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LEONARDO DA VINCI'S FOOTBRIDGE IN KAZAN: A BRIDGE BETWEEN TWO CULTURES IN THE NEW ISTANBUL PARK.

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ABSTRACT

Kazan is the capital and largest city of Tatarstan Republic, Russia. With a population of about 1.150.000 people it is the eighth most populous city in European Russia.
This last summer the city held the 2013 Summer Universiade. Over 10.400 university athletes from 162 countries participated in 13 mandatory and 14 optional sports, making the 2013 Universiade the biggest ever in the history of the event. For the first time in history a Cultural Universiade was also included, with many festivals and shows held simultaneously with the sporting events.
For this important event a number of facilities have been implemented including the new Istanbul park designed by the Turkish architect Hakan Kiran from Istanbul.
Within the project of the Istanbul Park was also present a modern interpretation of the footbridge designed by *Leonardo da Vinci* in 1502, made of duplex stainless steel, overcrossing, with a slightly tilted couple of arches, an urban road. The footbridge would be implemented in a second work stage and represents, in line with aims of the Cultural Universiade, the physical and cultural link between Kazan and Istanbul.

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Introduction

Fig. 1, Rendering

The LDV Kazan footbridge project is located in a new urban area, once upon a time abandoned, and now renewed with a new urban functionalities as a park. The footbridge design has been developed thinking to a connection able to act as a physical and cultural link. The cultural values of the historic areas of Kazan, overlooking the natural inlet of Kazanka river, could be considered in parallel with the historical geography of the Golden Horn, in Istanbul. This last, an inlet of the Bosporus, divides the Istanbul core forming a natural historical harbour. Similar situation is in Kazan where the flow of Kazanka water gives room,

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in the two banks, to spaces of high historical value that now can be considered as a belvedere pointing at the historic and cultural core of the city.

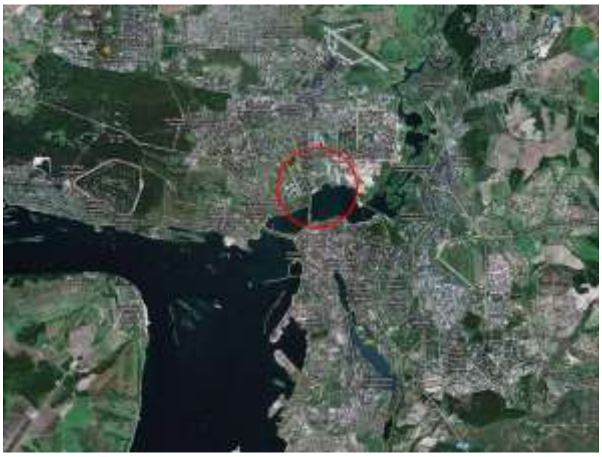

Fig. 2, Location at wide scale; Fig. 3, position in the new Istanbul Park area.

The design of this footbridge, like those for the Şirinevler area and for Gezi Park in Istanbul (Turkey), is part of a design experience which combined an in-depth technologic study with an anthropological approach developed by A. Stocco in the research field of the University of Nova Gorica, Graduate School.
These projects were developed by a design team, which operated synergistically with the aim of implementing the multiple inputs coming from the anthropological and technological studies in each project.



Fig. 4, Yeni Gezi footbridge; Fig. 5, Şirinevler footbridge

For the aim of this paper, in the case of the Leonardo da Vinci Footbridge, the intention is to give room to how the anthropological aspects were faced in relation to how the technological choices were made: the choice of Duplex steel, which has cultural reasons, starts from the most probably Leonardo Da Vinci's expected goals, at the beginning of XVI° century, in the design of such kind of stimulating bridge for Istanbul.

The Istanbul Park and the new LDV's footbridge

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Within the project of the Istanbul Park was also present a modern interpretation of the footbridge designed by Leonardo da Vinci in 1502, made of duplex stainless steel, spanning,

with a slightly tilted couple of arches, an urban road defining a continuous path from the park to the green areas on the Kazanka shoreline just before it joins the Volga river.
The footbridge would be implemented in a second work stage and represents, in line with aims of the Cultural Universiade, the physical and cultural link between Kazan and Istanbul.

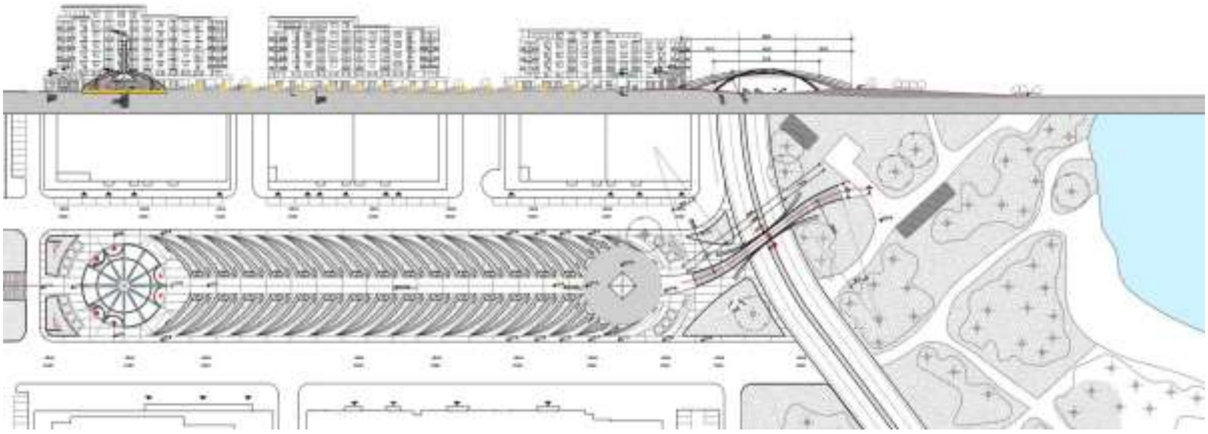

Fig. 6, Plan and elevation of the footbridge in the new Peace park context.

The footbridge axis is inclined if compared with the axis of the park and it is formed by a sinuous double curvature. The choice to differentiate the footbridge axis reinforces the architectural concept design of the park and, at the same time, acts as a connecting element between the straight formal axis of the park and the naturally soft and sinuous lines of the footpaths, which are present in the green spaces beyond the road in front of Kazanka water.
The deck defines a segmental arc that spans 60 meters. It is designed using a duplex steel box section having variable height:1.5 m at springers and 0.5 m at the crown. The width of the deck is variable from 5 m, at the entrances of the path, to 3 m in the middle.
Structurally, it behaves as a continuous beam, supported at the connections of the pair of arches, and in the centre. The pair of side arches spans about 35 meters, connects the deck at the third parts, and are inclined by about 30°, thus conferring a strong stability to the static behaviour of the overall structure.
Use of duplex steel as an innovative and technologically advanced material, defines a work of art which could be sustained over time and therefore able to stand up in such an aggressive environment, where maintenance efforts have to be as low as possible.

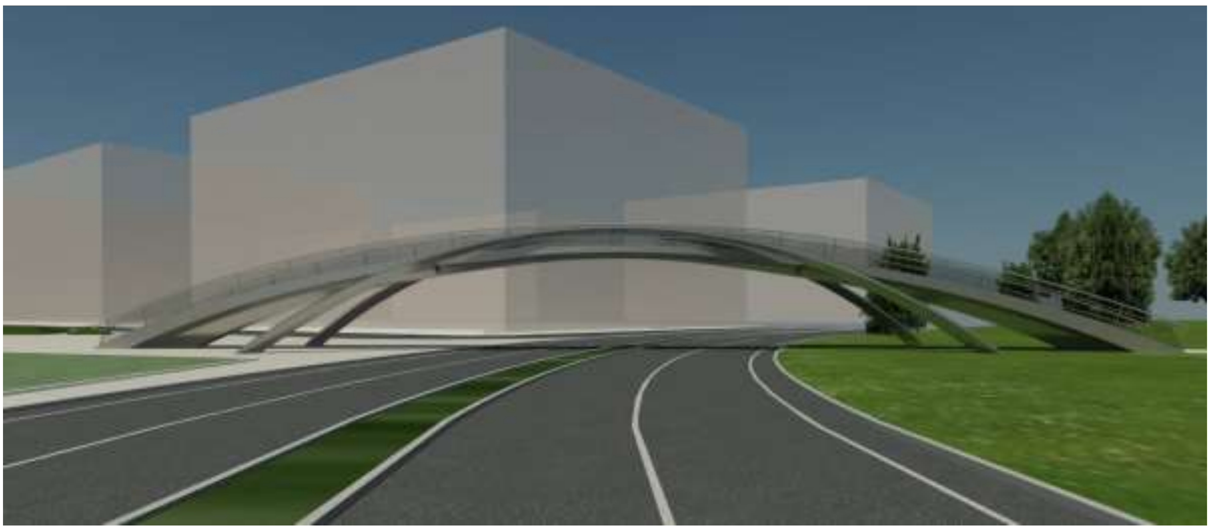

Fig. 7, Rendering

Leonardo da Vinci's footbridge

> "*I, your faithful servant, understand that it has been your intention to erect a bridge from Galata to Stambul across the Golden Horn, but this has not been done because there were no experts available. I, your subject, have determined how to build the bridge. It will be a masonry bridge. It will be so high that no one will be willing to cross it. I thought of making a wooden partition through which the water would drain away and of supporting the bridge on piles. I will construct this bridge in such a way that a ship under sails will be able to pass underneath...*"

With these words Leonardo describes, in a letter to Sultan Bayezid II, how he would have built a great bridge over the Golden Horn.
In an inventory of its holdings published in 1938 the Topkapi lists the letter as E-6184. The official identifies the author as "Ricardo 'the kafir' of Genoa (the year of the letter is not given).
Sketches in figure are found in a Codex stored in the Institute de France in Paris: Manuscript L.

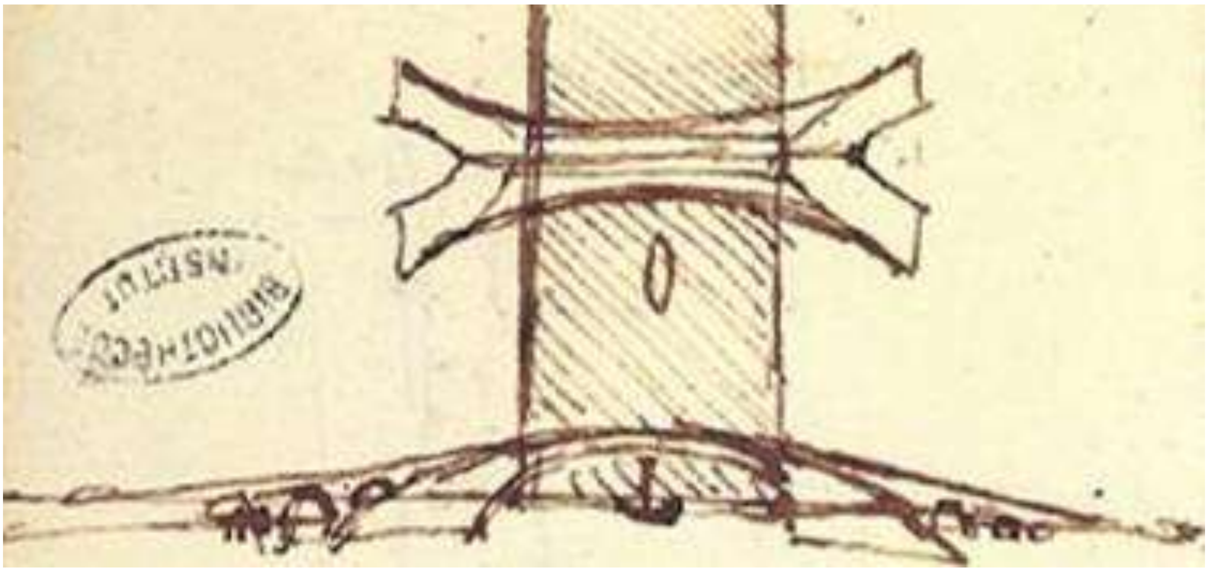

Fig. 8, Leonardo's sketches for the bridge

Leonardo's sketches reveal a masterpiece combining form and function: an arc bridge with a smooth silhouette and its ends flared outward as a swallow's tail. The form of the bridge combined with the clever use of masonry constitutes the essential Leonardo's concept vision especially considering the technological knowledge of those times.
Here a contemporary interpretation of Leonardo's bridge vision as a cultural link between Istanbul and Kazan: the bridge that Leonardo proposed for Istanbul realized with the aim to concretise the old concept in a practical and feasibly way adapted to suit current regulations and site conditions at best.
The aim of this new design is to give the content and spirit of the original old one without implementing a real formal copy, thus using the same approach as Leonardo but considering nowadays today's material and form knowledge implemented in a way to re-interpret Leonardo's ingenious approach. From this basic assumption to the use of duplex steel.

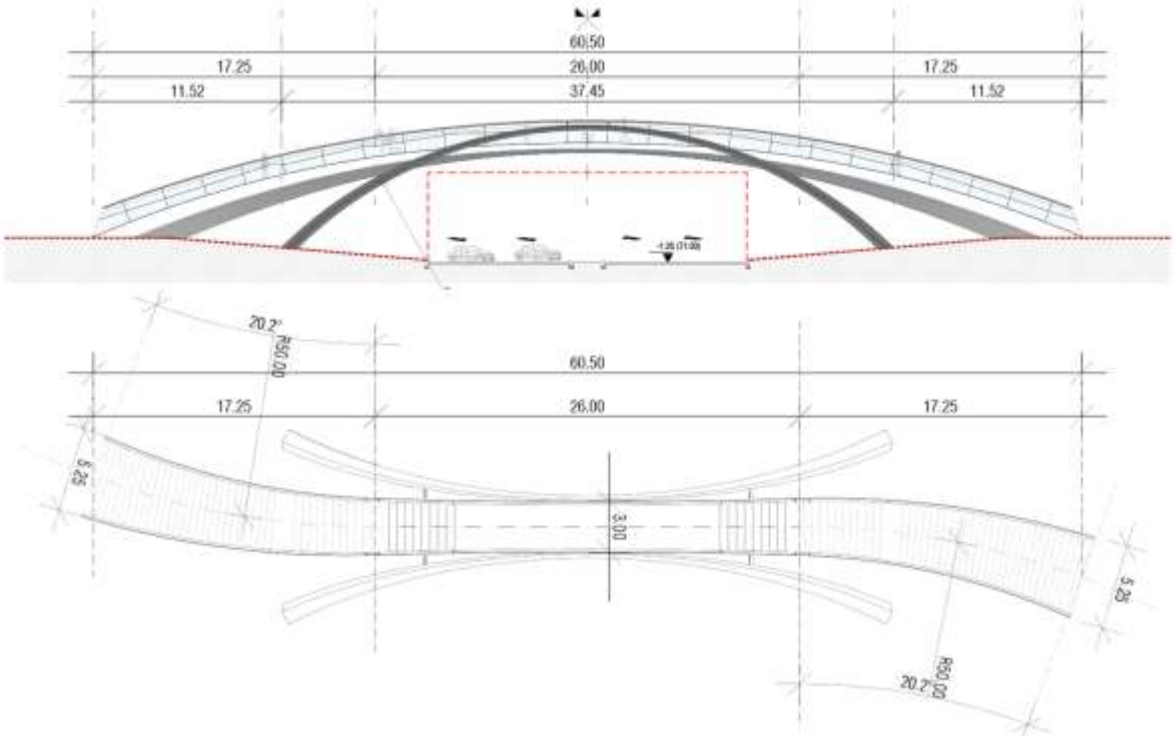

Fig. 9, Elevation and plan of the footbridge.

The pedestrian bridge takes its principal shape by the main segmental arch which constitutes the footpath of the footbridge. The deck is formed by a girder box section and it's fixed in two points to the arcs intersections and hanged at the crown with a couple of hangers.
The arch section has octagonal shape with 10 mm thickness and variable sizes. It is inscribed in a rectangle 1 meter height and 0.3 m width at the supports and in a square with side of 0.3 m at the crown. The calculation span is approximately 42.5 m with a rise of about 9 m.

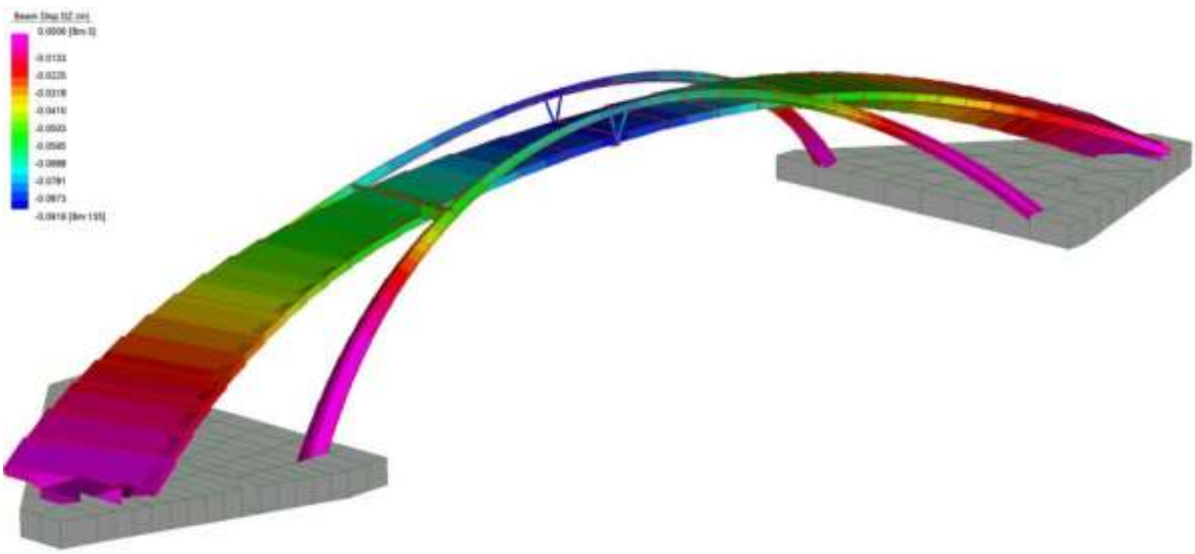

Fig. 10, Displacement in Z direction of FE Model

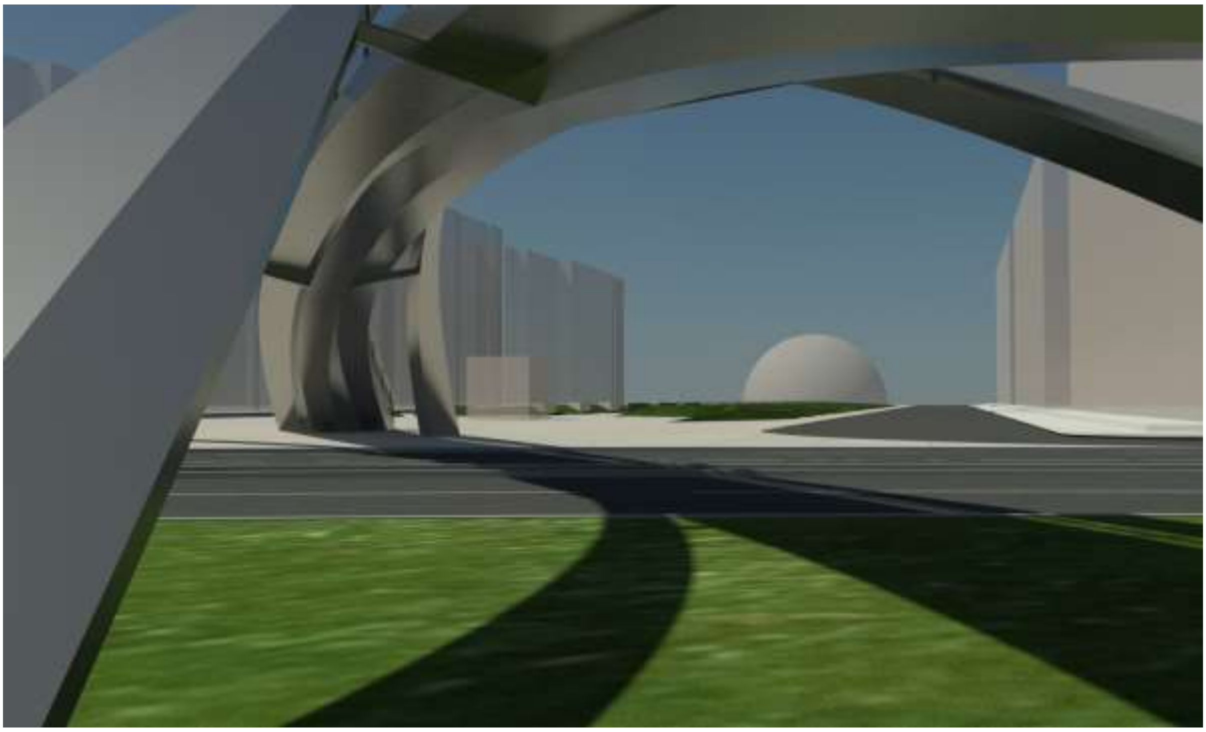

Fig. 11, Rendering

Structurally, the arches and deck have a common foundation system and the deck acts also as a tie: the pressure forces of the arches are eliminated by fixing the deck to the foundation, and in this way the system of forces is internally closed by tension in the deck which assumes, as well, the function of a tie.
The horizontal displacements between foundations are limited to about 7 cm without considering the foundation systems effects which would further decrease such movements.

Duplex in LdV Kazan footbridge

Stainless steel use is increasing in structural applications because of its durability which gives the construction a high level of sustainability.
The main applications of stainless steels are for structures where the difficulty and/or costs of maintenance make other alternative materials prohibitively expensive when considered using life cycle cost analysis: for example for components of construction which are critical to integrity or function of the structure where the owner does not want an inspection or maintenance or replacement burden for the future, or edifices that are required to have and maintain a particular, or high, aesthetic appearance.
URANUS duplex stainless steel is a kind of low nickel high strength stainless steel grades with high chromium and nitrogen; they may also contain molybdenum for higher corrosion resistance.
The development of these grades is relatively recent, first castings started in 1930 and since then metallurgical knowledge and production tools evolution have led to provide manufacturers and designers a group of highly efficient materials. They are used in the most demanding applications like oil and gas, pulp and paper industry, seawater desalination and many others.
Duplex stainless steels have design strengths between 400 and 460 MPa, 15 to 30% stronger than the design strength of grade S355 carbon steel that is generally used in bridges. Unlike carbon steel, no reduction in design strength for plate thickness exceeding 16 mm is required.

So lighter construction can be achieved with duplex stainless steels with all the induced benefits (e.g. foundations, transportation, inertia, larger and smaller span).
Duplex stainless steels display high levels of ductility (at least 25% for plates), which compare favourably with the relevant carbon steel grades, and their fatigue resistance is at least as good as carbon steels.
All steel bridge components subject to tension must achieve specified notch toughness in order to prevent brittle fracture. This depends on the minimum design temperature, stress level and material thickness. Duplex stainless steels display a more gradual ductile to brittle transition than carbon steels and retain their toughness down to around -40 °C.
URANUS duplex stainless steels can be welded using a number of widely available processes; provided correct welding procedures are followed, this method of joining should be no more difficult than with carbon steel.
The high chromium content of duplex stainless steels, along with molybdenum and nickel, give them very good resistance to chloride-induced pitting and crevice corrosion. All duplex stainless steels grades show very good resistance to stress corrosion cracking (SCC). It is important that the chosen grade of duplex stainless steel is appropriate for the intended service environment.
A European research program has shown that stainless steels including duplex stainless steel retain their stiffness better than carbon steel at elevated temperatures. By 800°C (1472°F), carbon steel has a stiffness retention level of about 10 percent, while stainless steel retains approximately 60 percent.
Duplex stainless steels have many desirable characteristics which are exploited in dozens of bridges all around the world where their mechanical properties can be beneficial in conjunction with corrosion resistance.

Conclusions

The use of duplex was dictated by the desire to create a work of art that could be sustained over time and therefore able to stand in such aggressive environment where maintenance efforts as to be low as much as possible.
By adopting Leonardo’s approach, considering today’s materials and achievable forms that could be implemented, the working team defined a generally stimulating design which allows the perception of the new place in the urban daily living landscape.
Adopted criteria design and proposed materials could make significant the startup economic investment, but this aspect have to be compared to maintenance costs almost absent.
A bridge or a footbridge is a major investment. However, the expense of its construction and maintenance will vary according to the materials chosen for its design and construction.
Analysis of the cost of such a structure is only meaningful if it includes all costs related to its construction, its operation and its deconstruction, over its entire lifetime, which in the case of bridges and footbridges should exceed 100 years.
In the case of stainless steel, this approach compensates for the higher capital cost linked to the choice of material: ultimately, it is offset, in whole or in part, by the benefits obtained in operation.
Environmental issues now constitute some of the parameters that must be considered in any construction project, including bridges. Stainless steel is an environmentally inert material: in particular, it does not release any element that could harm its environment.
Being rust-resistant, it does not require any special maintenance, unlike a painted material, which must regularly be stripped and repainted: two operations that are liable to pollute the rivers being crossed or the surrounding air.

The properties of URANUS duplex stainless steel can be fully used to advantage to give this bridge the best sustainability. For the freedom of form that it enables, it permits bold innovation that is often of value in resolving project-related constraints.

Acknowledgment

The concept design as well as the general cultural approach is the result of a synergic process developed by Prof. Enzo Siviero and Alessandro Stocco through the coordination of an interdisciplinary design team. In particular, this paper contains a synthesis of the work, developed by Didier Paul and Pauline Boillot (Industeel) from France, Federico Zago from Italy and Ali Ulvi Altan from Turkey. The team dealt with static and dynamic behaviour issues, historic and anthropologic issues through to the implementation phases of the footbridge.

References

1. Ludwig H. Heydenreich, Bern Dibner, and Ladislao Reti. Leonardo The Inventor. England: McGraw-Hill Book Company, 1980.
2. "500 Years After It Was Designed, Leonardo da Vinci's Bridge Goes Up!" Paintings and Public Art of Vebjorn Sand. - Internet: http://www.vebjorn-sand.com/press_release/20011101.htm, [10 June 2006].
3. "Welcome to the Department of Biomedical Engineering at Florida International University." Department of Biomedical Engineering FIU. - Internet: http://www.bme.fiu.edu/DirectorsMessage.htm [19 June 2006].
4. Martin Kemp, et al. "Inventions of Nature and the Nature of Inventions." Leonardo da Vinci Engineer and Architect. Ed. Paolo Galluzzi. Montreal: Montreal Museum of Fine Arts, 1987.
5. "Leonardo da Vinci." Engineering.com. - Internet: http://www.engineering.com/content/ContentDisplay?contentId=41003018 [10 June 2006].
6. Nicolas Pioch. "Leonardo da Vinci: From Sketches to Paintings." WebMuseum, Paris. - Internet: http://www.ibiblio.org/wm/paint/auth/vinci/sketch/, 14 Oct. 2002.
7. LEONARDO’S BRIDGE: Part 2. “A Bridge for the Sultan” Posted by Bulent Atalay. - Internet: http://newswatch.nationalgeographic.com/2013/01/22/leonardos-bridge-part-2-the-bridge-for-the-sultan/
8. Graham Gedge Associate Director Arup Materials Consulting Solihull, UK “Stainless Steel in Civil Engineering Applications” - Internet: http://www.bssa.org.uk/publications.php?id=57
9. Jean-Christophe Gagnepain and P. Soulignac ArcelorMittal Industeel - Internet: stainless-steel-world.net/pdf/SSW_0812_duplex.pdf
10. C. Lojewski , P. Boillot and J. Peultier ArcelorMittal Global R&D, Le Creusot, Industeel, BP 19, 71201 Le Creusot – France “Atmospheric corrosion resistance of duplex stainless steels: results of a field exposure program” - Duplex World 2010 conference proceedings, Beaune , France, October 13-15, 2010
11. Stainless steel in construction, “The performance of structural stainless steel in Fire” - Internet: http://www.steel-stainless.org/fire/
12. Catherine Houska, Consultant to IMOA “Stainless Steel Fire Testing”
13. N.R. Baddoo The Steel Construction Institute, Ascot, United Kingdom and A. Kosmač Euro Inox, Brussels, Belgium “Sustainable Duplex Stainless Steel Bridges” - Internet: http://www.worldstainless.org/Files/issf/non-image-files/PDF/Sustainable_Duplex_Stainless_Steel_Bridges.pdf
14. Amélie Fanica – Industeel, ArcelorMittal Group, Le Creusot, France Emanuele Maiorana – OMBA I&E SpA, Torri di Quartesolo (Vicenza), Italy “UNS S32205 for bridge construction: an experience of application” – Duplex 2007 International conference and expo proceedings, Grado, Italy, June 18-20, 2007
15. Constructalia The steel construction website “Stainless Steel in Bridges and footbridges” http://www.constructalia.com/english/publications/technical_guides/stainless_steel_in_bridges_and_footbri

dges

16. Datasheets of UR2205, UR2304 and UR2202 are available at - Internet: http://www.industeel.info/services/downloads.aspx

17. http://www.imoa.info/moly_uses/moly_grade_stainless_steels/architecture/fire_resistance.php

Keywords

Landscape, Cultural approach, Research, Footbridge, Steel, Duplex, Uranus, Leonardo Da Vinci.