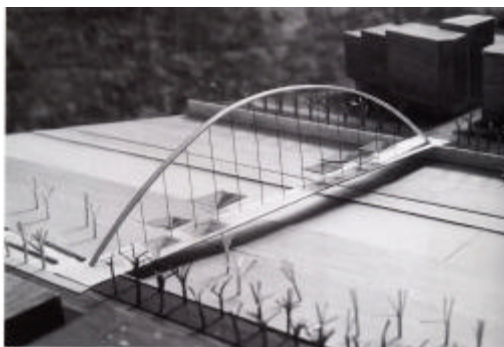
2.1 Work description

The pedestrian footbridge crosses the Ges river channel at the municipal area of Torelló, province of Girona.

The structural typology is a single steel arch of 32.87 m span cable-stayed by the deck. The arch's rise is 6.00 m. The deck consists of a steel framework supporting a lightweight concrete slab. The suspension cables are stainless bars.

The footbridge structural ground plan is “Z-shaped”, with central symmetry with centre on the middle point of the arch's ground plan projection. Both arch and suspender are in a vertical plane that crosses the deck's directrix, being assured the arch cross stability by means of two side crossbeams with the furthest end at the arch's base anchored to the abutment.

The idea comes from a competition –which we did not win- to make the new footbridge of the University of Lleida. We have always thought that design competitions are excellent moments of reflection and their results come often true somewhere else.



Pictures 7 and 8: University of Lleida Footbridge proposal model

The footbridge width varies from 4.97 m. at the span centre and 5.70 m. at the abutments, forming a bow-tie shape ground plan. Such ground plan, together with the arch's obliquity in

relation to the deck's mean directrix, create a curious effect because the suspension cables plane forms a virtual "wall" that the pedestrian or the cyclist can cross or not on their route.



Picture 9: Computer graphics of the bridge at its definite location



Picture 10: The footbridge finished

The arch has a square section of 480x480x8 mm and the suspender is rectangular: 1.000 mm wide and 650 mm deep. The ribs are reinforced beams and the suspension cables are stainless bars of 32 mm diameter protected by antivandalism galvanized tubs. The concrete slab, between 90-44 mm-width, is formworked by means of a collaborating formwork of corrugated sheet metal.

The River Ges is channelled by means of concrete walls founded on rock supporting the structure. Its integration into the walls is not direct: there are two determining factors in dispute. On the one hand, the natural terrain and the urbanization, outside the channelling, have a bound lower than the wall coronation bound. This situation requires to low to the maximum the footbridge slope but, on the other hand, the hydraulic determining factors require raising it over the walls. The solution is a compromise solution: cutting the walls and inlay the structure on them and limiting the footbridge lower bound to the hydraulic capacity of the section.

The footbridge rail is made of lightweight steel elements. On the upstream side a closed arrangement of the rail is used in order to protect the surfacing from the winter frosts. Downstream the modules are opened.

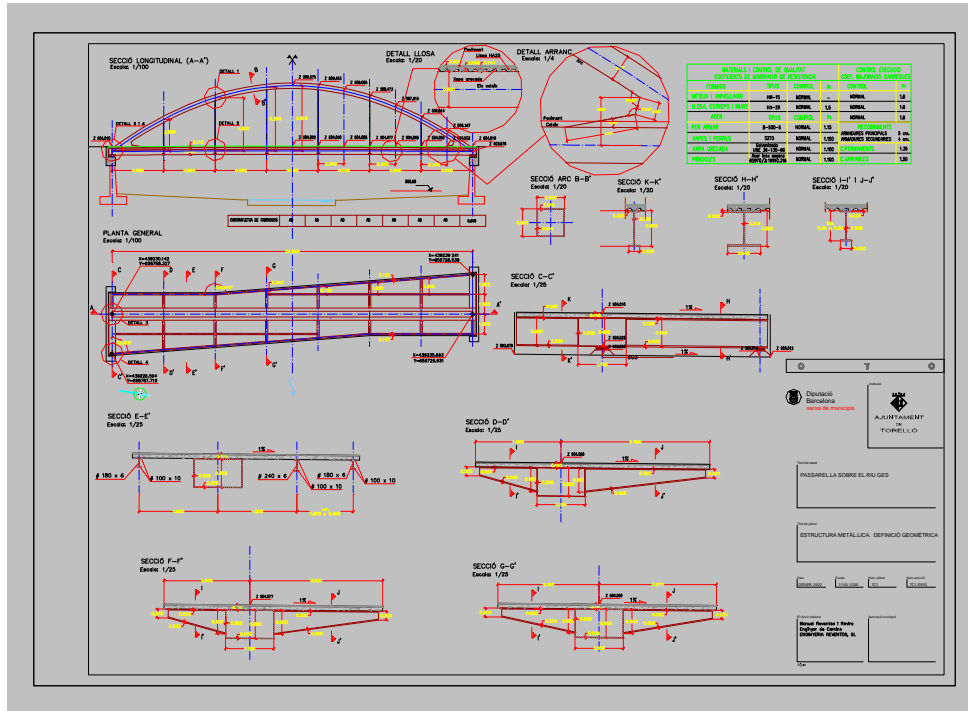


Figure 11: Steel structure plan



Pictures 12 and 13: Details of entry, stairs and ramp.

2.2 Construction budget

The budget (VAT incl.) amounts to 288.143,99 € (for a footbridge surface of approximately 172 m² turns out 1.675 €/m²), a lot of which is allocated to the entry ways.

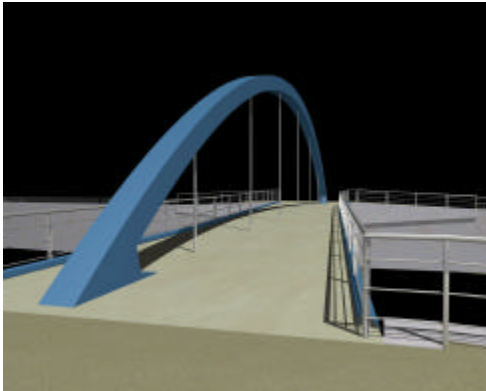


Figure and picture 14 and 15: Render and reality of the footbridge entry.

2.3 Work credits (Footbridge over the River Ges in Torelló)

Author of the Project:	Manuel Reventós Rovira
Collaborators Project Phase:	Josep Maria Prió Peralba Salvador Ràfols Segurana Francesc Pregona Tubau
Computer Graphics:	Jordi Comas
Construction Company:	Excover
Machinery Workshop:	Ascamon

3 FOOTBRIDGE AT THE CASTELLBISBAL SERVICE AREA

3.1 Work description

This preliminary plan is product of a design competition immersed in the tender of the complete remodelling of the service area, one of the first ones in the country and presently very deteriorated. The remodelling includes the building of a hotel, being the footbridge the entry way to it from the opposite “bank”, where another brand new building will be build. The competition was amongst construction companies. We were commissioned by ACSA.

The basic project requirements were the pedestrian comfort with the “fairly” closed cubicle protected from the rain and the price reduction of the base project, which was estimate to be excessive.

Using a few ideas from the base project we rearranged the situation and came to a solution with the following characteristics:

- Deck and cubicle consisting of a tubular Vierendel beam of 2.95 m deep consisting in turn of longitudinal tubes located in the four “corners” and uprights and crossbeams with curved square metal sections. The curved uprights and crossbeams overhang from the enclosures, showing both the external and the internal appearance of the rib.

- The deck is supported at the motorway area by a single tubular arch of 600 mm of diameter with suspension cables inclined both ways.
- The side enclosure is made of crystal stools supported by short extruded aluminium pieces, supported in turn by an axis that allows the change of inclination and therefore the cleaning of the stools.
- The surfacing is made of resin deck with finishing of rubber (“Parklex”), the ceiling of perforated stainless sheet plate, and the roof of curved polycarbonate and the rail’s handrail of wood.

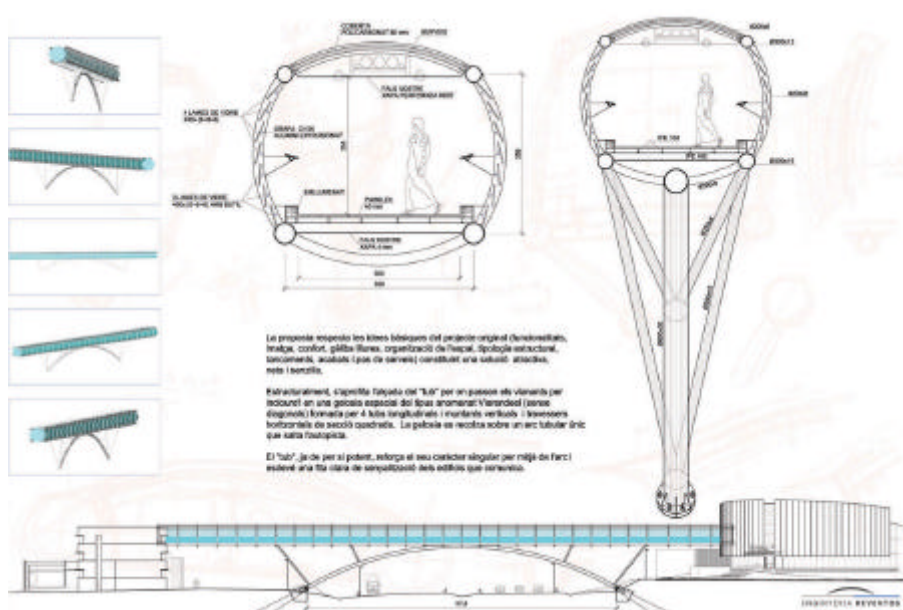


Figure 16: Competition's Poster

3.2 Work credits (Footbridge at the Castellbisbal service area)

Author of the Preliminary Plan	Manuel Reventós Rovira Albert Mas Soler
Collaborators project phase:	Marta Salellas Puigbert
Construction Company:	ACSA