

## Report of three-dimensional laser scanning of the triple church complex in Jerash

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### ABSTRACT

The structural analyses of heritage structures are quite important because of not only to understand the structural systems but also to restore the heritage structures. Prior to the structural analysis, it is necessary to measure the current status. In this paper, the results of the three-dimensional laser scanning of the triple church complex in Jerash are presented. The data shows: 1) the inclination of the ground (east to west: max. 35 cm / 15 m lower; north to south: max. 65 cm / 40 m lower), 2) the inclination of the columns in the nave of St. John the Baptist (toward west-southwest, especially the north-west one: approx. 4°), and 3) the position of four columns in the nave of St. John doesn't make a square (the northeast one is approx. 60cm to south, and the southeast one is approx. 40 cm to north). Therefore, it can be supposed the lost upper structure was originally unstable and weak.

### 1. INTRODUCTION

The Triple Church Complex (Sts. Cosmas and Damian, St. John the Baptist, St. George), built between 529 and 533, is one of the most important remains of Early Byzantine Jerash. The complex was excavated and documented by J. W. Crowfoot and C. S. Fisher, which is still the basis of every survey on Christian architecture in Jerash (Kraeling ed. 1938; Crowfoot 1931). The Church of St. John the Baptist has a central-plan, with the circle-shaped nave and four round spaces at diagonal axes, and the horse-shoe shaped apse at east. There are four columns with Corinthian capital, put at quadrangle position in center of the nave, which should support the upper structure. East two columns were fallen down and re-set up, but other two are still remaining as original condition. The similarity of this church with the bigger Cathedral of Bosra has repeatedly been pointed out. Two lateral churches, Sts. Cosmas and Damian at the north side and St. George at the south side, are similar basilicas, rectangle shaped nave with two aisles, and the semicircular apse at the east end. The upper structure and the upper part of the walls of each church were already disappeared, and the original form

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of the upper structure is still unknown. Crowfoot supposed that there might have been a timber lantern covering the circular nave of St. John (Crowfoot 1931: 22). He also supposed that the inclination (to west and south) of the ground and the weakness of its foundation caused a destruction of the church of St. George (Kraeling ed. 1938: 245).

Our survey aims at making a new documentation as the basis of formal analysis of the complex, and at considering about the stability of the structure. For restoration and conservation of this historical monument, it is significant to analyze the structural characteristics. Prior to the structural analysis, it is necessary to know the current status of the monument. In this survey, the form of the monument and the characteristics of its ground surface were measured and analyzed. Method applied is the 3D laser scanning on the ground level. This paper reports the result of the survey.

## 2. SURVEY

Three churches, with common continuous atrium to the west, are located side by side composing a unique architectural complex. The walls are severely damaged, and most upper part of the wall between Sts. Cosmas and Damian and St. John the Baptist were reconstructed in 1960'. Of these three, the central church has a rare circular plan with four round arms inscribed in a square and one projecting apse to the east. 3D laser-scanning is effective method to document the complicated form of the architectural composition with many curved surfaces, and archaeological objects scattered in and around the structure. The survey of 2011 was done from 8<sup>th</sup> to 17<sup>th</sup> July, applying "VZ400" of Riegl GmbH (Scan-range: 1.5~600 m, minimum resolution: c.8 mm).

The research area is about 35 m x 60 m, and the ground is gradually getting higher from south to north, so the floor level of the churches is about 4 m below ground at the northern edge. More than 20 tie points were marked by cylinder type reflector (5 cm high). The angular step width of laser oscillation of the scanner was set at 0.03 degree both horizontal and vertical directions, with the measurement step width to be c. 0.6 mm per 10 m. Scanning positions were 57 and the number of measurement points was more than one billion.

## 3. RESULTS OF THE SURVEY

### 3.1 Situation of the slope of the floor

As already written, Crowfoot pointed out the sloping of ground of St. George to the south and west (Kraeling ed. 1938: 245). According to our survey, at St George, the floor was approx. 20 cm lower near the west entrance relative to in front of the chancel. In addition, the ground was also inclined to west at other two churches, St. John the Baptist and Sts. Cosmas and Damian, the both floor was approx. 35 cm lower near the west entrance relative to in front of the chancel. The distance between the chancel and the entrance was about 15 m, so the degree of inclination is approx. 13.3 / 1000 to 23.3 / 1000 (0.76° to 1.34°) (Fig. 1). The inclination to the south is comparatively slighter, the differences of the floor level in front of the chancel between St. George and Sts. Cosmas and Damian is about 65 cm in 40 m, the degree is approx. 16.3 / 1000 (0.93°). The



Fig. 1 Inclination of the ground towards the west (wall between Sts. Cosmas and St. John the Baptist)

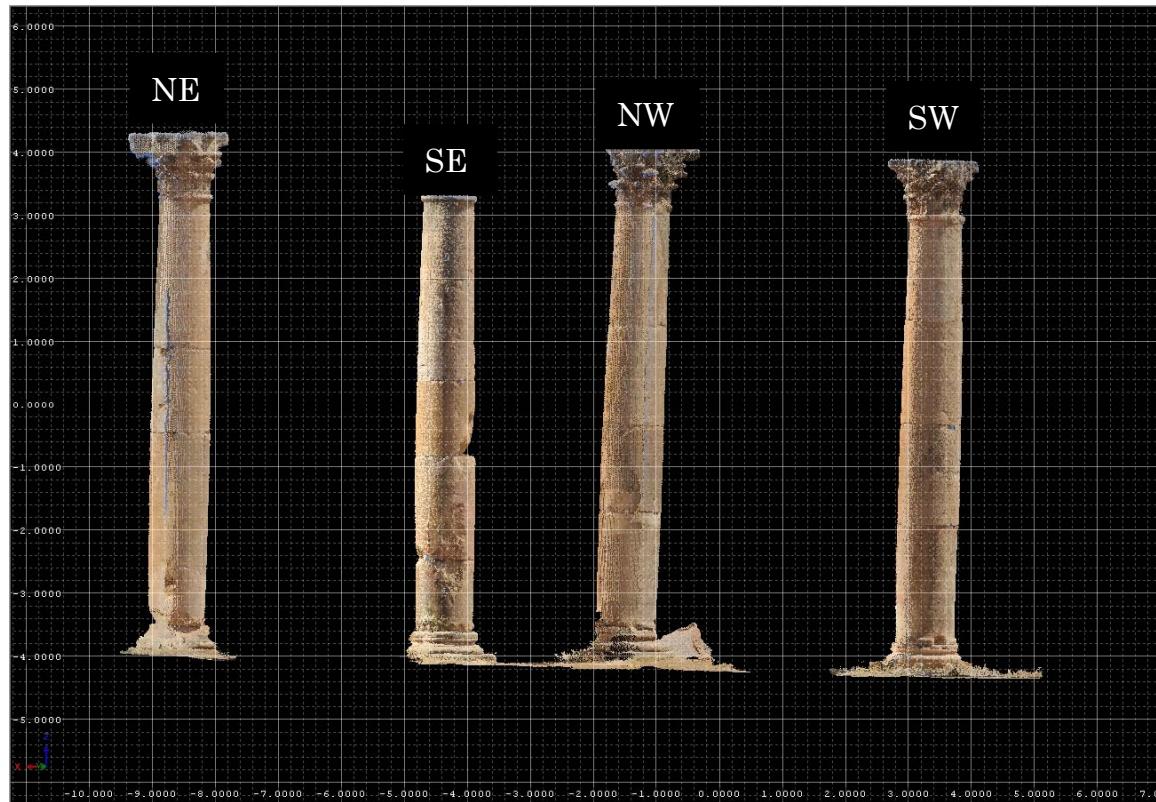


Fig. 2 Diagram of four columns of the nave of St. John

inclination of the ground as a whole towards the west-southwest is quite large, and seems to be enough to produce some serious structural problem.

### 3.2 Inclination of the columns of St. John the Baptist

Of four columns standing in the nave of St. John the Baptist, the two western columns survived through the long history, the other two in front of the apse were reconstructed after the survey of Fisher and Crowfoot (Kraeling ed. 1938: 241). Our data revealed that two western columns inclined toward the west-southwest, and the degree is largest (almost 4 degree) at the northwest column, with height of about 8 m and approx. 85 cm in diameter at the bottom of the shaft. The inclination diagram of these four columns is given as below (Fig. 2). The direction of the inclination is coincident with that of the slope of the ground of the churches. It is supposed that inclination of these columns was caused by that of the ground in many years, and that they may be at risk of advancing their inclination and of falling down.

### 3.3 Position of the columns of St. John the Baptist church

In the plan made in 1930's, the positions of four columns of St John the Baptist church are on the corner of a square shape forming the central part of the nave. In this old drawing, the distance between the columns is approx. 8.6 m from center to center (Fig. 3). The result of our survey, however, shows that the positions of two eastern columns in front of the apse are different from those given in the plan of 1930's (Fig. 4). Actually, the present position of the northeast column deviates about 60 cm to the south from the corner of the square given in Fisher's plan. A similar deviation from the ideal square is confirmed on the southeast column, where the difference is about 40 cm to the north. Although the dating of these two columns should be considered cautiously, the fact that the base of the northeast column and the lower part of the southeast column

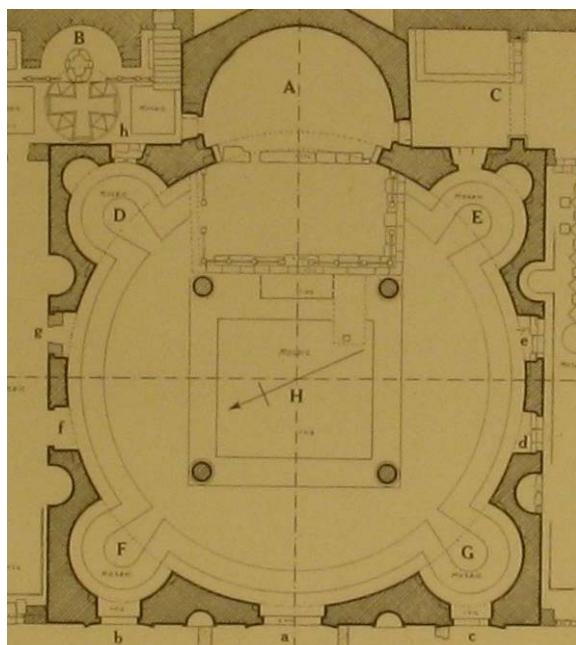


Fig. 3 Plan made by Fisher in 1930'  
(Kraeling ed. 1938)

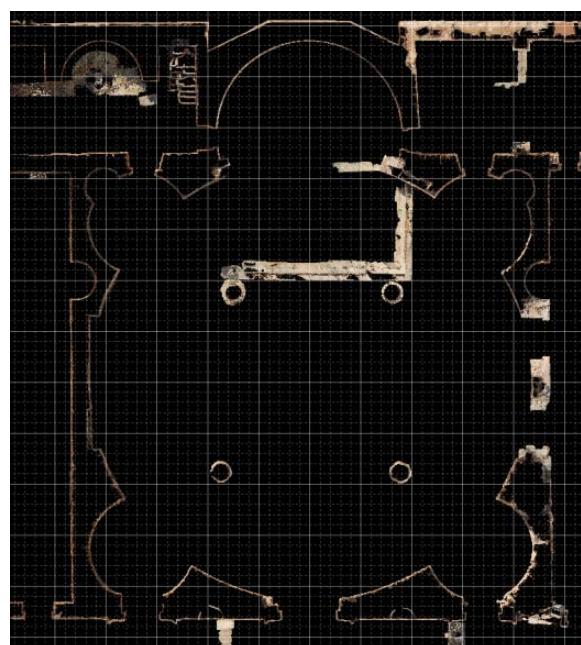


Fig. 4 Plan made by our survey

are clearly seen in the photo taken after the excavation in the 1930's may prove that their positions should be original, and the modern reset of the shaft was done keeping the original position of the bases. Thus, these four columns should have been originally put at slightly deformed trapezoid shape, with a longer side composed by two western columns which have been standing.

#### 4. CONCLUSIONS

3D Laser Scanning is an effective method of recording this site with so many scattered stone blocks around it, and the results of the scanning revealed the inclination of the ground and the columns, and the irregular position of the columns in the central space of St. John the Baptist church. Inclination of the ground will possibly influence on the structural stability of the present monument, and the two western columns of the church of St. John actually seem to be affected. For the future structural analysis and conservation, it is important to take into account of them.

In addition, it is interesting that the church of St. John the Baptist originally had a trapezoidal lay out of the columns in the center of its nave. As written above, Crowfoot supposed that there could be a wooden lantern structure on the nave of St. John. If the supporting columns were put not at square like but at irregular disposition, it should have caused some weakness and instability of the upper structure. When the church of St. John was excavated, the central area of the mosaic floor of the nave was seriously damaged, but at the other parts around the nave except two western exedras, the floor was sufficiently kept, even at the southeast exedra was found a few figure mosaics. These situation means that there happened the collapse of the upper structure before the first iconoclasm by the Emperor Leo III started between 726 to 730, and Crowfoot suggested that the collapsed was before the earthquake of 717 (Kraeling ed. 1938: 247-249). But, Byzantine historians documented several earthquakes in this region in 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> century, and considering the trapezoid position of the columns which our survey revealed, the collapse could have happened at even earlier date after its construction.

#### REFERENCES

- Kraeling, C.H. ed. (1938), *Gerasa. City of the Decapolis*, American Schools of Oriental Research, pp.241-249.  
Crowfoot, J.W. (1931), "A Preliminary Report of the Joint Yale-British School Expeditions to Jerash, 1928-1930", *British School of Archaeology in Jerusalem, Supplementary Papers 3*, 20-27.