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SURVEY AND STATIC CONTROLS OF THE SAN MARCO'S BASILICA IN VENICE

Introduction

San Marco's Byzantine Basilica and the Square (fig. 1) are in reality an open-air museum: a lot has been written and represented, in all the world and during many centuries, over this complex

In the last decades various investigations have been performed to find, besides the more historical aspects, the elements that could disturb a matter of state that had allowed the intact surviving of the complex over all the second millennium.

Fig. 1 San Marco's square and the Byzantine Basilica.
Сл. 1 Трг светог Марка и византијска Базилика

The absolute value of an architectonical monument of this type has necessary to foresee the updating of techniques that are able to keep in good shape a monument disturbed by the stress: this is mainly due to the enormous tourist passage, to subsidence phenomena, to sometimes destructive tides effects and to pollution in general.

Floor survey

Among the various relief works, structural controls, 3D and GIS experimental relieves that since some time are led over the St Marco's Basilica, one regards new methodological applications for the architectonical Goods relief and their representation, as they have in fact been experimented over the St. Marco's Basilica floor, where we obtained the precisions of the most recent instruments.

The first subject we are here referring regards new methodological applications for the relief and the representation of architectural Goods, as they were experimented over the San Marco's Basilica floor, where we tested the precision and the reliability of the more recent instruments. A particular attention has been further given to the data's transformation into digital representation and vectorial graphic. At present the instrumental survey 2D (fig. 2) or 3D (fig.

Fig. 2 2D Orthophoto of a floor part
Сл. 2 Дводимензионална ортофотографија дела пода

3) relief at the architectonical scale employs advanced topographical methods of digital photogrammetry, of laser scanner and other sensors. A complex reality, such that of Architectonical Goods has to be faced with necessary complex methodologies, that allow the constructions of models very close to reality by defining new grounds of architecture knowledge. This knowledge has to pass through integrated models, with the aim of getting a better relief result, in order to attend, at the end, the realization of an always more accurate geometrical relief that has to be, at the same time, a good support for the conservative and the cognitive project of this Good.

For what it concerns an architectonical very interesting object such as the floor, fully covered by mosaics, in the San Marco's Basilica, we have an almost completed relief project with the aim to realize a digital orthophoto of the same floor at the scale 1:1. It is a unique work both for the methodological point of view for the precisions we intend to obtain, both for the documental importance of such a relief, which has a superficial extension of 2600 square meters to be later used in restoring and floor conservation interventions.

Always keeping in mind the snaky floor, the chance to construct dime templates from a DSM (Digital Surface Model) that correspond to the vertical profiles of the same floor, offers the opportunity to perform conservative interventions not only for the esthetical point of view (that means the substitution of the lost or very damaged mosaic tesserals, also because thousand of visitors walk on the floor every year) but also for the reinstatement of the right floor level.

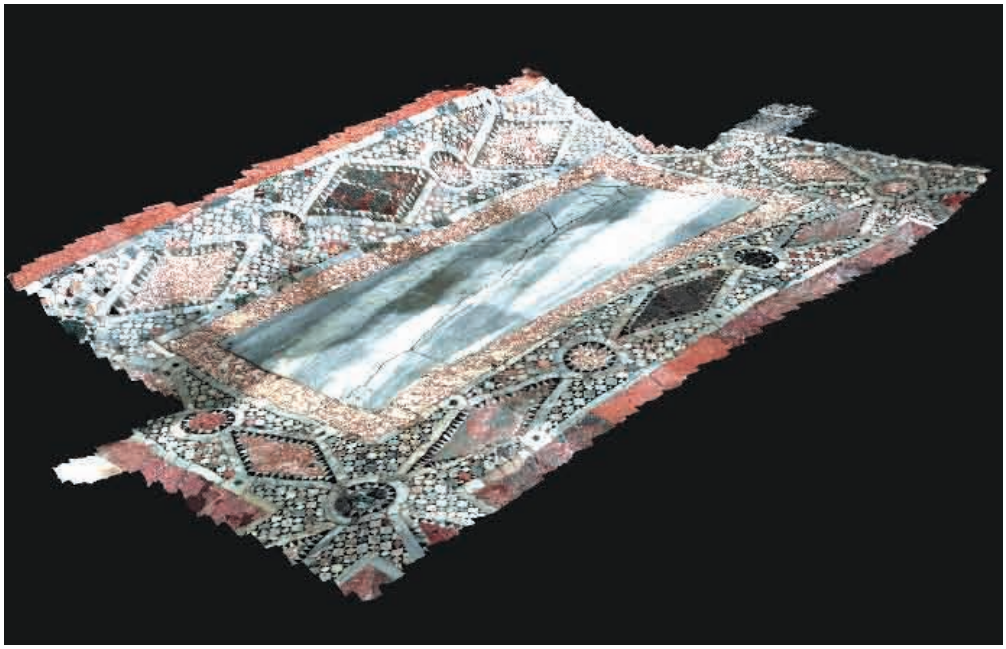

Fig. 3 3D Orthophoto of a floor portion
Сл. 3 Тродимензионална ортофотографија дела пода

The mosaic conservation, has been, until now, performed with empiric proceedings characterised by the presence of economical and technical problems. Since the previous phase, mosaic tesserals substitution is obtained on rectified photos taken at the real scale that by the way do not coincide with the real floor state: this is mostly due to the image distortion than to the non-plain floor. The so-performed results are to be considered quite good even if not perfect and, unfortunately, obtained with very high cost. The constant effort of the "Procuratoria" for the Basilica floor conservation and care has, in fact, addressed to the three dimensional reproduction of the same floor at the scale 1:1 in order to perform the individuation, the temporary removal, the reposition or the punctual substitution of the damaged parts, always respecting the typical irregular altimetry floor characteristics.

Keeping in mind these previous arguments, we have tested on a mosaic sample of about 100 square meters the real potentiality of the project introduced before the realisation of a digital orthophotos. At this aim, we have to consider that at the base of a 2D or 3D orthophotos we find the DSM floor performed by two different methodologies: with image autocorrelation and with laser scanner. Using the two methods, we realized two different orthophotos, one on the floor model obtained by interpolating the laser scanner data, and the other on the model performed with photogrammetry, by autocorrelation. The DSM obtained by comparing the final results with the two models present not very big variations but they are interesting and apt to further studies. During the experimentation, we saw how the laser sensors have to be carefully fixed with regard to the radiometric answer of a consistent net of reference points, even if their determination does not appear very simple and this is due to the surface type. The orthophotos in scale 1:1, made on a transparent support, have been directly compared with the musive floor surface over the same floor: we obtained a very good result, both on the geometrical and both on the chromatic side.

It is now worth to say that the GIS (Geographic Information System) are more and more employed in the Architectural and Cultural Goods. For this reason it was necessary to create a GIS, opportunely dedicated with the purpose to care all the existing documentation, geo-referred to the vectorial plan at the scale 1:50 and at the 2D and 3D orthophotos, able to evidence all the information necessary to conservative interventions. We don't have to forget the damaging objects history, because this can be the consequence of evolution process occurred by the time, but it can also be referred to very recent periods. The GIS is, in this case, able to permit the reading of phenomena in a period of time in which they manifested and for this reason able to give various elements useful in the following phase of conservative intervention. The System we are here referring, gives the possibility to read, metre by metre, the floor reproduction at the scale 1:1 and to realize plottings on opportune supports at the textile base of the floor orthophotographical image, defining, in this way, a very useful document in order to proceed to restoration. For the conservation, we precise that the mosaic floor restoration needs the use of wooden dime templates which can be obtained by automatic extraction of the 3D orthophotos profiles.

The later mosaic tesserals set up follows the historical definition of the altimetric part.

The use of the scale 1:1 underlines the main aspect of the mentioned intervention and its innovation, if you consider that never before we worked with this definition type.

All this has been possible with the development of the web technologies: the access to powerful computers has allowed the employment of softwares proper to the management of high definition digital images.

In this case we used Apex PCI v 7.0 programs for the images management and the model creation, and the ArcGis for the orthophotos display.

For the execution of the photogrammetrical takes we employed the digital metrical camera DB44 Rollei with 16 millions of pixels on a format of less then 4 cm per 4 cm, while to determine the support points we recurred to the more modern topographic instrument.

The static control

The necessity of a deep knowledge of the Basilica as well of its static nature has appeared with more intensity until the solution found in 1983 with the Procuratoria approval of a photogrammetry relief project of the entire building.

During the same years, we repeated, with three months intervals, the geometric levelling measures in order to control the structural elements of the "fabbrica" and to evaluate the floor conduct, characterized as already well underlined, by manifested raisings and sinkings.

From then, these controls have been the object of a more and more carefully attention until we got to a new, more modern and rational setting of a net of high precision geometric levellings regarding 74 bench marks.

The new measure series, achieved with levelling operations from the high precision mean, lead to identify the measure found in 1989 as the so-called measure 0.

With regard to the measures of height variation, probably the most important method referring to the static control, the employed scheme was an high precision level, carried out with the automatic level Zeiss Ni 1 (fig. 4) and different rods, as we can see later.

The materalization of the internal and external control points includes three different types:

- steel benchmarks on the ground floor: over these we put a rod with invar tape (fig. 5);
- benchmarks on the walls: composed by aluminium angular elements fixed on the walls and used with particular short rods (fig. 6);
- benchmarks composed by a steel bracket connected with a steel wire, stretched by a weight; in a particular position a little cylinder is fixed stopping a short rod (fig. 7).

Fig. 4 Automatic level Zeiss Ni1
Сл. 4 Аутоматска либела „Zeiss Ni1”

Fig. 5 Rod with invar tape
Сл. 5 Летва са траком од инвара

Fig. 6 Short rod on the wall
Сл. 6 Кратка летва на зиду

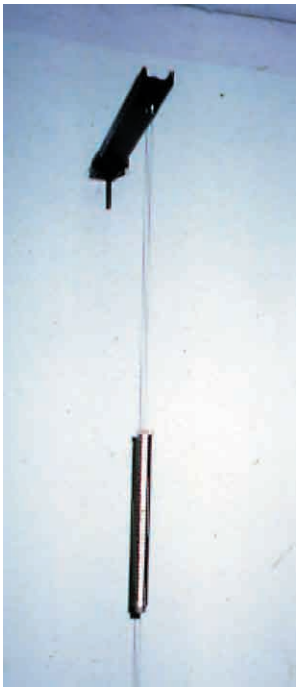

Fig. 7 Wire rod
Сл. 7 Жичани штап

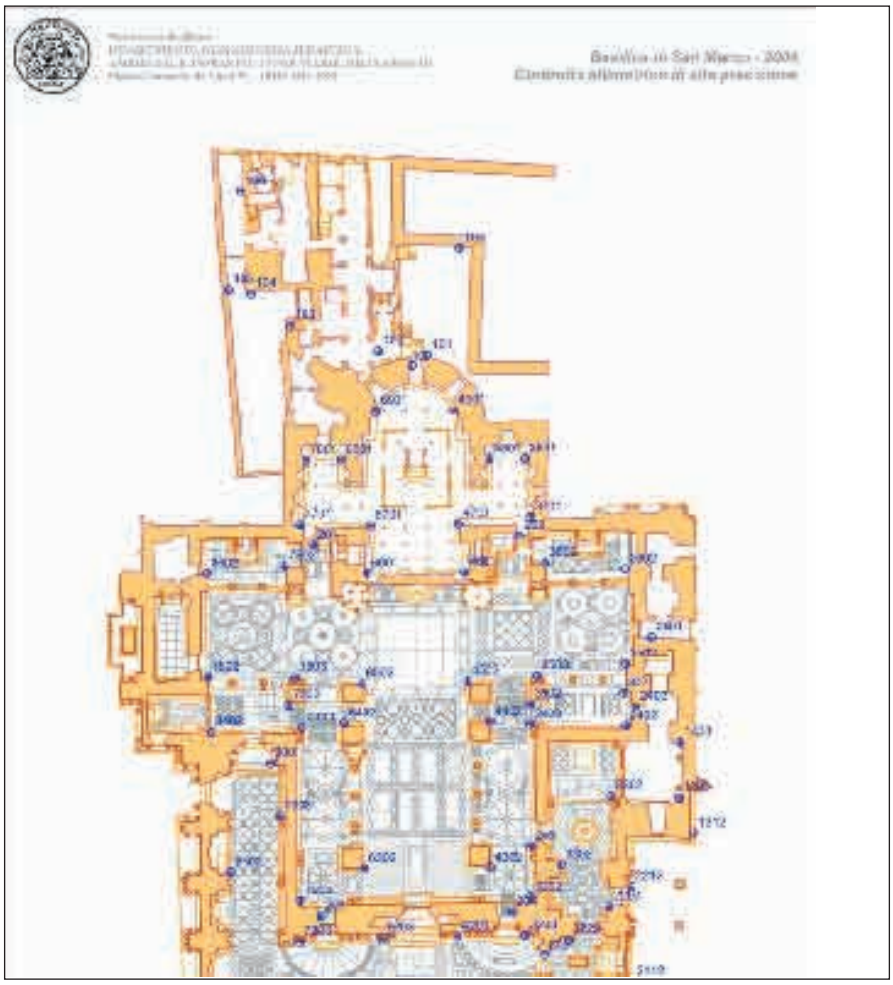

Fig.8 Connections scheme
Сл. 8 Шема повезивања

The figure 8 shows the connections plan and underlines as well the bench marks aimed distribution, set in correspondence of the most meaningful parts of the architectonical complex, as to evidence the global conduct on the base of the single control points movement.

The static control is carried out with measures series every year, following a choose that does not include the season thermal variations.

The total variations, referred to the 1989 measure, are reported on figure 9, where it is interesting to see the behaviour of the 6601 bench mark that presents an irregular variation, probably due to a damage occurred in the past to the bench mark.

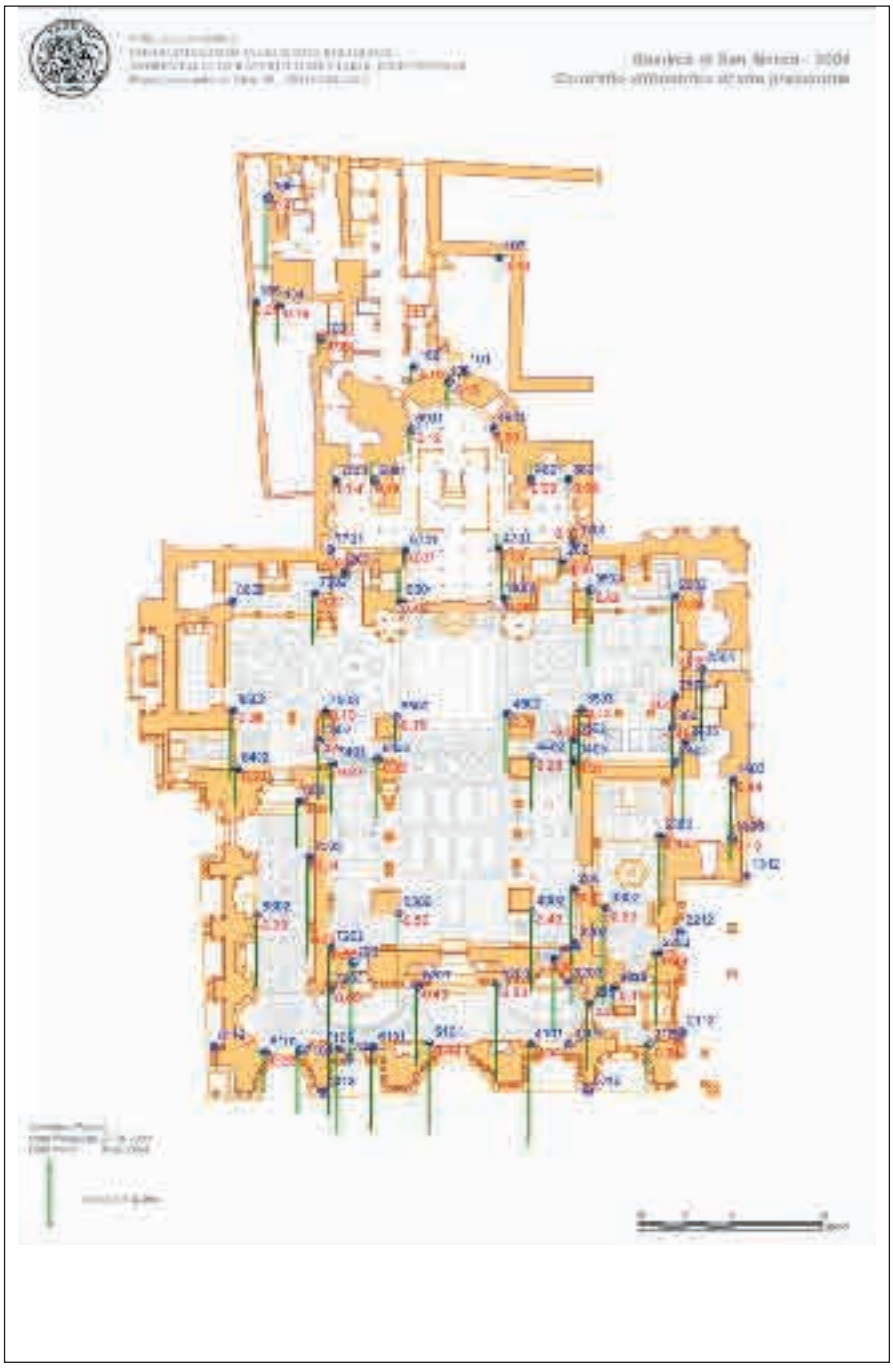

Fig. 9 Total variations
Сл. 9 Укупне варијације

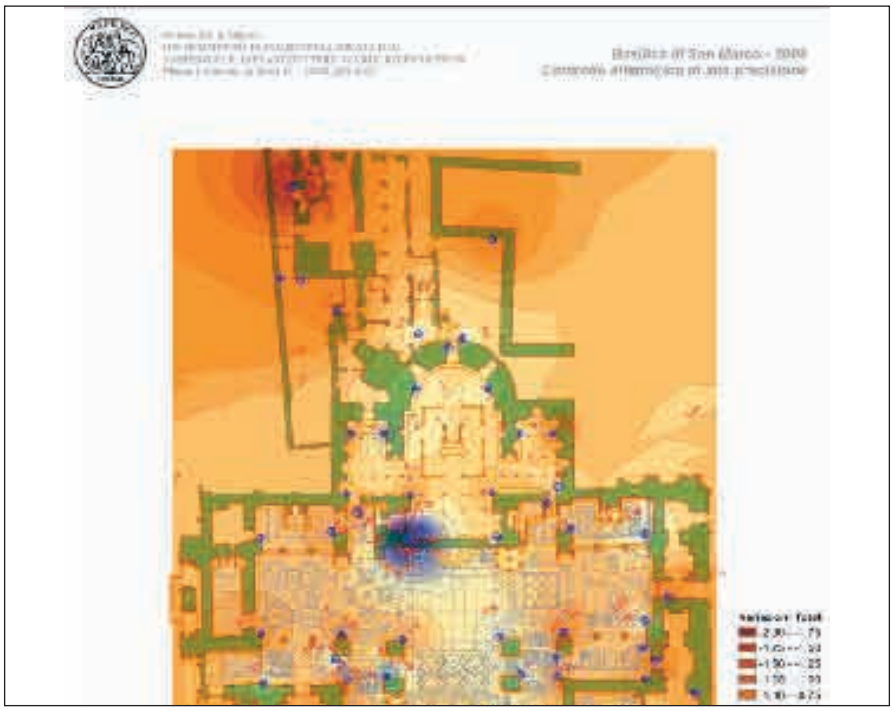

Fig. 10 Total variation with contour lines
Сл. 10 Укупно варирање са изохипсама

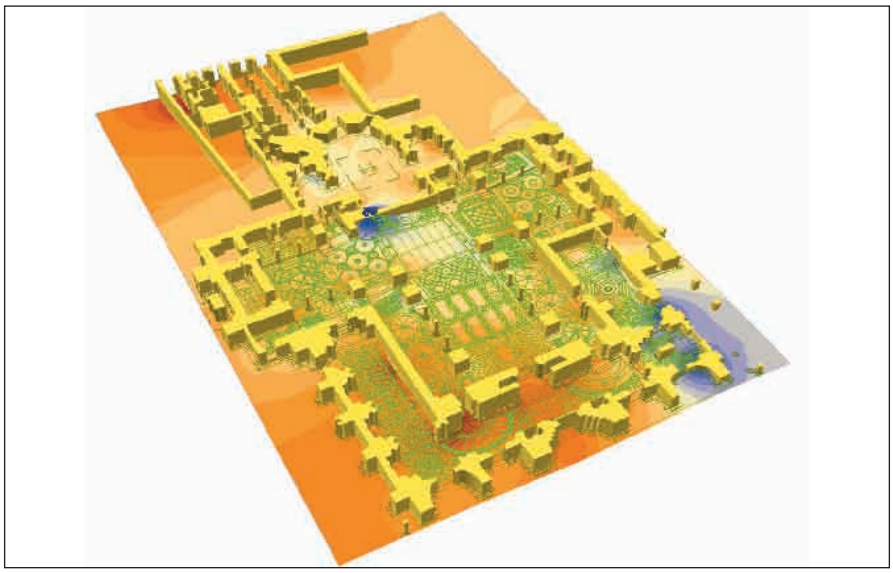

Fig. 11 Total variations - 3D view from the front
Сл. 11 Укупне варијације – тродимензионални приказ са чеоног дела

With regard to the results performed with the scientific investigation, it's possible to show (fig. 10) the total structure variation with contour lines, referring all to the initial measures series (fifteen years ago).

Finally it may be rather interesting to observe the total variation representation with a 3D view and with a large scale enlargement from the front side of the Basilica (fig. 11).

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Ђорђо Безоари – Карло Монти

СНИМАЊЕ И СТАТИЧКА ПРОВЕРА БАЗИЛИКЕ СВЕТОГ МАРКА У ВЕНЕЦИЈИ

Рад се односи на различите интервенције, неке већ обављене а неке у току, на византијској Базилици Светог Марка у Венецији. Снимање пода Базилике урађено је помоћу ортофотографија у размери 1:1. Овај посао је јединствен по примењеној методологији и по документарном значају рељефа који се у каснијој фази треба да подвргне рестаураторским интервенцијама. Што се тиче статичке провере, која се примењује већ око 20 година, у раду се углавном разматра прецизна контрола висине. Оваква контрола ради се на око стотину нивелационих тачака, распоређених на унутрашњој и спољашњој страни Базилике, које су међусобно повезане путем геометријског изравнавања.