WHOLLY DOCUMENTING HOLY MONUMENTS

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Commission V, WG V/5

KEYWORDS: Close Range Photogrammetry, Geometric Recording, Analytical Restitution, Architectural Heritage Conservation, Photographic Recording & Documentation, CAD, Surveying

ABSTRACT:

The Church of the Holy Sepulchre in Jerusalem is an impressive monument built around the site where Jesus Christ has been crucified and buried. The complex of the monument comprises meny churches, chapels, monk cells and numerous other places of worship and extends in an area of approx. 10000sqm situated in the heart of the Jerusalem Old City.

The Laboratories of General Geodesy and Photogrammetry of the NTUA in collaboration with the University of Athens undertook the huge task of documenting the Church of the Holy Sepulchre in Jerusalem at a scale of 1:50. Such an extensive survey has never been carried out in the past. For this work to be completed seven consecutive years of fieldwork and processing the field data were necessary.

A team of surveyors, photogrammetrists, architects, archaeologists and photographers worked in harmony and proved in practice the merits of the interdisciplinary collaboration. The field data collected included survey measurements to more than 20000 points and approximately 2000 metric and 3000 non-metric photos.

In this paper the fieldwork and the processing of the raw data are described. The combination of conventional survey and photogrammetric methods proved once more ideal. The raw data were combined to the desired drawings in order to ensure copmlete and thorough restitution of all parts of the monument. The results are also presented, discussed and assessed for their accuracy and effectiveness.

1. INTRODUCTION

1.1 Historical Background

The Church of the Anastassis (Resurrection) or of the Holy Sepulchre, as it is mostly known to western visitors, lies majestically in the heart of the Old City Jerusalem and has a very long history spanning over twenty centuries (Figure 1). The first church in this site was erected by Saint Helen, the mother of Emperor Constantine the Great, when she discovered the Holy Cross at the beginning of the fourth century A.D. Since then a lot of constructions, modifications, additions, rennovations and alterations took place, the major one being that imposed by the crusaders in the 12th cent. A.D. when they conquered the Holy Land.

Figure 1: The Church of the Anastassis, Jerusalem

1.2 The Status Quo

Today the Church complex is a living monument and it is visited every year by thousands of pilgrims. All different Christian Communities are represented and active within its walls. Greek Orthodox, Roman Catholic Franciscan, Armenian and Coptic priests and monks and others are more or less coexisting in harmony worshipping the same God. The monument is divided into sections each one “belonging” to a Community. There are, of course, sections of it common to everybody. This unique state of ownerships is respected by all Communities and is very hardly seen by the visitors. It constitutes the Status Quo of the Church of the Holy Sepulchre, which has its origins in historical tradition.

1.3 The need for documenting the Monument

During all these years of its existence, very few efforts had been made to geometrically document the monument in an objective and thoroughly scientific way. Perhaps the most complete, although not fully, geometric documentation was the one carried out by V.C Corbo (Corbo, 1981), a Franciscan monk who devoted a long time of his life to this goal. Without modern means Corbo managed to produce drawings of good quality, but of debatable reliability. Another serious attempt was the one carried out by M. Cooper and his team (Biddle et al. 1992 and Cooper et al. 1992). However, their effort was concentrated mainly on the Edicule, i.e. the construction within the Church of the Holy Sepulchre covering the Tomb of Christ. Hence the need for a thorough geometric documentation was more than apparent.

It was a good opportunity, that in 1993 the National Technical University of Athens and the University of Athens joined forces to confront this task, having at the same time the full support of the Greek Orthodox Patriarchate. The fieldwork was extended to seven consecutive monthly campaigns from 1993 to 1999. Every year a team of surveyors, architects, photographers and archaeologists worked in harmony for the collection of the field data.

2. THE GEOMETRIC DOCUMENTATION OF THE CHURCH OF THE HOLY SEPULCHRE

2.1 Description of the Monument

The Church of the Anastassis in Jerusalem comprises within its walls the main large Greek Orthodox church, the Katholikon, the Holy Rock of Golgotha, the Tomb of Christ and the place where the Holy Cross was discovered. Adjacent to these main places of worship and pilgrimage are numerous little chapels, monk cells, store rooms, corridors and staircases, extending to approximately 12000 sq. metres in plan area and to about 35 metres of height difference. The main building complex has common borders with the Greek Orthodox Patriarchate, the Syrian Patriarchate, the Roman Catholic Monastery, the Ethiopian Monastery and a series of little stores (Figure 2).

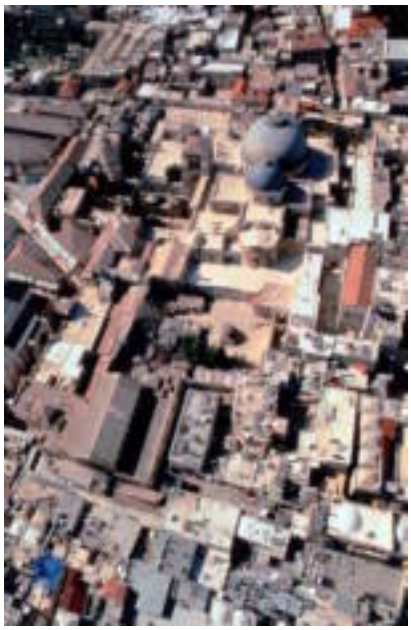

Figure 2: The Church of the Anastassis, Jerusalem

2.2 Drawings to be compiled

The determination of the final drawings to be produced by this effort was not decided until after the third campaign. This was due to the fact that understanding such a complicated monument and grasping its details need some time of familiarization. Finally, the production of a total of 25 main drawings was decided. They included horizontal and vertical sections through the main parts of the monument. Initially a scale of 1:20 was considered. However, later the scale of 1:50 was preferred, because of the size of the resulting drawings, but also because of the unnecessary accuracy required for the larger scale.

2.3 Personnel & Instrumentation

This work has been an excellent example of interdisciplinary collaboration. Even the initiative was the inspiration of an Architect and a Surveyor. The team, who have been working in situ for seven consecutive years for one month, comprised four Surveying Engineers, two photogrammetrists, two photographers, two architects and an archaeologist. All of them worked in harmony in order to complete the difficult task.

For the necessary data collection the most technologically advanced instrumentation was used. For the survey measurements a Leica T1610 electronic theodolite equipped with the reflectorless DIOR 3002S EDM was used. This instrument ensures the accurate measurement of distances without the need for a reflector, thus enabling the pointing and determination of remotely situated points in the vast Church complex. For the photogrammetric takings two metric terrestrial cameras were employed. A Wild P31 (10x12.5 cm^2, with a 45 mm lens) and a Zeiss (Jena) UMK 1318/100 were mainly used with black and white cut film of 125 or 400 ASA sensitivity. However, in a lot of cases the 6x6 amateur Hasselblad camera was employed, in order to confront situations, where the other two were unable to.

Premarking of control points was decided in most cases, as this ensured high accuracy. It should be noted that all care was taken not to harm the monument in any case.

The instrumentation was completed with two PC's, which were installed at a nearby office, and were used for downloading the field data and performing initial calculations, in order to ensure data integrity before leaving Jerusalem. Moreover all necessary parnaphernalia were also used to set up a fully fumctional darkroom for making sure that all photographs have been taken correctly.

2.4 Data Collection

The field work was executed for one month each year for seven consecutive years. The data collected during those 210 days comprised:

- Establishment and measurement of 150 theodolite stations
- Determination of 23000 geodetically measured points, including control points, section points, detail points etc.
- 1500 metric and 500 non-metric images for photogrammetric processing
- 2000 photographs taken for documentation purposes

All collected data were suitably archived on site. Especially for the measured points a special codification was devised, in order to enable the own developed calculation software to distinguish the various kinds of points.

Each point was codified with a six digit number, the fields of which had a special meaning:

| A | | B | C | | D | E | F |

A: Kind of point, 1 → theodolite station
2 → premarked control point
3 → detail control point
4 → section point
BC: Code number of crossection
DEF: serial number of point

3. DATA PROCESSING

3.1 Calculations

During the time following each monthly campaign all collected data were suitably processed. All calculations not executed in situ were completed at home in order to enable the survey work. All measured points were determined in a common geodetic reference system. The X-axis of the system was determined by two points on the long axis of the Greek Orthodox Katholikon within the monument complex. The south entrance of the Church was given the height of 754m above sea level, using a nearby vertical reference point. In this way all external influences on the determination accuracy of the points was excluded.

All survey stations and the control points of the first campaign were adjusted in a common network. However, this was considered unnecessaary thereafter as the geodetic measurements ensured the required accuracy for the survey stations.

It is estimated that the accuracy achieved for the survey stations was of the order of 5mm, for the premarked control points of the order of 8 mm, of the other detail points about 12mm.

3.2 Survey and Photogrammetric Work

The basic section lines for each crossection were plotted within the AutoCAD environment. Initially version 10 of the software was used, while for the last campaign, i.e. seven years later version 2000!! For the correct projection of the points a 3D rotation was considered necessary. For this purpose special software was developed, in order to perform this rotation.

It was also established that most photogrammetric software refuses to perform the adjustment of a stereopair if the reference system of the control points does not simulate the situation of the aerial photography. This means that the reference system should have the Z axis pointing towards the camera.

All photogrammetric stereopairs were oriented and plotted either on a Leica DVP digital stereoplotter, or an Adam MPS-2 analytical stereoplotter. The three dimensional photo-grammetric outputs were later processed by the team of architects, in order to produce the final drawings (Figure 3).

Figure 3: A sample of the vertical crossections – South facade

An interesting project was the compilation of the drawing of the roof tops. As aerial photography over the Old City Jerusalem was prohibited, the plan was compiled by suitably adjusting photogrammetric measurements from several 35mm colour slides taken with an amateur camera and a zoom lens with unknown geometry (Georgopoulos and Modatsos, 2002) (Figure 4).

Figure 4: Rooftop plan

A total of 35 drawings were produced. Included are the four plots of the plan drawing. All these plans cover an area of 40000 square metres approximately at the scale of 1:50.

4. CONCLUDING REMARKS

This unique project can never end. The complexity of a monument such as the Church of the Holy Sepulchre, does not present an easy task, when its documentation is concerned. Moreover the fact that it is a living monument presents even more difficulties. All religious communities active within its walls and the endless crowds of pilgrims who visit the Church every day all year round present even more obstacles, which can never be overcome or set aside. One should work with respect to the place and the people active in it.

However this project has been an excellent example of co-operation. On one hand, there is interdisciplinary co-operation. Surveyors, Architects, Photographers, Archaeologists and Photogrammetrists worked harmoniously for a really long time under adverse conditions to complete the difficult task. On the other hand there is interreligious co-operation. Greek Orthodox,

Roman Catholics, Armenians, Syrian Copts and Ethiopians agreed and allowed our group to momentarily disturb their peace and perform our measurements.

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