BASILICA OF SAINT PETER MARTYR FROM VERONA IN S. ANASTASIA (VERONA): STRUCTURES GEOMETRIC SURVEY AND PHOTOGRAPHIC CAMPAIGN FOR THE PRESERVATION PROJECT

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ABSTRACT

The intervention planned for Saint Peter Martyr Basilica in S. Anastasia, the biggest church in the town, includes an early stage of preservation of the external faces and monitoring of the good functioning of the roofing structure, while postponing the project for static improvement and the more complex and well-organised preservation project of the internal ornaments to a second stage.

The choice to primarily work on the exterior faces was dictated by the need to block all direct and indirect causes of decay and deterioration affecting the whole architectural complex.

A major preventive fact-finding campaign preceded the opening of the building yard, carrying out global topographic mapping of the building, image rectifications of internal and external faces, taking 59 samples of material for physico-chemical analyses, 84 samples for the analysis of water contents in the masonry and thus developing a *corpus* of graphic documents detailing the material-pathological structure of the Basilica's exteriors.

Moreover, preliminary analyses led us to historical archives to retrieve existing documents needed to develop an historical analysis relative to both the Basilica's building and architectural origin and the restorations done over the centuries. Besides indirect sources, data of stratigraphic units were processed to reconstruct the composition of the construction with an archaeological method.

Even though still unsolved by the restoration activity, problems related to the building's statics were discovered, in that the Basilica presents a rather complex, though harmless, crack network. The surveys of the Basilica's morphology, statical quality, and sudsidence are being completed in order to systematise the project that shall concern all of the Basilica's structures. All the operations relative to the first phase of works were represented on graphs identifying: stratigraphic readings relative to the historical-archival and archaeometrical sources, the material-pathological situation and every working procedure. Moreover, the graphs directly refer to the specifications enclosed to the report, with the metric estimates and special tender specifications.

Carrying out such a deep survey campaign on the church of S.Anastasia was necessary in order to gain the cartographic and photographic basis for the conservation project of the basilica's external facade and of its interior, planned by the Campanella Tessoni Architetti Associati office (geometric, material and pathological survey and preservation project), in co-operation with the *Laboratorio di Diagnostica per la Conservazione e il Riuso del Costruito* of the Politecnico of Milan (stratigraphic readings, mensiochronology and structural survey).

The building's conservation conditions are not good, its exterior has been harshly attacked by dust particles, pollution and humidity, while its interior by hot air circulating due to the inadequate heating system and by humidity rising up and spreading which, in certain spots, has reached over two meters of height.

Apart from these matters, which are important but anyway concentrated on frameworks' surfaces, it's possible to see, just by looking at it, that there are obvious problems regarding the whole building's statics. Especially the intersection area between the nave and the transept, seems to be the most damaged one, from a structural point of view, even before having seen the geometric survey's results.

With the purpose of solving these problems, both structural

and strictly material, we began organizing an important phase of research which, starting from archive research and historic records analysis, has gone in many different directions, dealing matters regarding chemistry, physics of materials, mensiochronological analysis, reading of stratigraphy.

The geometric and photographic survey and the structural analysis which are the objects of this paper, are of use for and strictly correlated to these phases.

Approaching such a huge building, as S.Anastasia's Basilica – almost 95 meters long, 26 meters high and with a 75 meter bell tower – demanded the optimization of a well-established methodological procedure, in order to work within reasonable time and without any waste of money and work, therefore carrying out an important preliminary study for both the strictly geometric phase and, more important, for the photographic one. The phase of geometric survey was organized so as to assure the maximum accuracy of draughting on a 1:50 scale, even though, due to paper-size problems, we decided to print it on a 1:100 scale.

The survey was carried out making use of topographic precision instruments, a Topcon GPT 3005 total station, capable of reading, apart from traditional prism measurements, also non-



Figure 1. The traverses

prism measures, to survey parts impossible to reach otherwise. Due to the building's complex structure, we decided to draw a traverse which allowed us to place the church in space and, at the same time, to accurately identify the physical limits within which we have afterwards performed the detailed surveys.

The spotting of station points (that match with the traverse's angles) was carried out so as to form a closed perimeter, in which the first station matches with the last one, this in order to assure accurateness and minor tolerance of mistakes; we also accurately chose the points so as to minimize "blind" areas impossible to reach with the instruments' direct reading.

This traverse is made up of 11 stations, 8 of which are on the outside of the building (100, 200, 400, 500, 600, 700, 800, 900) and 3 on the inside (300, 1000, 1100); in addition to these stations, there are other two, 1500 and 1600, which represent a "straddle".

The next step, necessary to survey the building's interior, was creating another traverse, which allowed us to connect the church's external and internal perimeter,



Figure 2. South elevation

so as to identify the walls' thickness.

This traverse is made up of 6 stations (300, 2000, 3000, 4000, 5000, 6000) one of which, 300, is in common with the external traverse; as before, we had to carry out a straddle with station 7000. After having calculated the two traverses using the Meridiana 321 software, we went on with the survey, making use of the foregoing station points, and due to the building's complexity, we had to take over a thousand measurements just to define the interior. In addition to the measurements taken with the topographic instrument, we surveyed all the details, using laser distance meters and traditional longimeters, necessary for the draughting of the survey on a 1:50 scale. The lay-out, apart from the plan, also concerned the four external elevations and nine sections of the interior.

As I mentioned at the beginning, the geometric analysis demanded a particularly deep and accurate analysis on the visible pathological state regarding the building's statics. So it was necessary to organize a survey project that allowed us to quantify the 12 columns' and the facade's out of plumbs, as well as the floor's altimetry analysis and that of the wooden chains' springer's heights.

The first eight columns near the church's entrance were verified, using the total station described before, measuring 10 points on each column on the profile towards the nave and fixing other 12 points on the pillars placed on the columns' capitals.

The first four columns towards the transept, which, from the historic records analysis, turned out being the first ones built, and which also appeared as the most damaged, were verified not only on the transversal axis but also on the longitudinal one.

To calculate the facade's eventual out of plumbs, the facade



Figure 3. West elevation



Figure 4. Longitudinal section facing West



Figure 5. Transversal section of the transept facing North



Figure 6. Transversal section facing South

having also two other serious vertical damages near the toothing of the aisles' walls, we carried out the reading of 56 points whose reciprocal shifting was later on compared and analysed on 3D using Autocad 2004.

All the resulting information was represented within the geometric draughting, but also by means of specific diagrams capable of synthesising and revealing the structures' shifting as clearly and accurately as possible.

The floor's altimetry analysis needed a separate study in order to create a quick method for reading a great deal of data: we decided to divide the surface we had to survey in a 2 x 2 meter grid, developing it until 0.5×0.5 meters in case of more serious problems. The actual identification of the points to survey with the total station was carried out making use of a measuring tape graduated every 2 meters, that we longitudinally moved by two meters every time we finished reading the row of points.

This method allowed us to survey, in less than a day time, over 500 points necessary for covering the whole flooring area, that have been elaborated afterwards using Meridiana 321 to create the contour lines and to elaborate the most important outlines.

For what concerns verifying the wooden chains' heights, we preferred not using the total station, due to the darkness and roughness of the material they're made of, which doesn't have the reflectivity features necessary for a correct laser reading; also, considering their position, using the topographic instrument would have forced us to identify many additional station points in order to make sure the reading was taken from shooting angles that were not excessively of partial view.

So we made use of a Topcon laser self-level, RL-VH3 model, to identify a virtual plane, at approximately 160 cm of height, from which we measured the elements' distance at the intrados by means of a Leica laser Disto distance meter, taking various readings for each measurement, due to the problem regarding materials.

The resulting data was later on drawn into graphics on the same boards where the data on columns' out of plumb had been drawn to scale.

The results of these surveys confirmed our first impressions on the eventual out of plumbs of the first columns towards the transept, though pointing out other problems regarding the state of the wooden chains longitudinal to the nave, which have a delta of approximately 15 centimeters between the first and the last one. Also the transversal chains, placed at a higher level than the longitudinal ones, show misalignments in the range of 8 to10 centimetres and a borderline case at 17.

Less alarming results come from the analysis of the data issued by the reading done to verify the facade's out of plumbs, where no noteworthy misalignments were found, especially in proximity of the cracks mentioned above.

The altimetric state of flooring has instead resulted nearly constant, with a slight inclination, of approximately 2 centimetres, towards the presbytery, but with important depressions in the order of 10 centimetres localized in the transept area.

Parallel to the geometric survey's lay-out, we performed the photographic campaign for acquiring the necessary materials to realize external and internal photographic rectifications.

Also in this case, as already mentioned, it was necessary to previously plan the photographic survey so as to assure an optimal covering of all fronts and, at the same time, to work on



Figure 7. Geometric draughting of columns' out of plumb

digital images at a 240 dpi minimum resolution. Digital working, the shooting project is a key factor that allows us to define the minimum number of shots that must be taken in connection with the front's dimensions, the reproduction scale's and the final printing resolution's.

We made use of a Canon Eos 300D reflex digital camera with a 6.3 Megapixel photosensor capable of producing 3072 X 2048 pixel images, equal to approximately 18 Mb of information per file. With the help of an elevator capable of reaching twenty meters of height, we shot over 700 pictures, for a total of 2.5 Gb of data, from which we later chose 279 images to be used for the mosaic.

All the pictures have been taken at maximum resolution and in *.jpg* format at minimum compression. We could have also shot in *.raw* format, so using a *lossless* compression, but, exclusively due to managing and recording problems (we would have had approximately 7 Gb of image data only), we preferred a *.jpg* format at minimum compression; the sensor's sensibility was

set at the lowest level (ISO 100 equivalent) and, only for the interior, we made use of an additional flash light whose guide number is 55 at ISO 100.

We added an autofocus lens to the camera for most of the shots, with a 35mm focal length which, due to the sensor's reduced dimensions (22.7 x 15.1) compared to traditional film's (36 x 24), produces single shots' clips which are 1.6 times bigger, making the lens used work like a 56mm. For some shots that had small space behind the operator, we decided to use a 20mm lens, which, due to what was explained just above, is equivalent to a 32mm; we have also made use of a medium (70-100mm) and a super 300mm telephoto lens for bell tower shots.

With the purpose of eliminating eventual barrel and pincushion distorsions due to the use of wide-angle and telephoto lens, all the images, before being rectified, have been corrected by means of the PTlens software, to eliminate or at least minimize deformation's radial component which rectification softwares are not able to correct.

With the aid of the same total station used for the geometric analysis, we fixed almost 400 topographic bases, which we later used as true coordinates for the photo-rectification process.

For this purpose we used Sierrasoft's Geomatics Rasta module, using from 5 to 6 basis points for each single shot, instead of the 4 demanded by the program as a necessary and sufficient condition in order to have a better control of mistakes, and to eventually be able to leave out the point which is drastically out of range from the calculation.

We worked in a different way on the creation of the nave's and aisles' vaults' intrados' photoplane, made up of 74 pictures, 32 pictures of the vaults and 42 of the arches.

Due to the vault's geometric feature, we couldn't use the same software used for the fronts' rectification, since it is exclusively for elaborating the data regarding planes.

Using instead the Panorama Tools software, with various iterations we were able to eliminate deformations due to the perspective view of a concave object.

The result, after the elaboration, can be considered like an orthophoto even if, due to the program used, it cannot guarantee the same accurateness regarding the metric congruence.

On the contrary, the placing of each shot in order to form the mosaic is totally correct, and it was carried out by creating a



Figure 8. Altimetric data of the flooring with grid of over 500 points



Figure 9. Image rectifications of the transept facing North and the nave facing East and West

geometric grid as a base by means of measurements taken with topographic instruments.

Considering the use we created the photoplanes for, that is materials' mapping and identifying the state of decay, we thought it necessary to not limit images' quality to the one provided by the rectification software; for this purpose we decided to use Photoshop software for calibrating shades of colors and tones in a more precise way. Regarding this specific matter, in fact, Photoshop is able to give higher quality results. In some shots we also introduced a *colorimetric target* so as to make sure we reached a high chromatic accuracy, and that allowed us to eliminate eventual chromatic dominant due to sunlight's temperature.

We performed the draughting (in a scale of 1:100) of the four external elevations, of the counter-facade, of the nave's and aisles' fronts, of the transept's four elevations and of the vaults' intrados.

Based on these photoplanes, we also laid out a stratigraphic analysis for the four external elevations. This analysis, using "high definition" photographic tools, allowed us to – after having verified the reading of the stratigraphic units - draught the elaboration and interpretation of the various construction activities that took place in time. The stratigraphic analysis' boards describe the "perimetric

measurements" of the stratigraphic units (S.U.) and of the architectural elements (A.E.); they also tell us, through appropriate patterns, activities' construction chronological sequence, pointing out the walls' discontinuous areas and the building's "critical spots".

Stratigraphic reading is also an essential analysis for the choice of uniform sampling for the mensiochronological analysis; it's also a valid tool for buildings' archaeological and fact-finding studies, and is based on relations between bricks' measures and the construction period. For S.Anastasia's



Figure 10. Image rectification of East elevation



Figure 11. Nave's and aisles' vaults' intrados' photoplane

Basilica we made nineteen samplings to certify the different construction activities resulting from the stratigraphy, also strengthened by the excellent results of the physical-chemical study on additional samples taken from bricks and mortar.

The great quantity of work resulting from these studies has allowed us to improve a working method that can be successfully employed again on other types of buildings; it has also shown that the use of different disciplines within such a complex process, as that of fact-finding and of historical construction study and also, in this case, of monumental construction, is a key factor for achieving results that go beyond the "pure" geometric (quantitative) and photographic (qualitative) data.

The up to date technological means tend to favor an always more useful inter-operability between information resulting from each discipline, though still leaving the concretization of final results to the sensibility and skill of process supervisors.



Figure 12. South elevation's stratigraphy reading

At last, it's important to point out that this long cognitive method's final result is not considered only as a key factor for the intervention and conservation project, but, from the moment it is drawn-up, also as a documentary source of historic value.