Don Bosco Bridge at Arenaccia: the architecture white as light

A. De Luca and G.Lucibello
Department of Structural Engineering, University Federico II, Naples, Italy

A. De Martino
Department of Constructions and Mathematic Methods in Architecture, University Federico II, Naples, Italy

G. Mautone
Professional Engineer

ABSTRACT: In this paper, the realisation of a reinforced concrete variable-thickness skew vault bridge recently awarded a special mention at AICAP 2009 Prize is illustrated. The bridge was already presented in the ARCH'07 Conference during its construction phases, and is now completed. In the paper special attention is focussed on the material used (self-compacting concrete with special mix design to allow casting onto doubly inclined surfaces), on the concrete protection issues leading to choose a full surface protection with the use of mosaics and, finally, to the aspects related to the correct architectural design which involved the proper insertion of the bridge in the surrounding urban environment. In this activity special attention was paid to the aesthetic value of the construction in its entireness.

1 INTRODUCTION

The Don Bosco Bridge at Arenaccia is a reinforced concrete variable thikness skew vault which has been realized in the historycal center of the city of Naples. The bridge, was completed on 21 February 2009 and was awarded a special mention at the AICAP Prize 2009 for best concrete construction within the category of bridges with the following motivation:

"..in the design it is enviseaged the brilliant insertion of the construction within the urban environment, the valuable aestetic result, the functional efficiency and the elegant structural conception.."

The main structural feature of the bridge were presented in the previous ARCH'07 Conference (De Luca 2007). The structural construction of the bridge started July 24, 2006 and was completed just one year after beginning, on August 10, 2007 allowing the traffic to pass over via Don Bosco which represents a main road of the city of Naples. After completion of structural part, the Administration decided to ask the designers to complete the urban insertion of the construction by designing a small plaza in front of the bridge. This phase was carried out during 2008 and the construction was completed on February 21, 2009. The decision of the designers to protect the concrete surfaces with mosaics represented an opportunity for coniugating structures, art and architecture. The intervention of an Artist was involved in a "three hand design": Structure, Art and Architecture. The insertion of the new construction within the urban surrounding represented then a major task for the designers. In the present paper the following two aspects are analyzed: 1) the properties of the concrete used (self compacting concrete to be realized on inclined surfaces), 2) the architectural aspects concerning the insertion of the bridge in the urban environment.

Figure 1 : The Don Bosco Bridge at Arenaccia

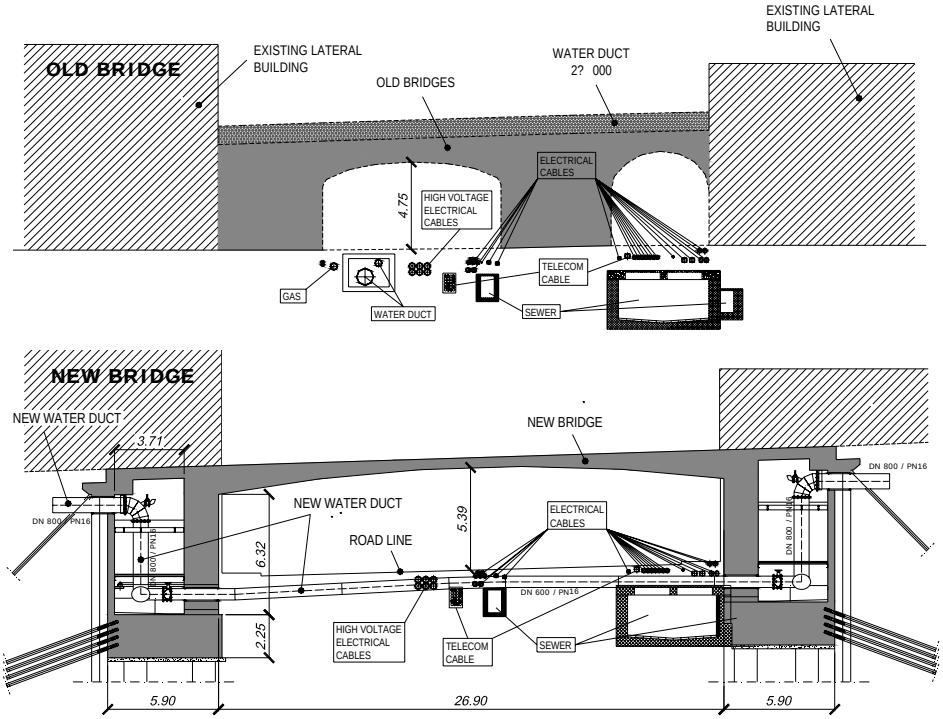

Figure 2 : The old vs new bridge with utility networks placement indications

2 BRIDGE DATA

The bridge spans 26.90 m over Corso Novara with an angle of skewness of 38.54°. The deck overall length is about 30.5m while its width is 19.85m. The vault thickness ranges from 1.5m (at the abutments) to 0.5 (at the crown) with a rise of 0.5m.

To give an idea of the vault slenderness, other interesting geometrical parameters are:

(1) The average thickness(s) to span(L) ratio: s/L = 1/27;

(2) The span(L) to rise(r) ratio: L/r = 54;

(3) The span square to rise ratio: L^2/r=1.450 m.

This last value, frequently defined as “static coefficient”, ifs proportional to the arch thrust. For the Don Bosco Bridge the “static coefficient” assumes very large values if we consider that the world maximum value is reached with 3.000 m for the Infant Dom Henrique Bridge (Fonseca 2007).

Due to its location within an old and densely populated area, the design of the via Don Bosco Bridge was influenced by a large number of constraints. Among these, a major role was played by

existing utility networks, located as shown in Fig.2. Among these constraints, those which most strongly affected the design of the new bridge were: two 1000mm water ducts, a major sewer, existing lateral buildings and a bundle of telecom and electric cables. These aspects have been yet presented in (De Luca et al. 2007,2009).

Figure 3 : The old vs new bridge

3 MATERIALS

3.1 Special mixture for SCC on inclined surface

One of the interesting aspects of the Don Bosco Bridge was the choice of a special mixture for the concrete. Due to the high percentage of reinforcement (Fig.4) it was decided to adopt a Self Compacting Concrete. The need for studying a special mixture for SCC derived, from one side, from the need of casting the entire upper part of the bridge in one shot (approximately 1000 m^3 in one day), and from the other side from the need of having a slope of 3% in two directions. The SCC then had to be self leveling but not too much, fluid but not too much, viscous, but not too much. So, having decided the following properties:

(1) Compressive strength class: C35/45 SCC;
(2) Environmental exposure class XA3;
(3) Maximum gravel diameter: 25mm;
(4) Chlorides content class: cl 0,20;
(5) Water-cement ratio: A/C≤0,45;
(6) 7 days compressive strength: ≥28N/mm2;
(7)14 days compressive strength: ≥35n/mm2.

It was then necessary to set up and test several concrete mixtures to chose the best among them for its properties in terms of fluidity and viscosity. For this purpose, it was also set up a special testing procedure for checking the adequacy of the mixture in terms of viscosity (Fig.5). The final mixture was defined to have a V-Funnel and slump flow test values respectively of 8'' and 550 mm. These values were used during casting for checking quality of all the concrete in the mixers.

The finally employed mixture is: water 180 kg, 42,5 class cement 450 kg, filler 200 kg, dry sand (diameter range 0÷4mm) 600 kg, washed sand (diameter range 0÷4mm) 650 kg, gravel (diameter range 0,4÷12,5mm) 100 kg, gravel (diameter range 12,5÷25 mm) 100 kg, super fluidifying additive 5,5 kg and tickening 2,5 kg; with a water-cement ratio 0,4 and a water-superfine ratio 0,28.

Figure 4 : The deck heavy reinforcement

Figure 5 : Special testing for checking viscosity on an inclined plane and slump flow test for SCC

3.2 Concrete protection

The bridge is located in the historical center of Naples with densely population and intense traffic, so it has been decided to coat the concrete exposed surfaces to ensure their protection and therefore durability. Specifically a white translucent glass mosaic with decorations on the vault and on the abutments has been chosen. The coating glass mosaic (of Trend Vitreo series) is composed of little 2 x 2 cm square small tesseras mounted on 31,6 x 31,6 cm sheets (Fig.6-7).

The decision of the designers to protect the concrete surfaces with mosaics represented an opportunity for coniugating structures, art and architecture. The insertion of the new construction within the urban surrounding represented then a major task for the designers. Particular attention was paid in the realization to check that the design was respected. In Fig.8 are compared the drawings developed during the design phase and the construction as realized. In the following sections of the paper the architectural design is explained.

4 THE DON BOSCO BRIDGE: THE ARCHITECTURE, WHITE AS LIGHT

The architectural intervention on Don Bosco Bridge, as nowadays visible, was born with unspecified limits on the South West side due to uncertainty about the demolition of an old ruined building in place of which a small plaza would have ben realized. So the request for a balaustrade design, turned into a chance to improve a highly deteriorated urban habitat starting from the initial simple purpose of bridge substitution. The new balaustrade, since from first sketches, has been proposed as a visually permeable element simultaneously provided of an its own expressive and formal meaning, in daylight and at night, transforming an anonymous promenade in a place characterized by a proper character. The new reinforced concrete bridge is constrained between residential buildings and, especially on the East side, gives to observer the misleading feeling to rest on one of these buildings. So the original project incorporated other aspects involving not only the balaustrade design but also the vault intrados and abutments formal definition. It was decided to clarify on the East side, the structural independence of the abutments from the boundaries, while on the west side a continuity of the abutments on the retaining wall and the stairs was established. The presence of shops and of a cultural association

venue for children entertainment highlighted the decision of the Administration to demolish the old ruined structure, to reinforce the walls containing the road with consequent birth of a new little urban open air space.

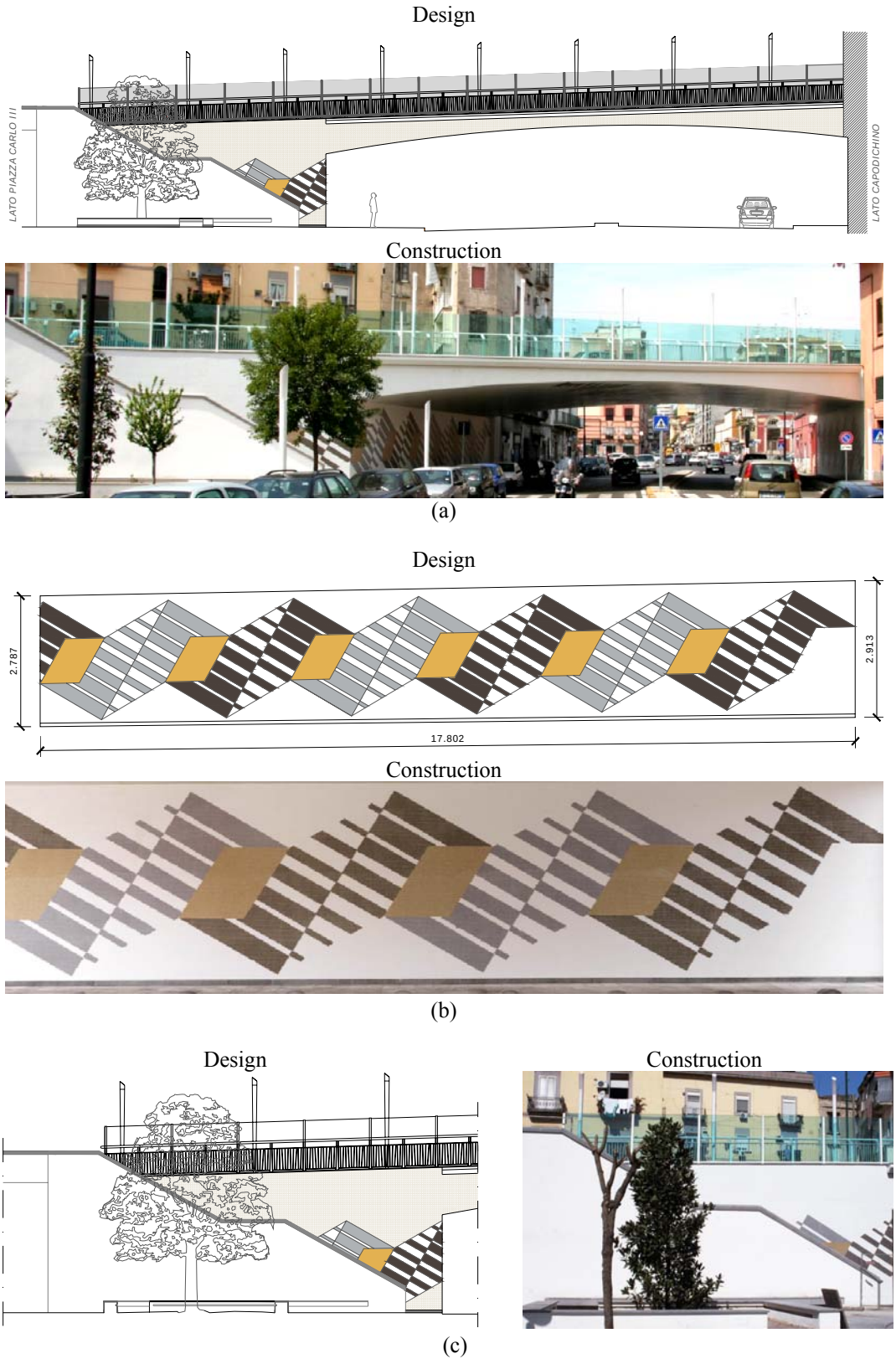

Figure 6 : The bridge as designed vs as built : (a) The Elevation, (b) The Abutment, (c) The stairs.

4.1 Balaustrade-sidewalk system

The new balaustrade (Fig.6-7-8) is composed, on the lane side, of iron panels forming a varied pattern deriving from the rhythm of the vertical elements and, on the external side, of a modular sequence of glass panels fixed on channel steel profiles masts. Between vertical elements are placed the lampposts shaped as slender torches. All the iron parts are white gloss painted and the flooring is of volcanic stone.

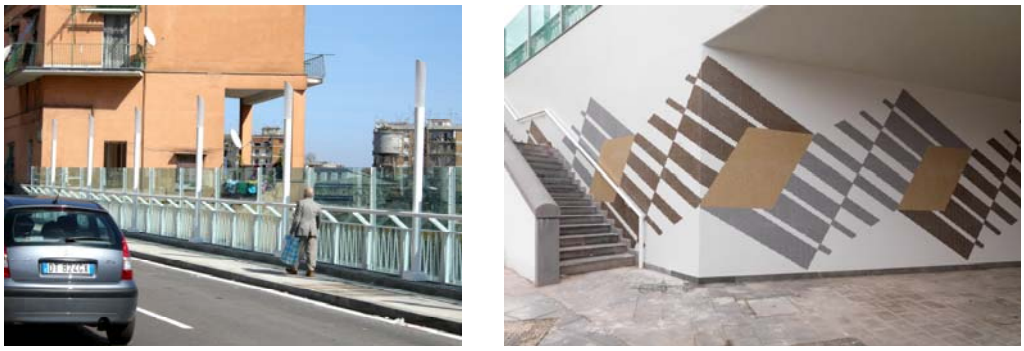

Figure 7 : The west abutment whit the new stairway and the balaustrade

4.2 The insertion of the bridge in the urban environment and aestethic issues

As yet underlined, the laconic cut of the stairway that connects the two city levels, highlighted by the thick grey sandstone handrail, became occasion to "clean" an old highly deteriorated tuff wall and to rearrange the chaotic crowd of ruins, brushwood and waste that lied on sidewalk that just few years ago has been interested by a cleaning intervention by Naples Municipality; so the sidewalk insertion has been the occasion to fulfill this enterprise started with the Corso Novara viaduct demolition. A long sandstone seat embedded in the white new stair wall and two L seats that embrace a tree (we hopes become tall and full of flowers) are the elements inserted to turn this place in a little relax place for children entertainment and to simply chat. In Fig.8 it s reported the situation before and after the intervention. It is clear that the "three hand design": Structure, Art and Architecture, with the cooperation of three professional figures dealing with the three different aspects allowed to have a coordinated design and to control the quality of the final result.

Bridges built in urban areas too often feature elements lacking order, disconnected, and various: beams, crosspieces, bolts, welds, aprons, little shelves, shelf girders, railings, guardrails, mashes. These elements often form a disorderly universe that allows no possibility of cleanness of form in creating an insertion in the urban network. The infrastructure thus becomes, too often, synonymous with poor architectural quality. Concrete, with its vocation for the continuous structure, lends itself to eliminating the diversity of elements: piers, main and secondary girders, crosspieces, stiffeners, bracings, etc. The mosaic then offered the possibility of creating a uniform whole.

Hence, the decision to clad the bridge with mosaic tesseras gave the new infrastructure complex a very obvious character, making it readable from the road crossing it even at long distances. Design had, in this case, set up, after consulting the Artist Mariangel Levita, an abstract design of great sizes in tones of black, grey and golden-yellow on a white background, the idea to transform the passageway into a true promenade amid art and architecture. The design on the down-slope abutment bends then towards the new stairway both to mark the thickness of the abutments (six meters deep) and to suggest the continuation of the walk towards the city's upper level.

The protection of the concrete surfaces, with a view to durability and sustainability of a public work, formed the point of departure for an artistic operation and for the best fit of the infrastructure into its urban context, where the bridge becomes something that does not arrogantly state its presence but that rather seeks to fit its various parts in, discreetely. The mosaic is like a mantle in Christo's installations, which enwraps all parts of the bridge to give it conformity and continuity. The whole (mosaic, balaustrade and light masts): white as light.

Figure 8 : The small plaza before and after intervention

5 ACKNOWLEDGEMENTS

The bridge construction, completed on 21 February 2009, has been financed by F.E.S.R. P.O.R. Campania 2000-2006.

REFERENCES

Adão da Fonseca A., 2007. The Infant Dom Henrique Bridge over the River Douro, at Porto. Arch'2007, 5th International Conference of Arch Bridge, Madeira, Portugal, 12–14 September 2007, p.931-960.

Coppola, L. 2007. Concretum. McGraw-Hill.

De Luca A., De Martino A., Ricciardelli F. and Mautone G. 2007. L'utilizzo di calcestruzzo autocompattante (SSC) per la realizzazione del ponte Don Bosco a Napoli. Giornate Aicap, 24 Convegno Nazionale, Salerno, 4 – 6 ottobre 2007, p.591-598.

De Luca A., De Martino G., Ricciardelli F. and Mautone G. 2007. Replacement of ponte Don Bosco: A r. c. variable thickness skew vault in the urban environment. Arch'2007, 5th International Conference of Arch Bridge, Madeira, Portugal, 12 – 14 September 2007, p.815-830.

De Luca A., De Maio F., De Martino A., Marangi G. and Mautone G., 2009. Il Ponte Don Bosco: La protezione del calcestruzzo occasione per un inserimento urbano. Giornate Aicap, 25 Convegno Nazionale, Pisa, 14 – 16 maggio 2009.

Okamura H. and Ouchi M. 2003. Self-Compacting Concrete. Journal of Advancede Concrete Technology, Vol.1, N.1, April 2003, p.5-15.

Rossetti V., 2003. Il calcestruzzo, materiali e tecnologia. McGraw-Hill.

Inspection, assessment and management of arch bridges