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3D Architectural Surveying of Diyarbakir Wall's Ulu Beden Tower with Terrestrial Laser Scanner

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Abstract

Turkey is one of the countries hosting many historical monuments. Many different cultures left rich traces of civilization in Anatolia. Keeping historical artifacts and documentation of these works is very important for the protection of this heritage. The technological progress changed the methods of surveying applications used nowadays. The changes in the methods of surveying applications reflected in the building survey applications too. The traditional surveying methods were replaced by digital photogrammetry and then by laser scanning methods. This work contains the building survey of the Ulu Beden tower which is a part of Diyarbakir walls. Diyarbakir is a province in southeastern Turkey and in the past, it was home for many civilizations. Hittites, Persia, Macedonian and Seleucid Greeks, Rome, Byzantium, Arabs, Seljuk Empire, Mongol Empire and Ottoman Empire are among these civilizations leaving the traces in Diyarbakir. Diyarbakir wall is the second longest wall after the Great Wall of China. Hundreds of years after the construction of the walls, it is necessary to protect and restore it due to the corruption and demolition over time. In total, 45 stations were built for an architectural survey with laser scanner and the gathered point cloud data were combined together within computer environment to obtain a 3D model of the structure.

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1. Introduction

Because the cultural assets has varied natural characteristics, different sizes and their complex structures, it is necessary to use advanced techniques and devices for detailed survey and documenting them. In past decade Terrestrial Laser Scanners (TLS) has become a standard instrument in terms of generate 3D data and models for studies of document cultural heritages and historic structures.

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This method allows obtaining millions of 3-dimensional points data in fast and reliable way so that make possible to generate efficient and dense surface geometries of cultural assets. Point cloud data provide base data for facade, plan and section drawings that require by measured drawing plans in addition to 3D model of structure. Measured drawing is a technique by surveying thoroughly; create plan and sections that allow rebuilding a damaged or ruined cultural object.

Development of techniques for documenting and monitoring cultural heritages are important in terms of architectural conservation practices, history of art and architecture, archeology and architectural researches. In the recent years advanced methods like photogrammetry and laser scanning has been used widely for documenting purpose, measured drawings can be obtained by this techniques which are indispensable part of architectural conservation projects. These methods also can be used for analytical documentation (construction features, degradations, changes, etc.).

In this study, 3D model of the Ulu Beden tower, which is part of Diyarbakir walls, is formed. By using this model, we obtained profiles, aspects and 3D models of the structure. The architectural survey of the structure has been obtained by plotting in AutoCAD with the data of 3D that was generated.

2. Study area

Diyarbakir Castle and Walls that is located on 100 meters far away from Dicle River Valley and that consists of inner and outer parts are the only sample showing architectural characteristics of about 30 civilizations that reigned over the city. It is shown that there are glyph patterns reflecting the period's artistic style in the castle and all the tablets of the history of Anatolia can be shown as a whole there.

Diyarbakir Castle and Walls are one of the most magnificent and the biggest monumental structures that is handcrafted and has the most important written records. There are 4 main entrance gates throughout the walls, called Dağ Kapı, Urfa Kapı, Mardin Kapı and Yeni Kapı. Black basalt walls are the important representatives of Medieval Military Architecture. The walls reach about 10-12 meters in height and 35 meters in width.



Figure 1. Location of Diyarbakir Walls.

Ulu Beden tower is located on the southwest of the walls surrounding the city. Also known as Evli Beden tower, it is stated in the tablets that the dungeon was built by Architect Caferoglu Ibrahim in the name of Artuklus Ruler Melik

Salih in 1208 upon his plan. The tower that is very similar to Yedi Kardeş Tower in the way of plan and decorations has a cylindrical plan.



Figure 2. Winged lion and double headed eagle glyphs.

The tower has a gorgeous view with double headed eagle, which means symbol of dominance, winged lion symbolizing greatpower, sfenks glyphs, the tablets surrounding the tower from top to bottom and mukarnas decorations. Two lions glyphs facing each other is seen on the two sides of the tower's belt where it gets thick in the middle part and these figures are in rectangular frames. Their heads are curvy; bottom parts are puffy and the details are invisible.

3. Laser scanning technology

After a decade of continuous development, TLS systems have reached a high level of automation allowing fast and accurate surveys in cultural heritage (Lerma et al., 2009). Terrestrial laser scanning technologies have a wide of application area, especially in the fields like engineering projects and recording cultural heritage. Because this technology allows photo-realistic navigation and presentation of cultural heritage objects, 3D models with better geometric accuracy, large amount of details and high-resolution textures, it can be used in many fields related to cultural heritage and archaeological areas for different purposes.



Figure 3. FARO Laser Scanner and TotalStation.

In studies of documentation the cultural heritages, laser scanners that are working with triangulation methods are preferred in the close range measurement of small objects and statuaries. On the other hand, long range laser

scanners that are working with the phase comparison method are preferred in studies of recording the historical structures, archaeological and big zones.

Documentation

When it is about documentation of a structure, primarily, it should to be detect geometrical data of this structure. Plans, profiles and views of the structure are drawn. These technical drawings give us information about the geometry of the structure. Acquiring these drawings related to the structure is called architectural surveying. It takes too long when this process is done with traditional methods. However, it finishes in a short time and all details of the structure are acquired when it is done with the laser scanning technique.

In this study FARO Focus 3d Terrestrial laser scanner was used. The laser scanning system which contains of laser scanning device and a tripod can survey more than 900.000 points per second with the ability of scanning on 3600 in horizontal and 3000 in vertical. Scanning distance can reach about 150 meters. Data acquired from the device was processed by registering 45 stations in SCENE which is FARO's own software and 3D model of the structure was created.



Figure 4. Colorized Point Cloud of Ulu Beden Tower.

Surveying Techniques

The work we have completed consists of fieldwork and office work. The fieldwork consists these stages; preparation for fieldwork, marking target points on surface of the wall, geo-referencing the control points for measurement by Total Station, determine coordinates of target points from these points and last stage is to scan the structure and its surrounding by laser scanner. The point cloud data that is acquired from the field were transferred to computer then processing and registering for using appropriate applications. Before scanning stage on land, scanning process has to be planned. In the planning stage, locations and numbers of the stations to be scanned have to determine. The number of locations of the stations to be scanned should be enough to include the whole structure and all details. In the planning of scan stage, it should be determine which coordinate systems make referencing while acquired point clouds are registering. This coordinate system can be a geodesic coordinate system or a scanner-center local coordinate system. Target points must be surveying in same coordinate system if the scanning reference system has chosen as geodesic coordinate system.

Architectural Drawings

There are a lot of plug-in for CAD softwares to processing and drawing of point clouds. Final products were obtained by scaled drawings of point cloud data in AutoCAD environment. These drawings has used for create sections and plans of Ulu Beden Tower. It is easier for architectures or drawing operator to obtain intended sections and plans to create architectural drawings of current restoration project that working on it.

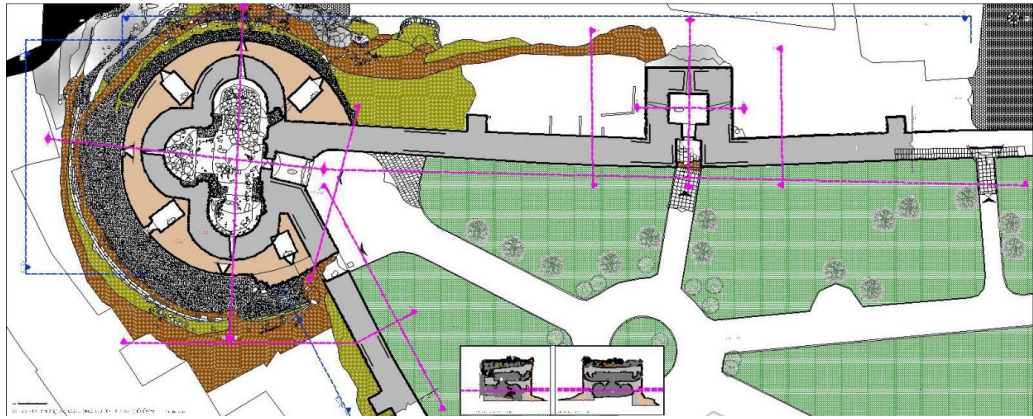


Figure 5. 2D plan of Ulu Beden and its environment from top view.

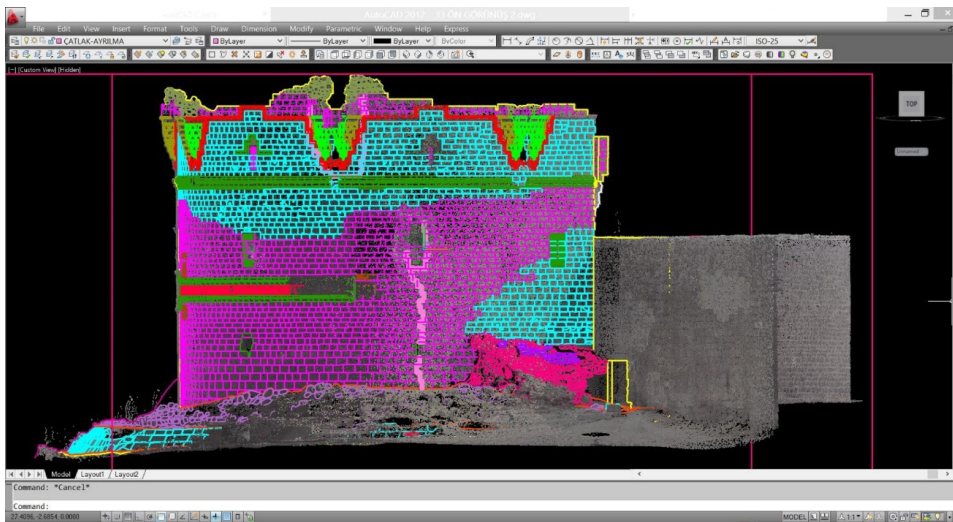


Figure 6. Overlapping Tower's façade with point cloud data.

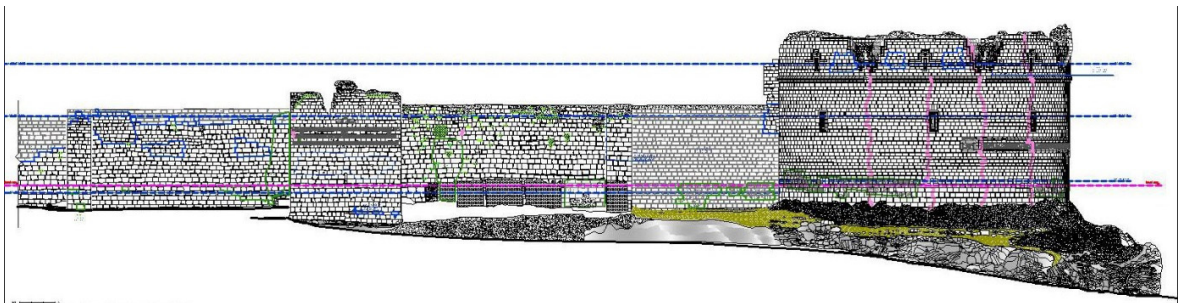


Figure 7. Drawings façade of Walls and Tower.

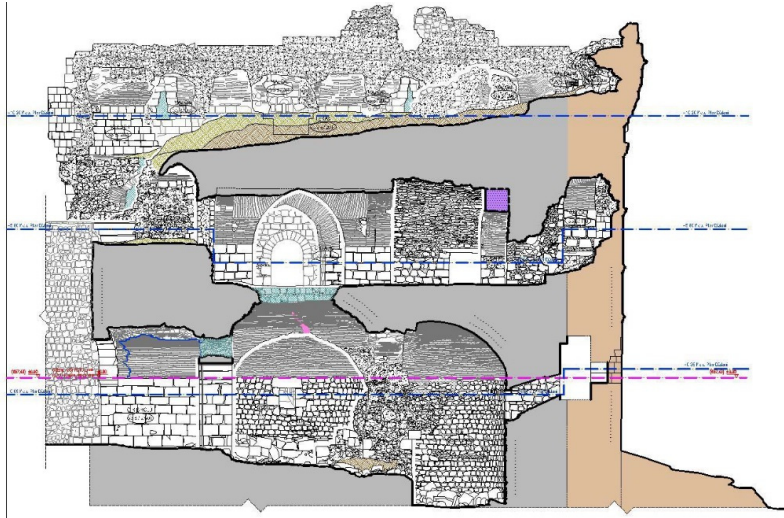


Figure 8. A section of Tower.

4. Conclusions

It is an important issue that protection of cultural and historical heritages for human history nowadays. For preservation and restoration of this structure, it is necessary to do documentation studies and creating a digital cultural heritage archive. The conveniences that providing by technology has reached the promised stage. After 3D model of structure has acquired by using this technology, it can acquire intended sections and facades of structure. Furthermore, it is indicate this technology will be an indispensable technique in terms of surveying accuracy, precision and capabilities of merging with different survey technologies in same coordinate system. Advanced technologies may not be single solution, in this situation deciding which method or methods can be use depending on conditions of working field or status of structure.

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