Edited by Marc Muylle

eCAADe 26

architecture 'in computro'

INTEGRATING METHODS AND TECHNIQUES

Antwerp 2008

A CD-ROM containing the digital version of the proceedings is enclosed with this book

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1st Edition, September 2008

www.ecaade.org

Printed by Antilope Printing: Industriestraat 5 - 2500 Lier - Belgium
www.antilope.be

ISBN 978-0-9541183-7-2

eCAADe 2008

ARCHITECTURE 'in computro'
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Proceedings of the 26th Conference on
Education and Research in Computer Aided Architectural Design in Europe

September 17-19, 2008
Antwerpen, Belgium

www.ecaade08.be

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Acknowledgements

I am first of all indebted to the authors that honour this publication with their work as well as to the keynote and technical session speakers.

The work of an international team of reviewers was instrumental in reviewing each of over 200 submitted abstracts. We were very pleased to note that with the growing number of CAD related conferences, we still obtained very high quality abstracts. As the reviewing process totalled to over 600 reviews, our reviewers had to evaluate many more papers than we were able to accept. It is never easy to take the responsibility of omitting papers, especially with a growing number representing young talent. Based on the reviewers' recommendations, the eCAADe council assisted greatly in the decision process.

The reviewers for eCAADe 2008 were:

Henri Achten, Aleksander Asanowicz, Martin Bechthold, Jakob Beetz, Vassilis Bourdakis, Alan Bridges, Andre Brown, Luisa Caldas, Scott Chase, Kathleen De Bodt, Bauke de Vries, Ellen Yi-Luen Do, Wolfgang Dokonal, Dirk Donath, Jose Duarte, Dietrich Elger, Thomas Fischer, Harald Gatermann, Evelyn Gavrilou, Jens-Peter Grunau, Jeremy Ham, Christiane M. Herr, Adam Jakimowicz, Joachim Kieferle, Marc Knapen, Mike Knight, Volker Koch, Branko Kolarevic, Jose Kos, Alexander Koutamanis, Silke Lang, Thorsten Michael Loemker, Earl Mark, Bob Martens, Tom Maver, Javier Monedero, Volker Mueller, Michael Mullins, Marc Muylle, Herman Neuckermans, Rivka Oxman, Giuseppe Pellitteri, Chengzhi Peng, Hannu Penttilä, Frank Petzold, Rabee Reffat, Peter Russell, Bjarne Rüdiger, A. Benjamin Spaeth, Martijn Stellingwerff, Peter Szalapaj, Chris Tweed, Jos van Leeuwen, Johan Verbeke, Andreas Voigt, Jerzy Wojtowicz, Tadeja Zupancic

I know that it is a repeat but it must be said again that during the whole preparation eCAADe president Henri Achten and, the ever-so-helpful conference liaison officer, Bob Martens were always available when needed!

Nobody can organise a conference like eCAADe 2008 alone, whatever his resources might be. Without a team no conference is possible. By this I would like to thank, for all their efforts, Leslie Luypaert (international affairs), Nadine Tulfer (finances), Wim Maes (graphics), Toni Van Remortel (website en db), Christophe Gabriëls, Jean Claessens en Steven Wittevrouw (IT-Team), the student helpers and everyone from the technical team of the University College Artesis Antwerp (formerly known as Hogeschool Antwerpen).

My special thanks also go to Saskia Gabriël and Stijn Verbeke (technical chair), two of our PhD. students who worked hard to make the proceedings a truly scientific document. I am in debt to the latter who with his hard work and especially his sense of solving problems became indispensable for this conference.

We express our gratitude to the companies supporting the conference with their generous donations: Bentley Systems and AutoDesk, and our sponsors the City of Antwerp, Port of Antwerp, Van Os furniture and Le Duc d'O sweets.

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Palladio's Bridges: Graphic Analysis and Digital Interpretations

Representing Palladian Designs with New Technologies

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Abstract. *The paper presents some results of a research on the digital reconstruction of some bridges designed by Andrea Palladio. The use of new technologies has enabled us to investigate the morphology of every single element and to be compared each other. Using the method of video animation, we have analyzed some of them in order to simulate the human perception and to understand their spatial configuration, but also to visualize the point of view of a man crossing a river or a canal. The last step was to prepare the models for producing some physical maquettes with the technique of rapid prototyping that have enabled us to verify the quality of the digital construction. Some different kinds of powder were used to identify the best one for the representation of architecture.*
Keywords: *Digital reconstruction; geometric analysis; unbuilt projects; video; rapid prototyping.*

Palladio's designs for bridges

For the fifth centenary of the birth of Andrea Palladio a research project started with the aim to study some important bridges designed by the Vicentine architect. Some of them are published in his treatise 'I Quattro Libri dell'Architettura', others are kept in various historical archives.

The research was based on the reconstruction of Palladio's wooden bridges, published in the III Book of his treatise (an arc solution of a bridge, the Bassano Bridge), and the two versions for the Rialto Bridge in Venice. Owing to the little graphic information about them, we have faced great difficulties of interpretation. In some cases we had the plan and the longitudinal elevation as the main drawings to describe the project, but sometimes we had just an elevation, without any information about the width of it and nor any constructive details of the way in which it was thought for the realization.

But thanks to the digital reconstructions, some relevant aspects were revealed, concerning above all the rigorous geometry of every form and the symmetry of the structure. In fact the aim of this research was, not only to model the 3D maquette of the structure, but also to understand the hidden relationship between the single parts and the general morphology.

Wooden bridges

The wooden bridges are described by Andrea Palladio in the Third Book of his treatise, where there are texts and drawings that show the main idea. Some of them seem to be very simple in their formal configuration, but in reality it is possible to identify a rigorous geometry that allows us to understand the great ability of the architect in solving complex problems of form and function. In fact every bridge structure must consider aesthetic problems, as well as satisfy a static necessity, allowing people to cross the river and arrive at the opposite side.

We shall not analyze all the solutions adopted by Palladio, but we shall only consider the arc bridge solution, because of its singular way to solve the problem of having a bridge without elements touching the water of the river. Its geometrical analysis enables us to show the geometry that has determined the form. In fact, if we extend the 'colonnelli' – the small vertical supports – that hold up the structure, it is possible to recognize a common point that is the centre of the two circumferences where the two arches lay. The same point is also the vertex of the equilateral triangle, whose extremities are placed exactly on the shutter plane on the two shores. In the text Palladio observes that "you could make with a bigger or smaller arc than the one that is drawn, depending from the quality of the site and the dimension of the river", as in Figure 1.

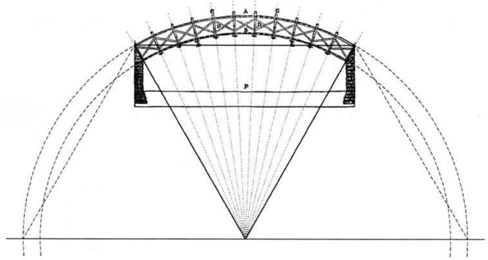


Figure 1
Palladio's drawing of the arc wooden bridge and geometrical analysis (elab. A. Sdegno).

After the analysis of the drawings published, we started a digital reconstruction of the three-dimensional structure (Figure 2), trying to understand Palladio's initial geometrical conception and then pass to a more sophisticated study that could give the perception of an hypothetical 'promenade virtuelle' across the bridge, in order to have a visitor's realistic visual impression.

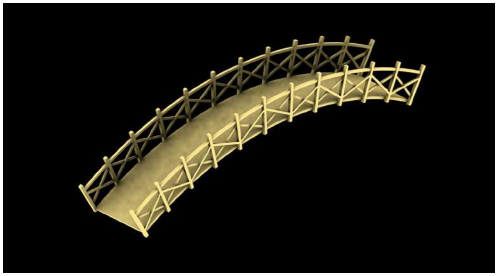


Figure 2
Digital reconstruction of the arc wooden bridge (elab. A. Sdegno)

The last step was the physical reconstruction of the structural configuration with the rapid prototyping techniques, enabling us to compare it with some other models at the same scale. The powders used in the process of sinterization are of three kinds: nylon, aluminium and ceramics. The last one had the best results both in term of solidity and in term of beauty, due to its clear yellow colour.

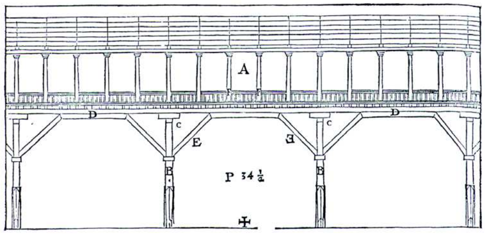
The Bassano Bridge

In 1567 the bridge on the river Brenta, near the centre of the town of Bassano, was destroyed by a flood. Palladio was asked to give a solution keeping some aspects of the preceding one but trying to define a new idea with some architectural components. In fact its structure was based on a horizontal path covered by a roof on a series of Tuscanic pilasters, all of them made in wood.

After two other destructive episodes – the first one natural and the second one due to the Second Word War – the bridge was reconstructed respecting Palladio's drawing, so that we can say that the actual one is very similar to his intention.

In his treatise we can find all the information about the structure, since we have a scheme of the plan, the elevation and the section along the path (Figure 3), and some measures in Venetian palm that allow us to have the right dimension of it, although we do not have the whole drawing of the design, but only its most relevant parts.

Figure 3
The Bassano Bridge from the Four Books of Architecture, by Andrea Palladio.



The activity of reconstructing the bridge with new technology started with the 3D modeling of the main horizontal and vertical elements, and then we passed to the visualization of it with some rendering software – such as the radiosity, to have the best solution in terms of final restitution – which give us the possibility to calculate the natural illumination and compare it with the real one.

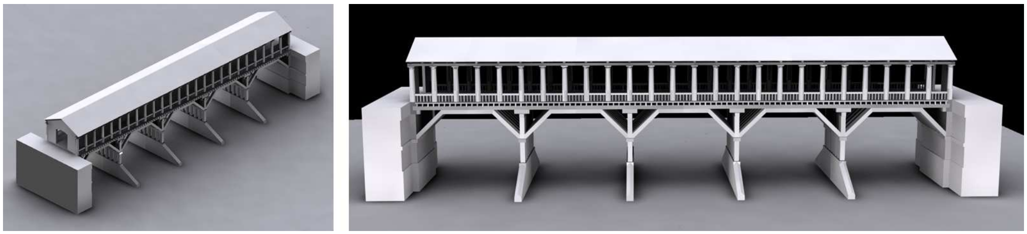
After this step we tried to explore it generating a video animation, recreating a human point of view and moving it inside the scene. In this way it was possible to compare it with a real camera moving on it. The virtual and the real bridges were presented in the same sequence for a double comparison at the same lighting.

The Rialto Bridges

The most interesting solutions of bridges by Andrea Palladio were, without any doubt, those on the Rialto area in Venice. These show a true intention to respect the main idea of the design, which was to have a poly-functional bridge, an idea that we can find also in the one which was eventually realized by Antonio da Ponte. The bridge – located in the central market area of Venice - had, in fact, to fulfill a variety of functions. Apart from the main one, which is to cross the Grand Canal, there was the need to have shops for the commerce of goods and food. Some other common characteristics are: the use of a multiplicity of arcs as structural elements inside the water; the use of architectural orders, and the timphan in the central part of it to give a hierarchical order to the whole complex.

The two palladian solutions are similar, but at the same time very different. Since neither of them is identified by the architect with the name of the area (Rialto), they seem to be two abstract designs of bridges without any real collocation in the space of a town. For example, Palladio speaks about the second one published in his book – as a 'bellissima inventione' for a noble town, without saying that it is Venice.

Figure 4
Digital reconstruction of the Bassano Bridge (elab. A. Sdegno)



First solution of the Rialto Bridge

The first solution of the Rialto Bridge is described in two drawings conserved on a single paper at the Civic Museum in Vicenza, and it was dated between 1553 and 1554 (Figure 5). There we can find a partial elevation on the recto and a full plan on the verso. As a metric specification we find some quotes that give us the information about the dimension of the structure. In fact the bridge is 132 feet long (1 Venetian foot is cm 34,77) corresponding to mt 45,89, while the two courts at the end of the bridge are 32 x 26 'pasa' (pasa stands for step, and is mt 1,78, that is 5 Vicentine feet), which correspond to mt 57,20 long and 46,47 wide).

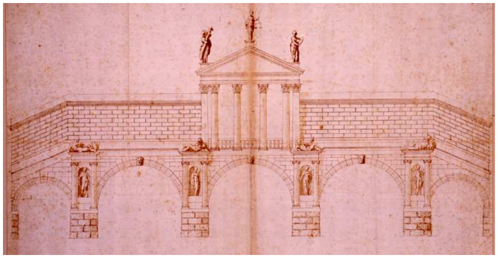


Figure 5
First solution of the Rialto Bridge (Civic Museum, Vicenza, drawing D25)

We have no other information about the interior of it, but from the plan we can identify two series of seven shops on the two sides – and some staircases that allow us to circulate around and on the bridge. Even if it is not clear the way in which you can reach the court with this vertical path – the number of steps of the staircase is not proportioned to the height of the building – we have to hypothesize that some elements are drawn as abstract symbols with no real relationship to the whole composition.

The first step of the reconstruction was to define the whole geometry in the plan, elevations and sections, trying to identify all the information which was not present in the graphic paper.

Then there was the phase of modeling the bridge, with the detailed parts of it, such as the architectural order, and in particular the Corinthian capitals. After having reconstructed all the parts, we tried to understand the position in the site, tracing the river sides and the water. The last phase before the rendering visualization was to create the texture maps and to apply them to the surfaces of the model. The final rendering was made with V-Ray algorithm in order to

Figure 6
Digital reconstruction of the first solution of the Rialto Bridge (elab. P. Ravagnan)

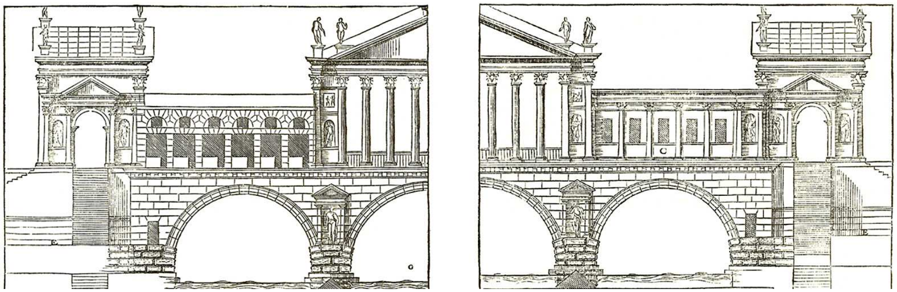


Figure 7
The solution of the Rialto Bridge published on Palladio's The Four Books of Architecture

obtain a pre-calculation and to accelerate the generation of single frames to create the video animation. In Figure 6 there are some of these slides.

Second solution of the Rialto Bridge

The second solution of the Rialto Bridge was much better known than the first one. This is due to the fact that it was published in the 'Four Books of Architecture' by Andrea Palladio, although – as we have just said – there is no reference to Venice in it. A lot of redrawings are in fact made by starting from Palladio's graphics in the treatise, such as those of Muttoni and Bertotti Scamozzi, in the XVIII century. Antonio Rondelet in 1841 wrote an essay trying to understand the history of the bridge better, showing not only Palladio's ideas but all the different ones, and studying the composition as well as the possibility of building it. His considerations about the construction were very useful to this research, also owing to the details that the author gave as suggestions.

The main drawings show the plan and the longitudinal elevation and section of it, giving a sufficient description of the principal parts. For an exhaustive representation we should have also some other sections and another side elevation, and the plan of the roof would give the exact configuration of the higher part of the bridge.

The analysis of the drawings allowed us to model all the parts of the bridge using solid and NURBS modeling. In fact, as we have some simple elements, such us walls and floor, there are a lot of very complex components – such as Corinthian capitals, for instance – that need some specific procedures to

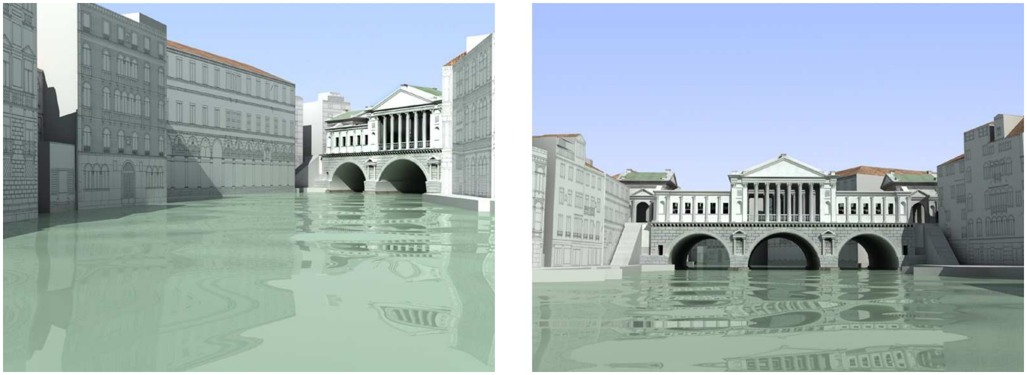


Figure 8
Digital reconstruction of the second solution of the Rialto Bridge: Structure of three-dimensional information about every single part (elab. P. Ravagnan)

obtain a satisfied solution both for the rendering phase and for the prototyping model. The use of NURBS permits to construct forms thanks to the geometrical genesis derived from the analytical phase.

After having reconstructed the whole bridge we decided to produce a video, simulating the perception of a hypothetical visitor on a boat along the Canal Grande. In order to obtain a realistic effect of the bridge, but an abstract representation of the contest – which allowed the best visualization of the Palladian structure – we decided to apply the drawings of the façades on the volumes of the buildings as texture maps, to get a general idea of the impact of the bridge on the canal.

The final video showed the point of view from the boat, but the walkthrough path inside it was also used to simulate a man's visit of the building.

The video was selected from the CISA - Centro Internazionale di Studi di Architettura Andrea Palladio in Vicenza to be showed during the great exhibition that will held in September 2008, in occasion of the 500th anniversary of the birth of the vicentine architect. The exhibition will then move to the Royal Academy of Arts in London and then to Washington.

For this occasion we are also preparing a 3D maquette in ceramics powder solidified with sinterization techniques, to obtain a physical model that can be compared with the preceding solution of the bridges.

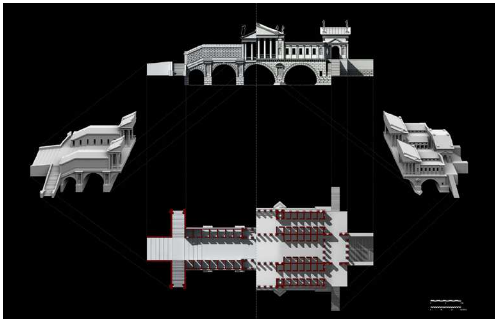


Figure 9
Digital reconstruction of the second solution of the Rialto Bridge: frames from the video animation (elab. P. Ravagnan)

Future development of the research

A possible evolution of the research is to digitally reconstruct one of the well known paintings reproducing the Palladio Bridge in three dimensions. In 1743, in fact, the Venetian painter Canaletto produced some ideal pictures – the so called 'capricci' – to give a new idea of Venice. The best known is the 'Capriccio con edifici palladiani', conserved at the Galleria Nazionale of Parma, in which, besides the Rialto Bridge, there are Palladio's Basilica and the Chiericati Palace, both of them realized by Palladio in Vicenza (Figure 10).

Figure 10
Canaletto, 'Capriccio' with some Palladian designs (Galleria Nazionale of Parma)

The aim of this research was to follow and establish a scientific procedure to analyze some non-realized historical architectures - through the study of all the documents, the definition of their geometry and form, and the digital reassembling of every single part – in order to reconstruct the architectural heritage of the unbuilt past.

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