

FOUR SINGULAR FOOTBRIDGES IN A GOLF COURSE IN MÁLAGA, SPAIN

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During the development of La Cala Golf Complex (La Cala de Mijas, Malaga, Spain), four singular pedestrian bridges were constructed as part of its 3rd Golf Course (Europa Course) in 2004 and beginning of 2005. The footbridges create permanent pathways for pedestrian, buggy and course maintenance vehicle traffic) over the Ojén River, which divides the area into two. The concept, detailed design and site construction management of these structures was all provided by Arup.

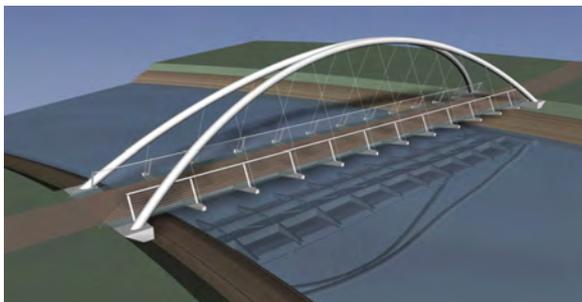


Fig. 1 Footbridge 1 visualization



Fig. 2 Footbridges 1 and 2



Fig. 3 Footbridge 3 visualization



Fig. 4 Footbridge 3

These footbridges are to be utilised by and are divided into two main types, in both cases with an arched structural form, but with significant differences in their overall aesthetic and structural behaviour. All of them have a singular character and a big effort has been made to design aesthetically pleasing solutions (with adequate structural sense), minimize hydraulic interference and respect the environment and golf game. Additional execution constraints existed as strict deadline and budget requirements, as well stringent restrictions to affect areas during the construction, coupled with the choice of an inexperienced contractor. Arup has accomplished the construction of these singular footbridges respecting these determining factors thanks to an accurate project and design and a close collaboration with the promoter and golf course designer during the project phase and with the contractor during the building phase.

The two footbridges situated further upstream (footbridges 3 and 4), with their whole structure elements under the boardwalk, are located in an area of the Ojén River where its channel is lined with rocky banks, that allow building foundations on them directly and allow horizontal load transmission. The aspect of these footbridges, with a span of 30 and 35 m, is one of an intertwined three dimensional truss of varying width and depth, made up of circular hollow sections. The form of the structures is curved in plan to ensure they adjust themselves to the layout of the buggy access

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pathways of the area in which they are located. The behaviour of these footbridges in spite of appearances is a hybrid between an arch and truss action, due to the bottom chords (or arches) being fully fixed at both ends, whilst the top chords remain free. It was decided to adopt these support conditions to guarantee acceptable behaviour of the structure with little or no maintenance required, as this was an important design criterion which was requested by the client.

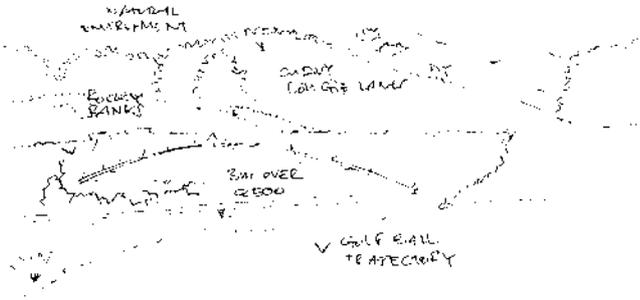


Fig. 5 Upstream determining factors

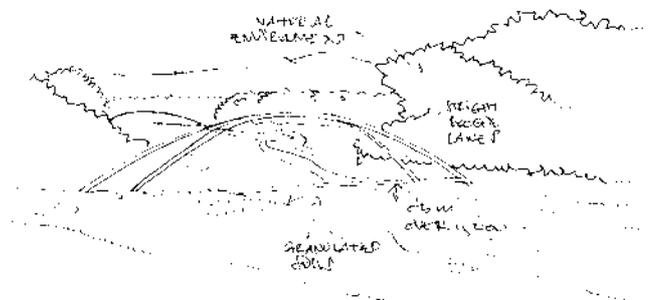


Fig. 6 Downstream determining factors

The two footbridges which are located further downstream (footbridges 1 and 2) span 40 and 44 m and are located in an area which displays geotechnical qualities (granulated soils) which restrict the use at a reasonable cost of a support system similar to that used for the two previously described footbridges. For this reason, the transfer of large horizontal loads at the supports has been done away with, creating a structure whose horizontal loads are in equilibrium, being balanced with a bow string type structural scheme. Each footbridge relies on two lateral arches which are each located in a plane inclined at approximately 23° towards the centre of the bridge, and are only tied to each other at their peak. The bridges unique decking has been designed with the need to elegantly incorporate a sewerage pipe. It is comprised of two box girders, tied together by a truss intertwined between the boxes, through which a large steel conduit is hung from the top chord (Fig. 5); the sewerage pipe is then placed within this steel conduit. The bars which make up the hangers are supplied as an exact length and are anchored to ribs which form extensions of the decking's transverse trusses.



Fig. 5 Steel conduit



Fig. 6 Positioning of footbridge 4



Fig. 7 Positioning of footbridge 3



Fig. 8 Loading Test for footbridge 1