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ALUMINIUM PEDESTRIAN BRIDGE IN PARCO SAN GIULIANO, MESTRE, VENICE, ITALY.

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Abstract. *This document suggests a solution for a new pedestrian bridge situated inside 'Parco San Giuliano', which is a masterplan for the environmental reclamation of an area located on the banks of the lagoon between Mestre and Venice .*

The footbridge crosses the San Giuliano Channel near the road and railway bridge which connects Mestre to Venice and overlooks the historical fort 'Forte Marghera' on the north side and the lagoon and the city of Venice on the south side.

The design proposes a lightweight and corrosion resistant arch tied bridge with an aluminium alloy superstructure made of two slender and inclined ribs which support, with steel cables, a deck system.

1 INTRODUCTION.

Between 1990 and 1995 architect Antonio Di Mambro, who won the international competition for the park, worked out the San Giuliano masterplan which provides for the restoration of a large area between Mestre and Venice which was deeply polluted by urban and industrial development during the last century.

The design outlines a blueprint for the future transformation of the site that integrates transportation improvements, land use changes, environmental reclamation and landscape construction [1]. Its achievement represents a long term program and will be completed in six stages starting from the central peninsula of San Giuliano to the perimetrical zones. Currently most of the first stage of this program which involves the central peninsula is about to be completed.

The proposed bridge spans the San Giuliano channel near where it flows into the lagoon and connects the San Giuliano peninsula with the tourist and scientific zones 'Area Pili' which is located behind the wooded area alongside the road and railway bridge to Venice. The pedestrian bridge is located in front of the lagoon and is clearly visible to people who cross the road and railway bridge to Venice or who arrive at the south of the peninsula, where most of the rest areas and services are situated, so that it will become an important landmark which will highlight the park.

2 BRIDGE CONCEPTION.

The design started with a preliminary analysis of the area looking at the channel's and the land's characteristics.

Until the opening of the railway bridge in 1864 the San Giuliano channel, which was opened in the middle of the sixteenth century, was one of the most important communication and commercial channels between Venice and the mainland. Since 1864 it has gradually lost its importance and now is mainly frequented by pleasure craft and by boats which transport food and building materials. The San Giuliano peninsula's embankment is mainly taken up by small docks, which will be transferred elsewhere to complete the first stage of the masterplan, while the south-west edge near the railway bridge is covered by uncultivated woodland.

For this area the Di Mambro design suggests the environmental reclamation and the restructuring of these embankments through the creation of pedestrian paths, the restructuring of the roadway to the San Giuliano Point and the creation of parking areas, 'piazzas' and rest areas.

Taking into account all of these aspects the first objective was to create a structure which would fit into the context of the masterplan and at the same time remembering its particular position in front of the lagoon and its distance from Venice.

The second objective was to allow access to boats along the channel and to vehicles along the road to San Giuliano and, at the same time, building a bridge which would be accessible in all directions to handicapped people.

The third objective was to design a light structure that would place a little load as possible on the foundation ground but at the same time would withstand the aggressiveness of the sea environment.

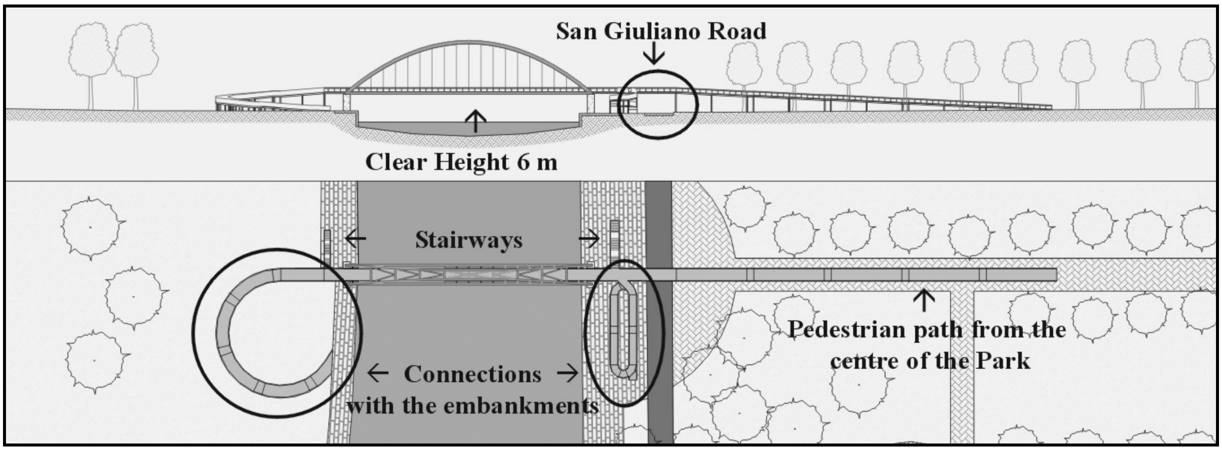

Figure 1: Bridge plan and elevation.

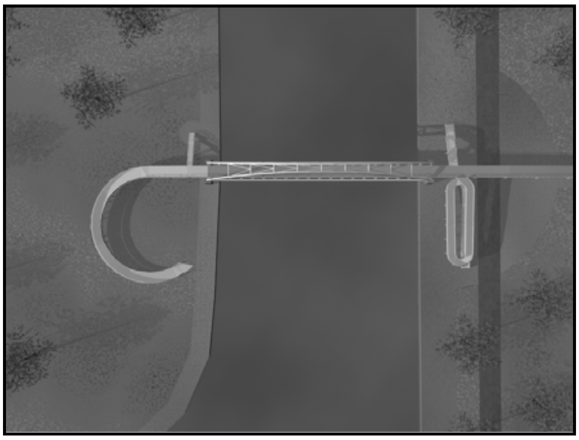

Figure 2: Plan view.

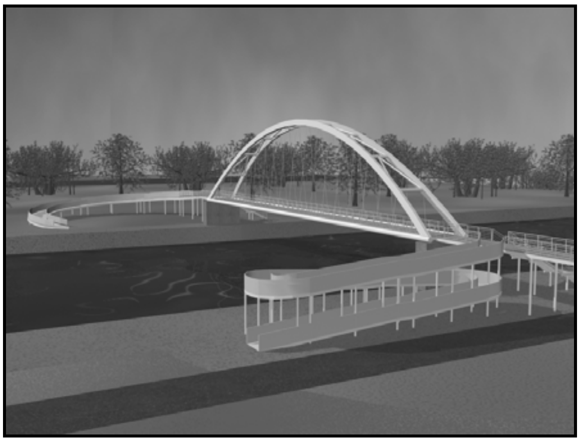

Figure 3: Perspective view.

Starting from these parameters the bridge design was drawn up. At the north-east end is a pedestrian path, 2,5 m wide, which comes from the centre of the park. It rises softly to a height of 4,3 m near the intersection with the San Giuliano road.

The footpath crosses the channel with an arch tied clear span of 52 m and descends to the south-west embankment following a circular course. This central part has a clear height of 6m over the water and is supported by two reinforced concrete piers placed on the banks, clear of the channel bed.

At the intersection of the north-east walkway the bridge is joined to the pedestrian path by a stairway connected with an O-shaped ramp which permits access to people going through that way. Similarly at the intersection with the south-west embankment a stairway is connected to the bridge.

The superstructure is made of 6082 aluminium alloy which has high mechanical resistance comparable to structural mild steel Fe360 , good corrosion resistance and good extrudability and weldability. It is available in all forms and is the most used in marine construction [2] [3] [4].

The lightness of the aluminium alloy (its density is around one third of steel one) allows a reduction of the foundation loading, giving, at the same time, a corrosion resistant structure. This is possible because the live loads are relatively light.

3 CENTRAL SPAN.

The central span shape was chosen between a suspension and a cable-stayed solution for the high aesthetic and historical value of the arch with the view of creating a structure that would fit harmonically in the overall context.

The span is made of two slender parabolic ribs which support, through steel cables, the deck, which takes in the horizontal forces.

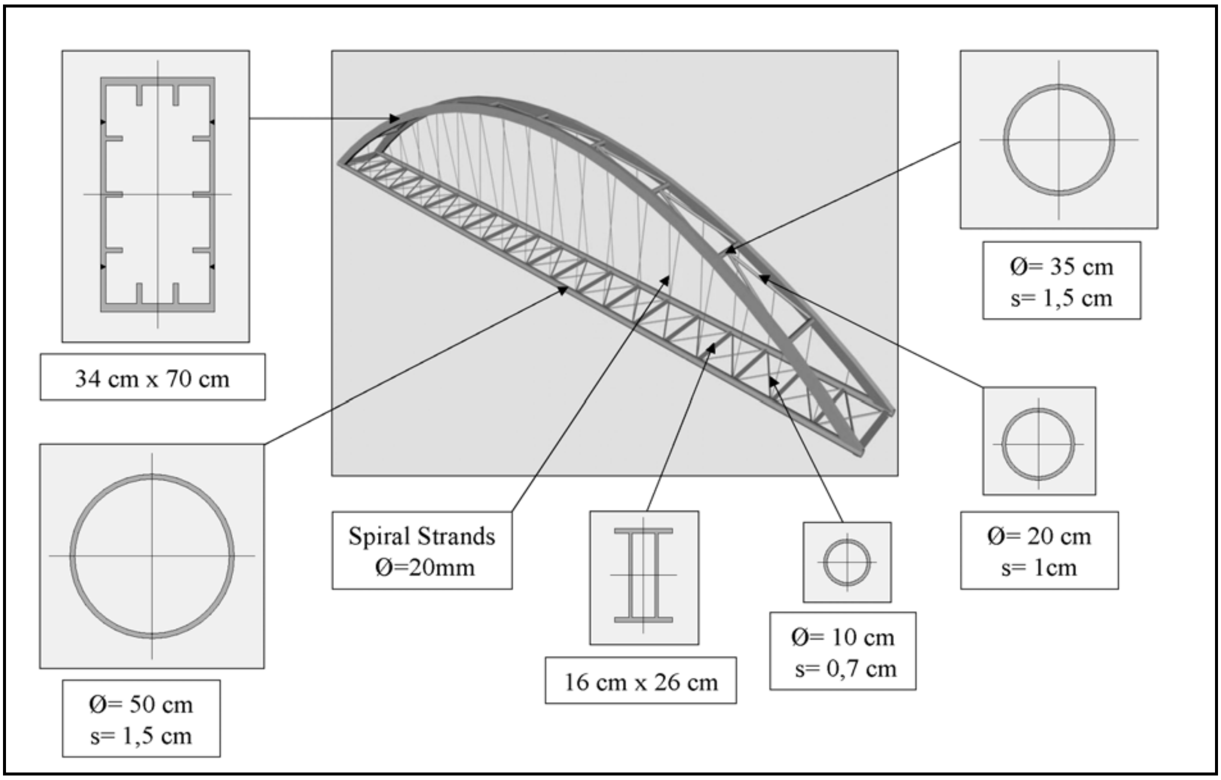

Figure 4: Central span structural elements.

The ribs have a rise of 10,95 m , are inclined 6° and have a distance of 1,71 m at the crown and of 4 m at the imposts. These consist of 340 x 700 mm rectangular section made of 25 mm top and bottom plates welded to 15 mm webs. Plates and webs are stiffened by longitudinal stiffeners 15 mm thick. These ribs are connected by tubular crossbeams Ø 350 x 15 mm. Ribs and crossbeams are stiffened by tube Ø 200 x 10 mm.

The deck consists of two lateral girders with a distance of 4 m , connected by 2,6m distance crossbeams and stiffened by tubes. The tubular girders are Ø 500 x 15 mm while the crossbeams have a double T section with two webs , 260 mm height and 160 mm width. The stiffeners are Ø100x7 mm . At the piers the stiffeners are Ø 120 x 10 mm. The walkway leans on the crossbeams.

The steel cables are Ø 20 mm spiral strands and are placed at the intersection between the deck's crossbeams and girders having a distance of 2,6 m.

Bolted connections are made with A4-80 stainless steel elements. Weldings are made with automatic or semiautomatic MIG process (metal inert gas) using 4043 A alloy which gives maximum corrosion resistance.

3.1 Design criteria.

The design started with preliminary plans and a two dimensional finite element model, then a three dimensional finite element model was developed. A linear static analysis was performed using Straus7 [5].

The design was based on the European Specifications for Steel Structures: Eurocode 6 [6] [7] and for Aluminium Structures: Eurocode 9 [8] [9] [10] and the Italian Bridge Specification [11] [12].

The design live load is 4 kPa. Wind effect is considered as an horizontal load of 2,5 kPa.

Maximum deformation was obtained at the quarter, loading half span and corresponds to a flexion of 8,92 cm equal to L/583.

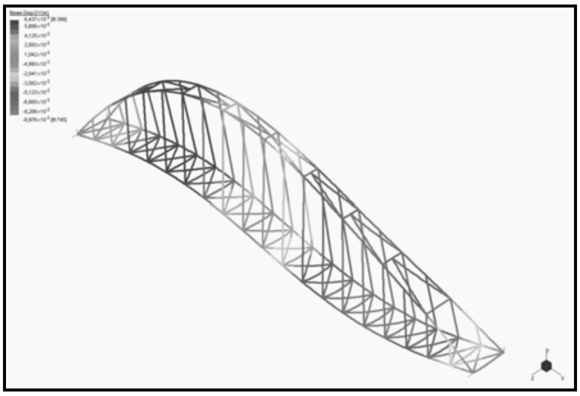

Figure 5: Deformed shape for half span loading.

4 DETAILS.

To simplify the structure's transport and assembly the central span is made up of blocks with maximum length of 12 m, all workshop built, which must be assembled in place through bolted joints. The arch and the deck are each one made up of five blocks joined with thick and stiffened plates connected with Ø 22 mm bolts.

The connections among girders, crossbeams and stiffen beams, at the deck, are mainly done through bolted joints while for the arch they are done mainly by weldings at the workshop.

The connections at the end of the cables are made through stainless steel open sockets joined to thick aluminium plate.

At the piers the structure leans on two galvanized steel beams which are supported by fixed bearings at one side and by unidirectional bearings at the other side.

The maximum displacement produced by thermal effects is about ΔL= 6,15 cm and is settled with the unidirectional bearings and a dilation joint on the path.

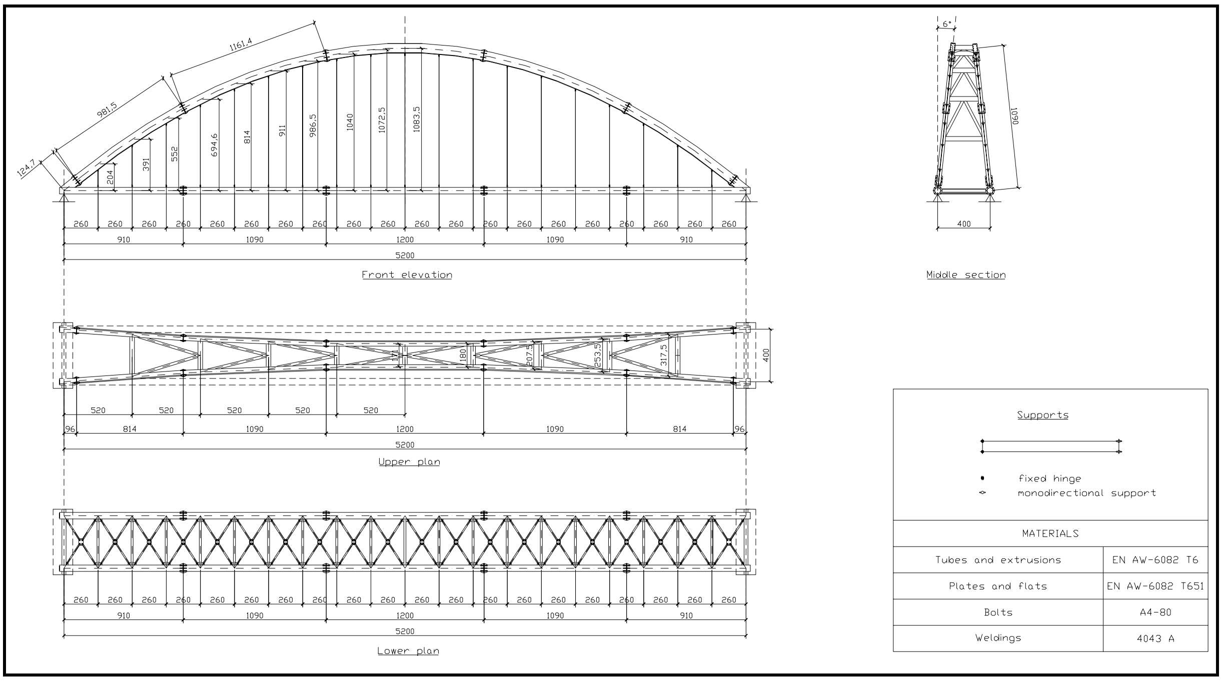

Figure 6: Central span structure.

The parapets are 1 m height and are made up of tapered H section, 95 mm height and 60mm width, located at a distance of 1,3 m and connected by cross tubes Ø 40 x 6 mm. The handrails consist of tubes Ø 60 x 8 mm. The H sections lean on 95 mm side square section which contain the light system and are bolted to the deck's crossbeams.

To minimise the risk of corrosion, where dissimilar metals are in contact, all bolted connections are enclosed within PVC pipes or separated by inert washers.

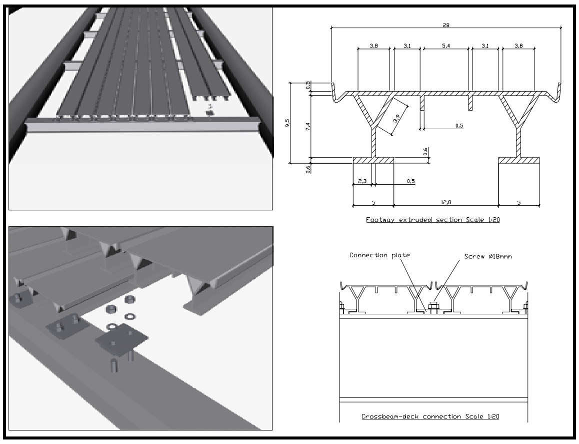

Figure 7: deck system.

Figure 8: Central span path view.

The footpath consists of extruded open sections joined to the crossbeams with shaped plates connected with Ø 18 mm bolts. These are covered with shaped, camel-coloured, anti-slip and wear-resistant rubber granules which provide an open structure that drains off all rainwater.

The dimensions of the external profile are depth x height = 280 x 95 mm while the weight is about 41 kg/m^2. The extrusions are easily and rapidly installed on the supporting frame by putting them together and bolting them.

The weight of the central span is about 300 kN while the weight, including the walkway and the parapets, is about 400 kN.

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