New Approach for Documenting Historic Buildings

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Abstract:

This paper discusses utilizing new 3D CAD system for documenting historical buildings. The 3D CAD modeling was used to generate three-dimensional drawings of the Main Justice Building Court yard. The courtyard, which covers approximately 4,500 square meters is situated over top of a parking garage in the Main Justice Building in Washington DC, and is comprised mainly of stonework.

The scopes of the renovation work includes salvaging the courtyard stone, demolishing and rebuilding the concrete structure of the car parking below the courtyard, and reinstall the salvaged stone back in its original location. Traditionally, the measuring tape is used to document the vertical planes, and conventional surveying equipments are used to document the horizontal planes. In this project, the courtyard stone pieces are inherited in the building structure and some of the stones have unique three-dimensional configurations that cannot be surveyed by conventional techniques.

ValcunÆ 3D CAD modeling was used to document the locations and the shapes of the stonework in the courtyard before removing the stone and demolishing the concrete structure. 3D CAD modeling has the ability to locate the required points in the three- dimensional space. 3D CAD modeling was used to generate 2D and 3D CAD drawings for the courtyard. These drawings were used to re-fabricate the dismantled stones, and to reinstall the salvaged stones in their original locations.

The field surveying of the courtyard was completed in 16 working hours. More than 3000 stone pieces were located in the three dimensional space to an accuracy range of 1/8" (Arch Second, 2000).

Key words: 3D-I Technology, Renovation, Surveying, Historic Buildings.

3D-I Technology:

The term three dimensional, or 3D, means that all objects can be described in terms of physical dimensions including location, size, and shape. Many engineering practices require locating and positioning objects in space; however, accurately determining a 3D location in space is very difficult. 3D-I technology uses laser beams and hand-held devices to instantly deliver and store data to Pocket PC for the creation of digital 3-D models of large objects or environments for design (Beliveau, 1996).

Similar in concept to surveying technology already used for mapping project sites and taking as-built readings, 3D-I uses precisely timed signals from two or more laser transmitters to establish the precise location of a handheld receiver. Unlike other instruments, the users don't need to level the instrument, and the 3D-I system updates the receiver position five times a second(Beliveau, 1996).

The 3D-I system is made up of two laser transmitters and a measurement tool. The two laser transmitters create a 3D measurement volume “a 3D-Intelligent environment” (Arch Second, 2000). The versatile measurement tool measures 3D points anywhere within this environment. This system provides a one person operation, indoor and outdoor operation, daytime and nighttime use, quick set up, and full CAD integration (figure 1).

Figure 1: VULCAN 3D-I system.

3D-I software can convert raw data into useful formats for specific applications. The 3D-I data collector is Windows CE based application. Data can be entered through a touch screen user interface. Users can collect, store, edit and view 3D measurements in real time including coordinates, distances, angles, areas, and volumes. This 3D-I surveying tool also allows for easy data transfer to and from a personal computer for use in CAD and Windows® based programs.

The 3D-I technology was chosen to document and create the as-built drawings for the stonework at the Main Justice Building courtyard for the following reasons:

A- Traditionally, the measuring tape is used to document the strait dimensions and the vertical planes, and conventional surveying tools are used to document the horizontal planes, angles, overall dimensions, levels, and radial dimensions. In order to take accurate measurements, these surveying tools require that the surveying stack to stay perpendicular to the measured surface. In the Main Justice Building case, many stone configurations in the courtyard have unique three-dimensional configurations, where taking field measurement while keeping the surveying stack vertical is impossible.

B- Conventional surveying tools require a clear eye of sight between the surveying machine and the surveying stack. Some of the stone pieces in the Main Justice Building courtyard have complex three-dimensional shapes, and the stone edges do not always have clear eye of sight to the surveying tools. The convention surveying tool cannot measure these stone pieces. However, the 3D-I system measuring bar can access these points.

C- The Main Justice Building courtyard contains more than 3000 stone pieces. In order to accurately document the locations of all stone pieces, four readings have to be taken for each stone piece. In conventional surveying techniques, these readings are taken by using both measuring tape and surveying tools.

In surveying the Main Justice Building courtyard, it was overcomplicated to co-ordinate this amount of electronic data from the surveying tools with the manual tape measurements. In the 3D-I system, manual tape measuring is not required.

Further more, in the tape measurements, each stone piece is measured separately, and any measurement discrepancy cannot be traced easily, while in the 3D-I technology, all readings are related to the same reference points, where the measurement discrepancy does not exist, and any human error can easily be traced(Frank,2000).

D- In the conventional surveying technology, at least two persons are needed to carry out the surveying task. At least one of them should be a surveying technician. In this particular project, documenting the stone requires architect participation in the field surveying in order to make the required sketches in the field, and to generate the final as built drawings. Most architects do not have the experience to run sophisticated surveying systems. However. The 3D-I technology produces Auto-CAD files, which are familiar to architects . The architect can also start generating the as-built drawing in the filed. In the 3D-I tool, the architect can assign layers, blocks, and files to the deferent building elements, and he/she can use them later to generate as built drawings.

Generating 2D Drawings.

The 3D-I system produces three dimensional space representation of the building. However, the required as-built drawings in this project are two-dimensional drawings.3D-I system also exhibit the measured dimensions in a form of three dimensional points, The users then have to connect these points to create the required drawings.

Further more, Auto-CAD treats the drafting and dimensioning in two-dimensional space and in three-dimensional space differently, thus the “plan view”, and “elevations views” in the three-dimensional space drawings will not supplement the required two-dimensional as-built drawings. In order to produce a two dimensional drawings out of the 3D-I three dimensional points representation, the following procedures were used:

First, Each 3D-I CAD file that is generated through field surveying was used to produce two sided elevations and a plan in 2D space. If more than one plan view is required, the building surfaces at different levels were assigned different “layers” while taking the measurement by the 3D-I system. Each of these layers then was treated separately as a new drawing.

Second, a Visual Basic macro was written through Auto-CAD 2000 to convert the point properties of the drawings which are produced by the 3D-I system. This Visual Basic macro can change the values of all Z coordinates of the collected points in the plan file to zero, all X coordinates values for all collected points of side elevation file to zero, and all Y coordinates values for all collected points of the side elevation file to zero.

Third, the collected points by field surveying are now represented in two-dimensional space. These points were connected by “line” command in Auto CAD to generate the two dimensional drawings. The dimensioning for these drawings was also created in a two-dimensional space.

Project Description:

The Main Justice Building is the United States Department of Justices headquarters, which is located in the Washington DC downtown. It was built in 1933. As with most new classical style building, the Main Justice Building facades are composed of highly decorated stonework.

The main offices in the building are surrounding a central courtyard, which tops a car garage. The scope of renovating the Main Justice Building includes salvaging the courtyard stone, which has historical value, demolish the concrete structure of the courtyard, apply new water proofing for the new concrete slab, and then reinstall the salvaged stones in their exact locations.

Since some of the stone pieces are dismantled, these stone pieces must be replaced with new stones.

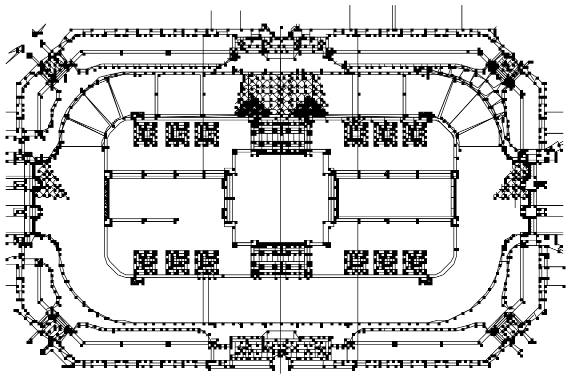

Figure 2: Plan of the Main Justice Building Courtyard.

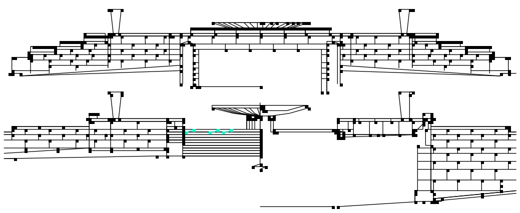

Figure3: Section and elevation of the Main Justice Building Courtyard.

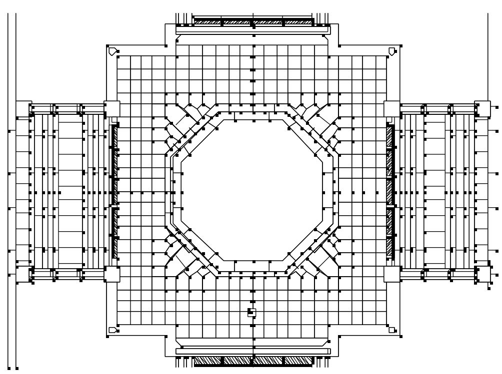

Figure4: Plan of the Main Justice Building Courtyard plaza.

Documenting procedures:

Since 3D-I technology was not used before to document historic buildings, new procedures were developed to accomplish the building documentation task. These procedures were summarized as follows:

First: A damage survey was carried out to document the courtyard stone condition. Each stone piece was inspected to report any damages, photographed, and given a number.

Second: 3D-I surveying system was used to prepare as built drawings for the existing courtyard. The courtyard was divided into 4 quarters; each is approximately 30 x 40 meters. At each quarter, a temporary benchmark was established and related to the benchmarks of the building. Using the 3D-I system, the architect who would eventually produce the as-built drawings did a one-man surveying task. Approximately 2000 readings were recorded for each quarter of the courtyard. Each quarter required approximately 3 hours to set up the system and to take field readings. The total time that was required to accomplish the 3D-I surveying for the entire courtyard was 16 working hours. The training period on how to use the tool, setup the computer software, and to run a demonstration lasted for 1_ hour.

Third: The AutoCAD files, which are generated by the 3D-I cad tool, were processed to generate conventional as built two-dimensional drawing. These drawings incorporated the stone numbers, the dimensions, and the damage survey. (Figure 2(,(Figure 3), (Figure 4).

Conclusion:

This paper examines utilizing the 3D-I technology to document historic buildings for renovation purposes. The results showed that the 3D-I technology proved to be fast, accurate, and more convenient for architects to carry out building documentations. New procedures were used to generate the two-dimensional drawings in order to document this historical building. The time used to carry out the surveying and to produce the as-built drawings in this project was a fraction of what it could take if the conventional surveying systems were used.

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