
Building Information Management based on Total Station Measurements and Laser Scanning

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Abstract

In this paper is presented a 3D measurement and visualization of the church of St. Nicholas on the island of Hvar. Survey of the church was conducted using a laser scanner and reflectorless total station with the appliance of methods such as constrained centring which ensures high-quality measurement results. Due to its quality, the obtained 3D model was used to create layouts, cross sections and views that were used for the renewal of the church of St. Nicholas. Multimedial presentation made upon a result of the created 3D model shows an additional possibility of applying the results of the 3D survey. Use of available technology and methods of geodetic survey is a great baseline for the Building Information Modelling (BIM) in order to ensure better building management.

Key words: 3D measurement, 3D model visualisation, reflectorless distance measurement.

1 INTRODUCTION

The increasing value and complexity of buildings, especially in urban areas, requires their proper 3D modelling in electronic environment. It can be done in phase of designing a building or later, for instance, when reconstruction is about to take place. In near future the property right registration will be enabled in three dimensions so a proper 3D measurement and building modelling will be needed (Jazayeri et. all. 2013, Roić 2012). Modelling buildings in three dimensions is also necessary to ensure their more efficient management and use through establishment of Facility Management or Building Information Management systems. 3D models of buildings are also used in process of creation of different thematic maps, eg. *Noise maps* (Cetl et. All. 2009). Neglecting the purpose of creating a 3D building model in electronic environment, its creating process is called Building Information Modelling (BIM). Term BIM was introduced nearly ten years ago to distinguish the information rich 3D modelling from the traditional 2D drawing. Many authors in their papers give definitions of BIM (Ceranic 2013, Eastman et. all. 2008, Iskidag et. all. 2012, Smith and Tardiff 2009, Robinson 2007). According to them, BIM can be described as a process which results whit a reliable digital representation of the building available for design decision making, high-quality construction or reconstruction document production, planning, and performance predictions. Also it is possible to make cost estimations of planned work

easier and more efficient with use of BIM. Although BIM can be made from blueprints or from scratches, in most cases first step in realisation of a BIM is a proper survey of building.

Main goal of our BIM was to produce quality enough 3D model of the St. Nicolas church in a way that it will be possible to create technical documentation for church renewal. Since there were no blueprints of the church, field measurements needed to be carried out. Because of the accuracy that they provide and relatively small size of the church, terrestrial survey method where used for acquiring spatial data.

2 FIELD WORK

Field work included reconnaissance of the terrain, establishment of local geodetic basis with stabilization of traverse points, and the very detailed survey of the exterior and interior of the church. Measurement equipment that was used consisted of a contactless measuring station Leica TCR 407 with accessories for constrained centring, measuring tape and hand laser distance meter. Field works were carried out over a period of four days.

2.1 SETTING UP A LOCAL GEODETIC BASIS

Having carried out reconnaissance of the terrain and the church, best position for traverse points were chosen. It was decided that is most suitable to set up six traverse points around the church and two traverse points inside the church (Figure 1). They were stabilized on field in an appropriate way so that measurements could take place.

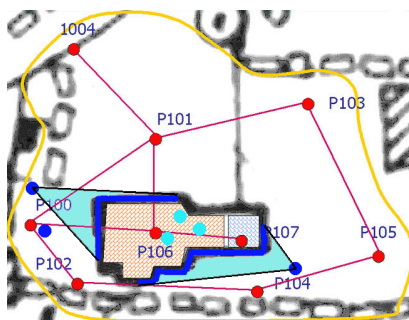


Figure 1 Local geodetic basis and laser scan positions

Geodetic basis was set up as closed and open(-end) traverse. Due to unfavourable configuration of traverse, accessories for constrained centring were used, and measuring directions were taken in both faces. By this, a satisfactory positional accuracy of traverse points was achieved. Through point marked as 1004 basis was connected on state coordinate network.

2.2 SURVEY

The exterior of the church was surveyed from six measuring points (P100, P101, P102, P103, P104, P105) while two points (P106, P107) were used for surveying interior of the church (Figure 1). Very detailed field sketches were made and a lot of photographs of the church was taken. Many of them were printed and used during survey to mark and numerate measured points on them (Figure 2). This “photo field sketches” are very suitable for this kind of survey. Besides measuring with total station, a lot of control measurements needed to be made (Figure 3). They were done by use of measuring tape and hand laser distance meter (Vidović 2004).



Figure 2 Field sketch on photography

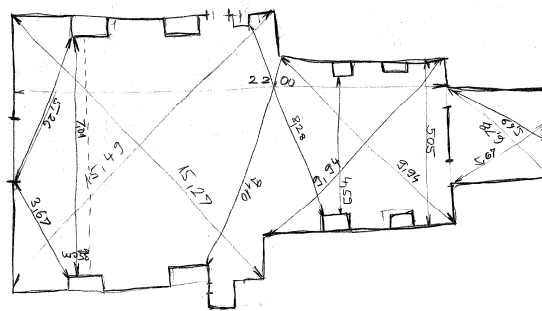


Figure 3 Field sketch-control measurements

Immediately after finishing measurements of the closed traverse, controls were made to see if there is a need to repeat measurements. Since the angular and linear misclosures were insight tolerance value (Table 1) there was no need for repeating the measurements.

Table 1 Angular and linear misclosures of closed traverse

Traverse		Tolerance
Linear misclosure f_d	0.05m	0.064m
Angular misclosure f_{β}	20''	1'

Church was surveyed from outside and inside by laser scanner. Outside survey was made by three scans from three measuring points, marked blue on earlier figure (Figure 1). Scans encompassed facade on the west side, the bell tower and the facade on the south side (Figure 4). The interior of the church was scanned three times from three measuring points (Figure 1): nave of the church, main altar and choir of the church. Results of raw and processed data of outside laser scan can be seen on figures (Figure 4 and Figure 5).

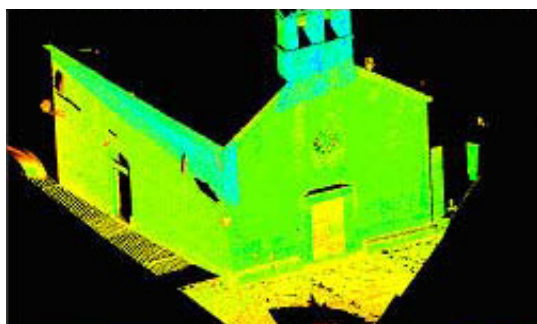


Figure 4 Result of outside laser scanning (Topić 2005)

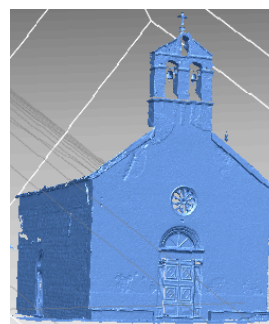


Figure 5 Result of outside laser scanning after data processing (Topić 2005)

3 DATA PROCESSING, 3D MODELLING AND VISUALISATION

Appropriate software was used for processing measured data. Microsoft Excel was used for processing computational part of the data acquired by total station. Upon obtaining the coordinates of surveyed points, they were imported into MicroStation, a computer aided design software created by Bentley Systems. Whole 3D modelling was done inside MicroStation. By connecting imported points and complementing model with data acquired by measuring tape, a wireframe 3D model of church (Figure 6) was created. Upon wireframe model a rendered model of church was made and more realistic model was achieved (Figure 7).

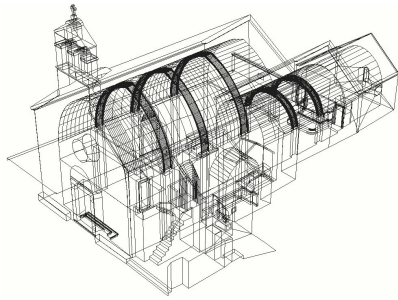


Figure 6 Wireframe 3D model

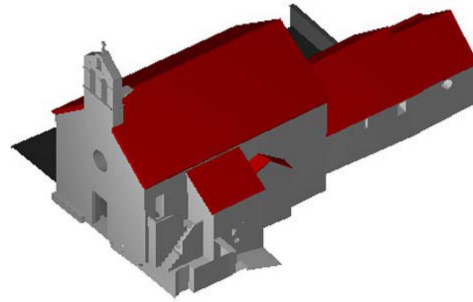


Figure 7 Rendered 3D model

Mostly because of the lack of the hardware resources and time, data that were acquired by laser scanning were just partly processed and used. In order to see if there are any discrepancies between two independent surveys of same object, an overlap of survey results was made. As it was expected there was no discrepancies between them, and results just fitted each other very well.

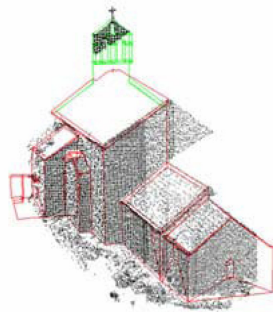


Figure 8 Result overlap of laser scan and total station measurements

After completing 3D model of the St. Nicolas church it was possible to create a corresponding technical documentation for church renewal. It was rather simple process of creating a desired cross sections (*Figure 9* and *Figure 10*) and views (*Figure 11* and *Figure 12*) of 3D model of the church.

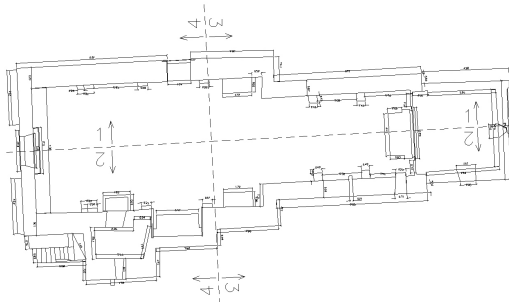


Figure 9 Ground plan with marked cross sections

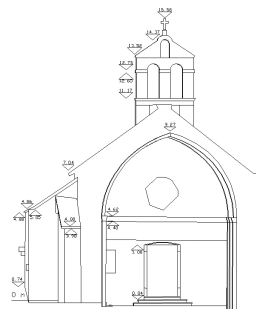


Figure 10 Cross section 4-4

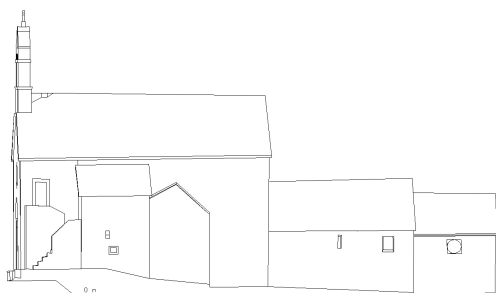


Figure 11 View of the church from south

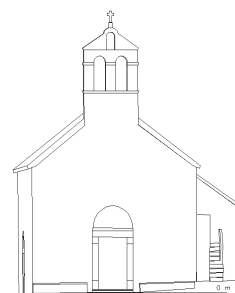


Figure 12 View of the church from west

The use of Virtual Reality Modelling Language (VRML) enable views of modelled object in a virtual world (Figure 13 and Figure 14). It is possible to create a dynamics 3D scenes through which user can take a virtual walk or see a 3D model from different angles and perspectives (Figure 15 and Figure 16). In order to do so, a photographs of St. Nicholas church that were taken during the field measurements were used to derive textures in 3D model. Photographs were edited in a raster image processing software and their perspective, rotation, size, etc. was corrected so that they can be used as a texture in 3D model of virtual reality. A 3D model was prepared in MicroStation and then exported to VRML World format with *wrl* extension.



Figure 13 3D model with textures SW view



Figure 14 3D model with textures SE view



Figure 15 Virtual reality - main altar



Figure 16 Virtual reality - inside of the church

Files created like this can be seen in web browsers online or offline by use of plugins such as Cortona VRML client, Cosmo Player, WorldView etc.

4 CONCLUSION

For purpose of designing a buildings as well as for their effective management, renewal or restoration or even for their possible registration into the 3D registers, which is expected in the near future, it is necessary to create appropriate three-dimensional spatial model of the buildings. The process of 3D model creation is called Building Information Modelling. Depending of purpose, BIM can be done from different sources. A 3D model can be created from idea or existing blueprints, but the most often case is that 3D model is made upon data of geodetic survey.

By use of adequate geodetic surveying methods it is possible to create a high accurate 3D model of a building that can be used for many different purposes. Once a 3D model is created, by relatively simple actions it is possible to derive any kind of spatial information, cross sections or views of the building. In this case cross sections and views were used for creating

technical documentation for renewal of the church. Upon survey data, it is also possible to create a high detailed, trustworthy virtual reality models. Regarding level of accuracy of derived 3D model, there is no barrier to use this model as a basis for creating Facility Management or Building Information Management systems.

Last but not least important fact is that a 3D modelling of a buildings, and their 3D survey, will find application in the establishment and maintenance of a 3D real estate registers, for example a 3D cadastre.

It is evident that there are plenty areas of possible application of geodetic surveying. Bearing that in mind, geodesy as a surveying profession that has the ability, skills and knowledge to produce high-quality spatial data, must take advantage of all the possibilities that are now offered and equally those that will bring near future, for the benefit of the profession and the wider community.

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