International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-9 Issue-3 September 2020

Al-Hadba Minaret in the Last 100 Years

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Abstract: Al-Hadba minaret is located in a central location on the right side of the river Tigris within the city of Mosul North of Iraq. It is one of the important heritage landmarks in Iraq, Mostly characterized by its curvature and height. It was built before more than 800 years. Later, It was destroyed due to military actions in the summer of 2017. Recently plans for reconstruction are going on. Accordingly, many different data has to be collected and organized to help form a model closer to the original shape. Prior to its destruction, careful surveying was performed to record the shape and movement of the minaret. This research provides a description of the results of this work. For a century, the minaret leaning has been slowly growing closer to the danger point. Modern construction techniques can be used to rebuild a more stable structure and avoid that movement.

Keywords: AlHadba minaret, Mosul heritage, leaning, deformation surveying.

I. INTRODUCTION

The Al-Hadba minaret in Mosul is believed as one of the most important historical and Islamic monuments in Iraq built by Noureddin Zanki around 1172 AD [1]. It is located in the old Mosul on the right side of the Tigris River fig. 1. The minaret remained steadfast all these years until the summer of 2017, when it was destroyed by fighting that also destroyed part of Mosul's oldest heritage area nearby the minaret.

Fig. 1. Al-Hadba as before and after 2017.[1].

Since the 1960's, there has been growing concern with regard to its safety as an important heritage site, as well as the safety of lives in the housing area near the mosque. Accordingly, some of the engineering observations and monitoring work began.

Revised Manuscript Received on August 19, 2020.
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Unfortunately, for the past hundreds of years, no clear or proven records have been available that can be relied upon as a basis for its leaning or shape comparison. There was no clear information about the serious tilt appeared in the body of the minaret and there was intermittent work related to some repairs to different parts of the minaret. It has been noted that this monument was under the influence of several factors causing damage and deformation, the most prominent of which is the type of soil beneath it [2,3]. Al-Shaikh [4] suggested that the prevailing wind effect was a cause of apparent creep, as well as the effects of pollution from water and air (Fig.2). Moreover, the minaret was not given adequate care for long periods. In this regard, the most important modern maintenance work was carried out by the Italian company y Fondedile S.p.A. in the early 1980s [5]. In which the body and foundations of the minaret were strengthened by the planting of special pilings. In recent years, however, it has been noted that some of these supports have lost their effect. The recorded information on the monitoring of the state of leaning dates back to 1964, when the curvature was recorded along the body of the minaret [6,7]. We have noted from these reports that it is difficult to compare the status of the minaret on successive dates unless referred to the same frame of measurements. In Mosul, a team has been formed composed of different departments to follow up on this situation. The author has personally supervised the monitoring work since 2010 and continuously used the most accurate device available from the total station instrument. During years of observation, much important data was recorded. [7] Now, after the destruction, there are efforts on many sides to rebuild the old City of Mosul, including the minaret, which needs to restore its true form to the utmost accuracy. The researcher presents in these lines what has been achieved in this field between 2010 and 2015. Most of the measurements were made using the total station device to measure previously inaccessible parts of the minaret body.

Fig. 2. Cracks appearing near the base of the minaret.

II. THE WORKING METHODOLOGY

For continuous maintenance, it is essential to monitor the shape and dimensions of archaeological buildings. There are many monitoring methods that vary according to cost, experience and accuracy of the results, including photography, surveying, GPS and laser measurements. One of the most accurate ways to carry out such work is by using the laser measurements included in the total station device, which is based on the principle of measuring distances accurately towards distant bodies through laser measurements and recording hundreds of data points in the memory of the device for later engineering analysis. All minaret points are less than 100 meters away from any observation point location. Accordingly, the TOPCON IS03 total station device was used in (NP) non-prism mode. It measures distances with accuracy of ±(3mm)m.s.e.

III. ESTABLISHING THE NETWORK OF MONITORING POINTS

The installation of the device on fixed points (control) is essential for accurate referencing. These points are in the form of a triangular network distributed throughout the surrounding area. The following parameters have been taken into consideration when selecting point locations.

1. Point locations are far from the minaret to avoid nearby pedestrians and machinery during future works and far from the stress in soil beneath the minaret.
2. The nearby Mosul's old houses are weak and not rigid enough to install reference control points on the roofs.
3. The soil of old Mosul contains a lot of gypsum and debris buildings as well as a lot of cavities.

These factors were taken into account and the author selects a surveying set of points as shown in Fig. 3.

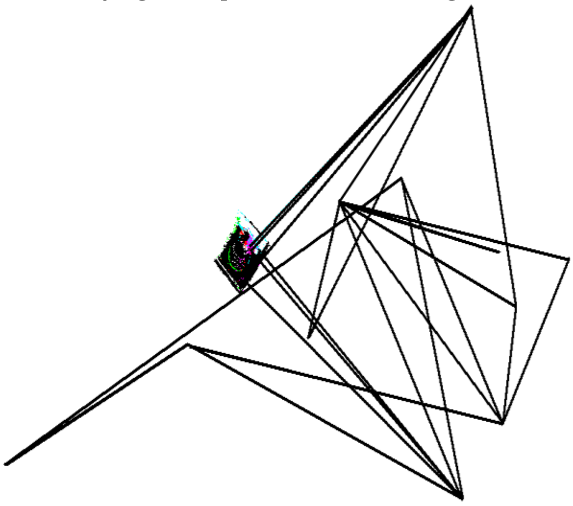

Fig. 3. A selection of the control point network around the minaret.

This selection was not ideal for the optimum distribution and number of control points. However, it was the most appropriate to start working. A main control point was selected in the garden yard where a steel marker was fixed. Some of the remaining points were installed above the roof of the mosque. Others were fixed in the courtyard. Many points were destroyed later by the explosions. Local coordinates have been used for all surveys.

IV. INSTALLATION OF OBSERVATION POINTS ON THE BODY OF THE MINARET

With the exception of the ground points on which the measurement device have to be set as explained previously, other type of points have been prepared and fixed on the outer body of the minaret to be monitored. Stainless steel bolts with a diameter of about 2 cm were prepared with a central defined mark. The bolts were drilled on the outer surface. It was necessary to hire workers who had been trained especially for this work. Each bolt is installed on the body of the minaret using the adhesive epoxy. All points are placed so that they are visible from more than one location and in the curved side of the minaret to ease later monitoring and interpretation.

V. RESULTS OF MEASUREMENTS

Using the total station device, more than 10,000 points were measured from several sides to form a digital model of the minaret's body. This “cloud of points” composes the exact shape of the outer body of the minaret Fig. 4. Preliminary results indicated that the base of the minaret was also exposed to tilt, although it was not clear to the bare eye as this tilt was found to be about 2 degrees towards the eastern face of the base.

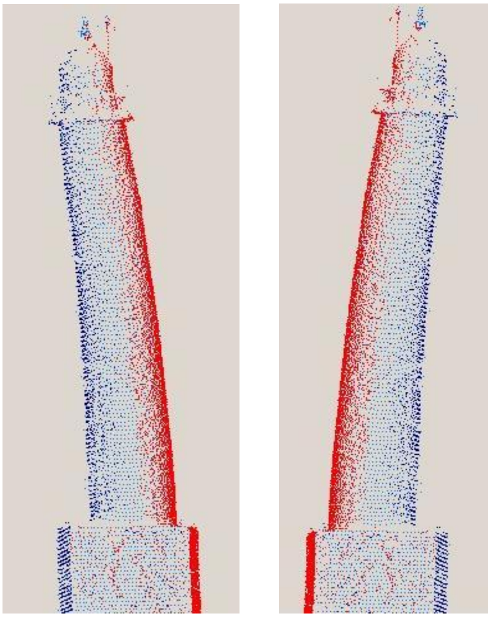

Fig. 4. Front and back views, results from the collected point cloud.

Continuous monitoring in summer and winter showed that the minaret was swinging in leaning clearly between the seasons of hot and cold seasons. This was possibly due to thermal expansion properties of the components of the minaret as well as the effect of humidity and rain.

The researcher also noted that the leaning fluctuates between the morning and afternoon during a hot summer day. This leaning movement reaches several millimeters. However, this movement does not represent the long-term tilt that is recorded through the monitoring program. (Fig. 5)

Retrieval Number: 100.1/ijrte.B4163079220
DOI:10.35940/ijrte.B4163.099320
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication

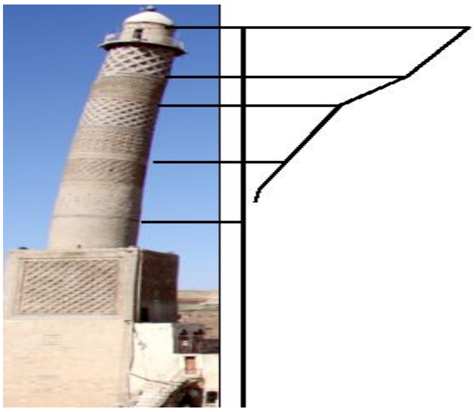

Fig. 5. leaning oscillations of the minaret occurs even within a single day.

VI. CONCLUSION

In this research, the design and implementation of an integrated system of continuous monitoring of the minaret leaning was discussed by installing observation points. It was observed that during the monitoring period there was a seasonal swing movement of the minaret between periods of hot and cold weathers. The coordinates of more than 10000 points have been registered. These points are the only accurate and available documents of the shape prior to destruction. The collapse of the minaret has called for rebuilding works, which will use much of the data obtained by this work to restore its original form. The researcher recommends that extra measurements should be made even on the remaining part of the minaret base, where it will contribute to clarify the shape of the minaret and the conditions at the early stages of its construction.

ACKNOWLEDGMENT

The author wishes to thank Mr. Ghassan Najim who gave valuable help during the course of measurements.

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Rasheed Saleem Abed was born in Mosul -Iraq in 1959. He completed his B.Sc. degree on civil engineering in Mosul., PhD degree in civil engineering (photogrammetry) from Anna University, Chennai, India in 2003. He is currently teaching surveying at the department of civil engineering and doing research work at the remote sensing center, University of Mosul.