THE SURVEY OF THE BAROQUE INTERIOR OF THE SAN LORENZO CHURCH IN TURIN

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ABSTRACT:

The present work concerns the San Lorenzo Church in Turin survey.
The studies were carried out in collaboration with a group of architects from the University of Florence who are studying the Guarini's works of art and, in particular, this masterpiece. The architects required information about the geometric characteristic of the Church. Particular attention was paid to the ingenious dome of the Baroque Church. It was analysed using LIDAR techniques integrated by classic topographic and photogrammetric methodologies. The interesting and enriching collaboration that took place between the two groups to achieve satisfactory results and the sharing of specific knowledge is also highlighted in this paper.

1. INTRODUCTION

There are several reasons behind the study of an "Architecture". In this case, above all, the deep desire to understand the architectonic "design", the hidden geometry that shapes and enlivens the space in the Church of San Lorenzo in Turin. The building contains a series of spatial inventions that are the fruit of contaminations of "art" periods which were skilfully evoked and reinterpreted by Guarino Guarini. Constructed between 1668 and 1687, it is one of the exemplifying works of the late Baroque period which influenced the architectonic development in Central Europe to a great extent.
In order to be able to interpret and understand this architectural complex, which is still being studied, more clearly it proved necessary to perform a survey using a 3D scanner to document the building, a "data restitution" acquisition method and a geometric verification of the "apparent" surfaces of the structure to document the building.
The three main stages of the work included:

- planning of the survey, laser scanning of the architecture and georeferencing of the data;
- elaboration of the survey data;
- geometric analysis and comparison of the data.

2. GEOMETRIC SURVEY

First, the two groups examined the church in order to plan together how to carry out the work.
Since the San Lorenzo Church has numerous particular details the LIDAR technique was chosen to survey them.
As the dome has many details that could be hidden in a single laser survey, it was necessary to plan several laser acquisitions to obtain complete as possible measurements of the area.
In order to allow the scan results to be put together and to define a unique reference system for the whole object, a reference network, made up of the 100, 200, 300, 400, 500 points, was created inside the Church.
As figure 1 shows, some already existing details of the floor were chosen instead of materializing new groundpoints as the network vertices, because of the value of the surveyed object (Inghilleri, 1974).

Fig. 1 – Example of some topographic vertices from a distance (on the left) and close up (on the right).

The network was surveyed using a total station (fig. 2) with topographical signals (Manzino, 1999); Monographs of the vertices were created to make it possible to occupy them again during any possible future works.

Fig. 2 –The Topcon 8001A total station.

The survey coordinates of the scheme (fig.3) were compensated (Cina, 2004).

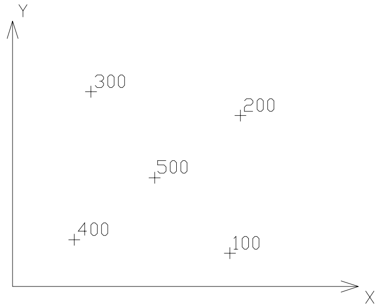

Fig. 3 – Scheme of the reference network.

During the survey campaigns some reference markers (of about 3 x 3 centimetres) were attached to the surveying objects with a special glue that does not damage the hall decorations. The material of the markers is characterized by an high level of reflectivity.
The same survey schema was adopted to measure the positions of the markers with two new vertices, 1000 and 10000 ,whose coordinates were determined from the local reference network vertices.
In the new network, the detailed net, defined by the 7 vertices (100, 200, 300, 400, 500, 1000 and 10000), the coordinates of the markers were evaluated using the tacheometry method (fig. 4). The detailed network was compensated with an accuracy lower than 1 cm.

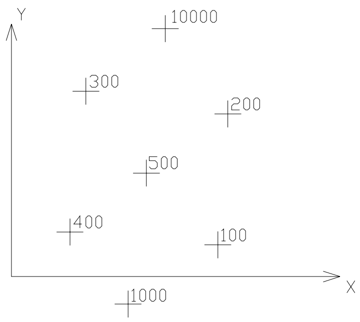

Fig. 4 – 1000 and 10000 vertices in the detailed network.

2.1 The LIDAR technique

A laser scanning instrument can be considered as a high automation reflectorless total station; by means of a laser based measurement of distance and accurate angular movement, a target object is sampled in a regular mesh of 3D points.
One of the most interesting applications of such an instrument is the fast and economic way of creating a DDSM; if other techniques (e.g. total stations, photogrammetry) were to be used it would be an incredibly time-consuming process (Bornaz L., 2002). Most laser scanner machines can nowadays also have a digital camera mounted on them: in this way it is possible to immediately assign RGB information to each point.

2.2 Survey methodologies

A Riegl LMS-Z420i "time of flight" laser scanner was used to survey the object. This instrument, besides the spherical coordinates, acquires and records data on the material reflectivity. The high reflectivity of the surface of the markers allows them to be distinguished from all the other scanned points made of different materials.
The laser was equipped with a digital camera (Nikon D1X) in order to obtain the radiometric information.
The camera is rigidly mounted onto the laser, therefore the position of the centre of the camera is known with regards to the centre of the laser instrument. The position of the camera becomes a known position in the laser acquisitions (fig. 5).

Fig..5 – The Riegl LMS Z420i Laser Scanner with the Nikon D1X camera.

If the coordinates of the markers are known they can be georeferenced in the reference system of the reference network and the data acquired by the different scans can be aligned to create a single point cloud (Bornaz, 2004), using these markers. The non-georeferenced point cloud obtained by linking all the scan data is represented in figure 6 in the left image while, the georeferenced point cloud obtained after alignment, using the markers, is shown on the right.

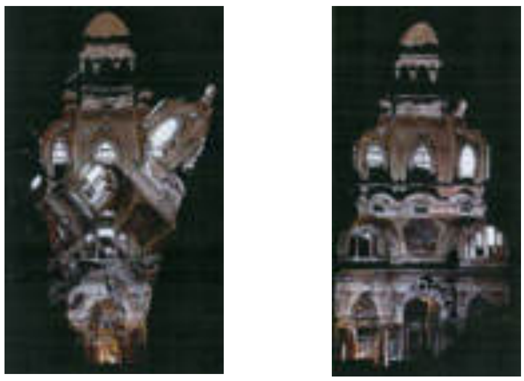

Fig. 6 – Non georeferenced point clouds on the left; georeferenced point clouds on the right.

3. ELABORATION OF THE DATA

A survey performed with a laser scanner produces a virtual model of the work surveyed under the form of point clouds. This allows any useful measurement to be extrapolated with a certain tolerance. It is necessary to check the errors produced by the instrument during the extrapolation and the influences of the frequent shadow cones that the architectonic and decoration elements cause (fig. 7). The information that is hidden by shadow cones should be acquired, if possible, through traditional surveys, with further surveys being carried out from different taking points or through interpretations.

Fig. 7 – A point cloud and mesh surfaces.

3.1 Software

The production of the point clouds and the determination of the elaborations was carried out using Rapidform 2004 and Rhinoceros software. These allow the object to be managed well, a good reduction of the error that is produced by the instrument through the interpolation of the points and then to quickly create the mesh surfaces that are necessary for the subsequent stages (Bornaz, Lingua, Rinaudo, 2002).

3.2 Elaboration

The thus created meshes, opportunely sectioned with vertical and horizontal plans, determine the “guidelines” that are necessary to draw up the products such as, for example, plans and sections.

The mesh surfaces have rounded off edges therefore, as a consequence, the guidelines also suffer from the same error.

In order to resolve this defect “guide points” were used which were extrapolated from the “clouds” with opportune section plans (fig. 8).

Both the lines and the guide points were projected onto a horizontal plan (fig. 9). Their overlapping made it possible to eliminate the “noise” made by the point cloud and to determine the edges of the various architectonic elements, thus making the drawing up of the final elaborations possible (fig. 10).

3.3 Restitution of the elaborations

The aforementioned procedure allows conventional graphic elaborations to be restituted, such as plans, detailed sections and virtual representations in 3D form.

It also proved possible to restitute the less important architectonic elements such as mouldings and decorations.

In the conventional representation of survey data, a point cloud represents itself without any arbitrary integrations. The lack of information due to shadow cones in the graphic transcription was integrated, where possible, with traditional surveys and/or the aid of previous graphic elaborations or of photographic interpretations. The graphic typification indicates the origin of the survey data (fig. 11) (Ferraris, 1998).

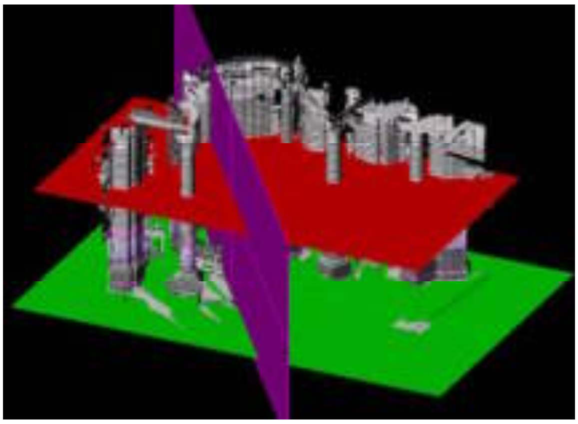

Fig. 8 – Sections of the mesh surface with the predetermined plans.

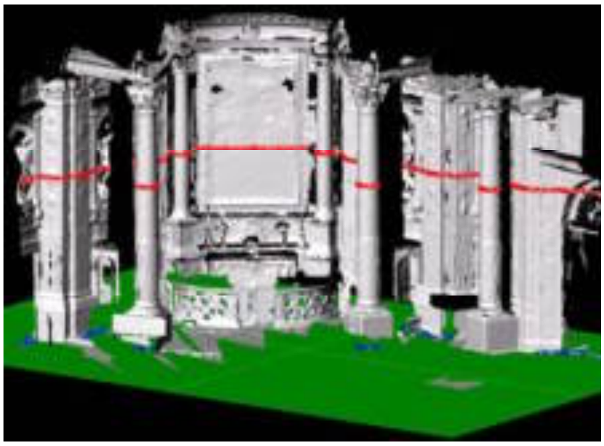

Fig. 9 – Extrapolation of the points that coincide with the sections.

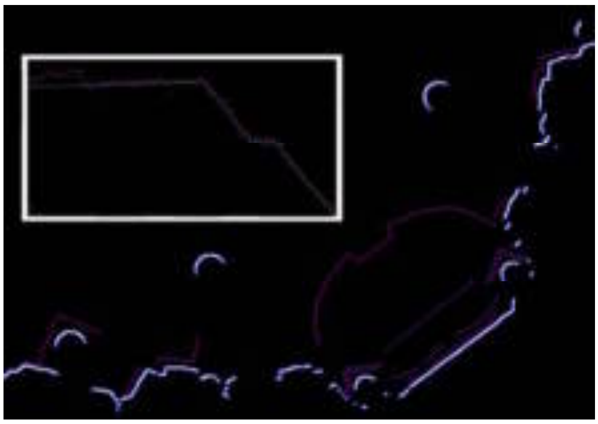

Fig. 10 – Projection of the sections and points onto a horizontal plan.

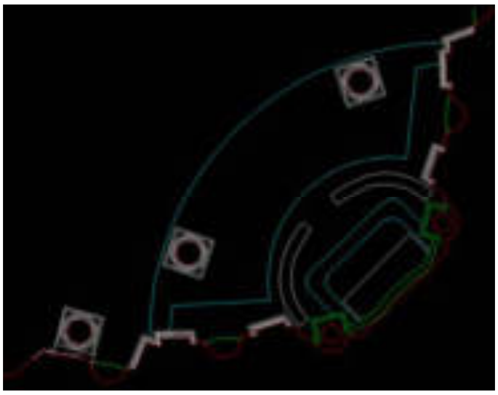

Fig. 11 – Details of the restituted plan.

4. GEOMETRY OF THE CURVED SURFACES

The study of certain surfaces, such as those of pendentives, ridges, webs and arches was carried out according to a rigorous geometric procedure:
- extrapolation of the points relative to the individual geometric elements of the object that had to be analysed;
- construction of “patch” type surfaces as close as possible to the “bearing” of the chosen points;
- reading of the double orthogonal projection;
- cutting the “patch” with specific plan or curved surfaces that border the profiles of the portions of the geometric research.

4.1 The arches

The profiles of the surface façades of the arches that are above the serliane, belong to two cylinders whose curves are read in O. P.; (fig. 12) the impost ones are part of the circumference while the line of keystones is a rampant segment. The surface develops as a circle with variable rays that perpendicularly move towards the impost plan along three directrices: the line of the keystones and the profiles of the impost. This construction follows the indications that can be found in the Frezier treatise (fig. 13).

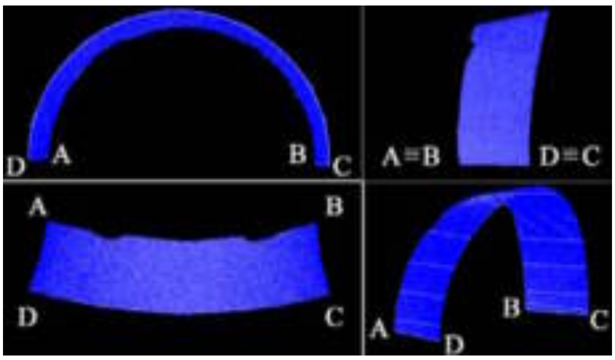

Fig. 12 – Orthogonal projection and axonometric view of the “patch” of the arches.

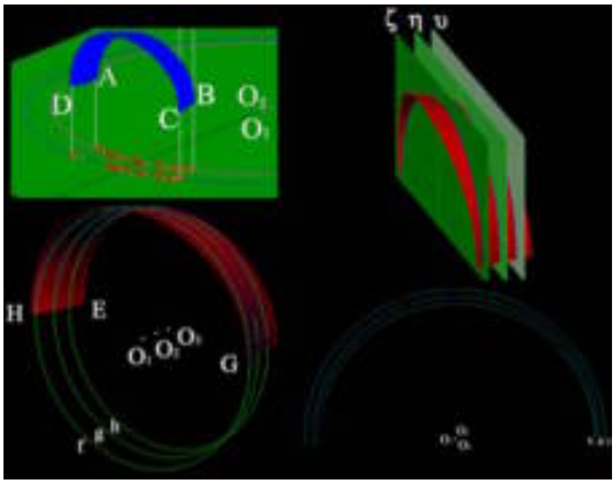

Fig. 13 – Study sections of the "patch".

4.2 The pendentives

The side profiles of the pendentives were obtained by sectioning the “patches” with cylinders whose curvature was read from the orthogonal projection (fig. 14). The horizontal profiles resulted to be circumferential arches; the vertical section, which was carried out in line with the keystones of the pendentives, or rather in the middle, is still a circular arch (fig. 15, 15a). The same geometric process was performed for all the pendentives (fig. 15b). A toric surface was obtained by rotating the keystone circle or the lateral section around the axis of the barycentre of the body of the church. All the pendetives belong to this surface. One of these, however, though having the same curvature, is parallely separated by about 15 cm (fig. 15c).

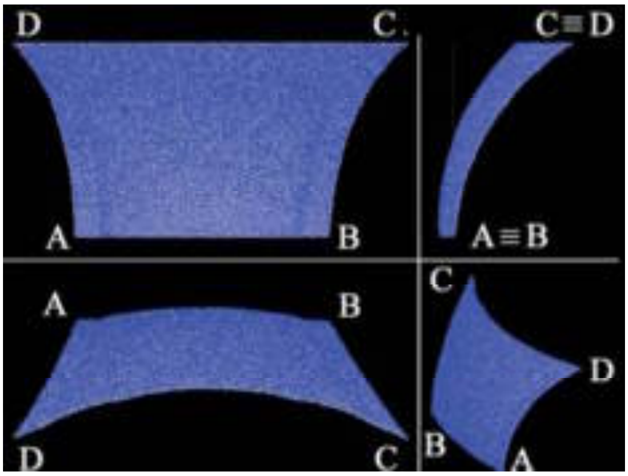

Fig. 14 – Orthogonal projection and axonometric view of the “patches” of one of the pendentives.

Fig. 15 – Sections with horizontal plans.

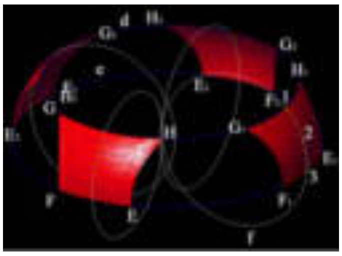

Fig. 15a – Generating arches of the surfaces.

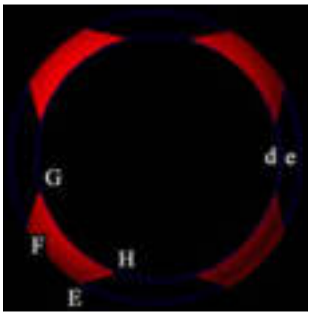

Fig. 15b – Projection of the four pendentives.

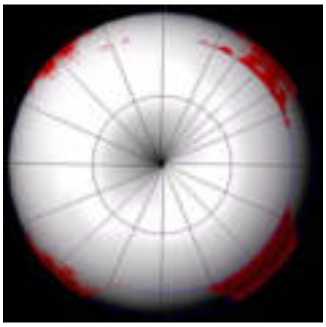

Fig. 15c – Overlapping of the "patches" with the toric surface.

4.3 Ridges

The surface sections of the ridges, with radial plans, are straight and they meet in a V vertex. The ridge surface therefore belongs to a cone. The front profiles of the arch therefore form a three-centred polycentre, that is, portions of a flattened ovoid.
The same operations that were carried out for each ridge were used to determine their relative surfaces. The sections of all the ridges, with a series of horizontal plans, form concentric circumferences; these, moving along the ovoid directrix of the ridges, create a flattened ovoid. The revolution surfaces of the ovoid profile therefore create a single dome from which the generating profiles of the ridge cones originate. They were constructed according to the indications in the Guarini's treatise (Guarini, 1968).

4.4 The webs

The profiles of the conoidal web was obtained by sectioning the "patch" of the surface with three plans perpendicular to the impost plan. The lateral and keystone profiles are polycentric (fig.16).
The horizontal plans were used to determine some profiles that belong to the circumferences. These, going from top to bottom, degrade in a curvilinear manner till reaching the ceiling of the arches which determine the profile. The curvature here increases and then decreases again (fig. 17).

5. CONCLUSIONS

The understanding of an architectural object is more than the description of its treatise. It is a synthesis of the architectonic "tendencies" of that time (A.A.V.V., 1998). The influence of Spanish, French and Roman Baroque architecture is very obvious in this case. Only part of the primitive solids remain. In the construction of the surfaces, the realisations with generating and directing profiles, whose matrix can be found in the concrete surfaces of Hadrian's era, prevail (Crescenzi, 2000).

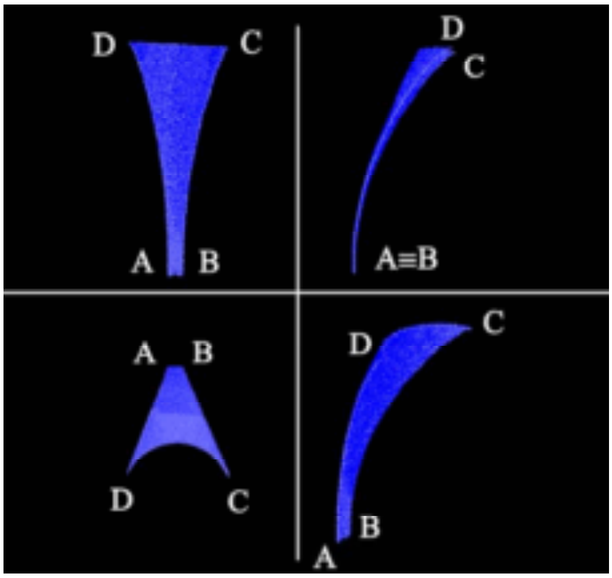

Fig. 16 – Orthogonal projection and axonometric view of the web "patch".

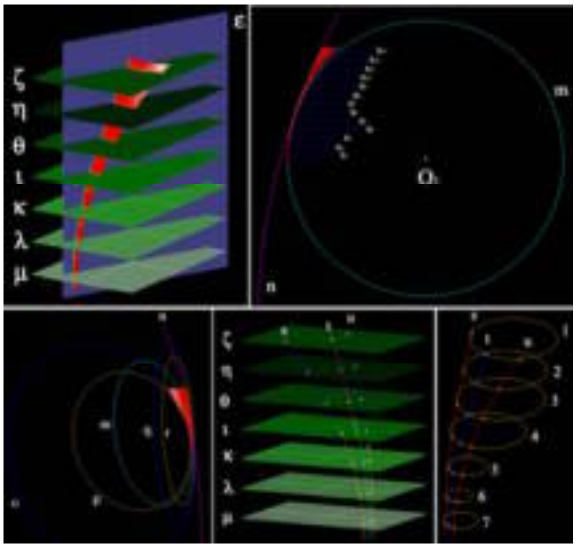

Fig. 17 – Web geometric analyses.

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