Conservation and strengthening of an early Ottoman tomb against the risk of earthquakes

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Abstract

The main goal of this presentation is to create an interdiscipliner atmosphere for the examination of the solution for the conservation and strengthening of an early Ottoman tomb which has structural problems due to the previous several earthquakes.

The tomb was built in Edirne for a poet and a soldier, Ahmet Ridvan, who was the Head of the Financial Department of the Ottoman Empire, with stone and brick masonry, in 1484. In the last earthquake of June 1978 the damages created in previous earthquakes were dangerously intensified. And the brick dome fell down dangerously.

Edirne, where this tomb is located and which was the second Ottoman capital, is situated on a seismic zone of Turkey. During the last four hundred years, approximately five considerable earthquakes which caused great damages, effected the historic buildings in this area. The next hazardous earthquakes are being expected by 2000s.

With this paper, the conservation problems of the masonry structure of the Tomb of Ahmet Ridvan which have dangerous structural cracks will be examined and a prevention project for the structural repair and strengthening will be developed.

1 Introduction

The tomb owner who survived for a while in 1483-1485 as a Head of the Financial Department of the Ottoman Empire, in the period of Sultan Second Bayazid, was the poet and soldier Ahmet Ridvan. In spite of the date of his death (1519), written on epitaph on a tombstone on the facade of the building
The date of construction of the tomb is supposed to be done in 1484, with classical Ottoman style by the reflection of the characteristics of pre-Anatolia Turkish tomb architecture. By him, a village in Dimetoka (today it is in Greece) had been dedicated for the financial support for the management of maintenance and treatment of this building. In the official documents of this waqf, the way of maintenance for the repairing of the tomb had been made clear. Ottoman waqf system which was, fundamentally pertaining to the Islamic religion, an official financial supporting system, had been working for a long time and today at least three previous restoration marks which were realised by waqf incomes, can be determined through the cracks.

2 Geometry and pathology of the structure

This regular polygonal building consists of twelve prismatic surfaces that all sides are equal to 3.40m.-4.5 Ottoman zira (1 zira = 0.75m.) and the thickness of the walls are 1.05m. (see Fig.1). The inner diameter of cylindrical trunk is 10.70m.-14 Ottoman zira on the direction of entrance-altar (mihrap). The fabric of masonry structure consists of three lines horizontal brick and one line horizontal stone that is in the combination with one vertical brick (see Fig.3). Inside, the masonry structure are timber-framed by two layer, inner horizontal wooden beams for the strengthening of the cylindrical trunk (see Fig.2). In the middle of the room there is a collapsed mausoleum belong to the family and Ahmet Ridvan (see Fig.1-2).

The dome of the tomb fell down, during the earthquake in 1978. Today investigation of several marks and structural cracks show that approximately five times previous restoration works had been realised with two times belted iron beams and brick filling in support of lime mortar. All these structural cracks are just visible through the destruction of three times plaster layers which each has different wall painting decoration layers.

3 Categories of structural cracks

In literature, structural cracking falls into two categories (see Table 1);

"The first categories is one where cracking has no effect on the structure, or least only aesthetic affect. This category is often classified in four classes(0.10-2.00 mm.) which are very often caused by initial shrinkage in new materials or by thermal expansion and contraction movements over a long period.

The second category is also divided into four classes. The use and serviceability of the building will be affected in the first three classes and in the fourth there is an increasing risk of the structure becoming dangerous.

The classes in the second category commence at 2.00-5.00 mm; at the upper limit doors and windows may stick, draughts and moisture may penetrate trough walls, and arches may crack and loosen.

The next class is 5.00-15.00mm. Cracks in this class are associated with serious structural damage. Doors and windows may be jammed, walls cracked
right through, and severe shear patterns may develop with, for example, diagonal cracking in ceilings, falling plaster, and collapsing arches. At the upper limits tile work and other slab finishes may fall off the building and plumbing and service pipes may be broken. This class is clearly associated with structural movement patterns which can usually be traced to settlement of posts, columns, footings, plates, and sleeper walls; or to the bending of beams or trusses.

The next class is 15.00-25.00 mm. Cracks in this class are extremely serious and easily discerned. Usually with clear patterns of movement end often the cracks are grouped. In older buildings arches sections of masonry wall, and thin structural features such as of masonry wall, and thin structural features such as chimney stacks and pinnacles may collapse or show signs of movement and impending failure...Cracking in this class may also be caused by sudden changes or the removal of supports....

Cracking in the last class which are greater than 25.00 mm. can be external evidence of a dangerous structure....”(e.g. Weaver [1]).

<table>
<thead>
<tr>
<th>Class of Crack</th>
<th>(A) Crack Size in mm.</th>
<th>(B) Physical Maximum Width in mm. (Full Scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P 0</td>
<td>Less than 0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>P 1</td>
<td>0.1 to 0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>P 2</td>
<td>0.3 to 1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>P 3</td>
<td>1.0 to 2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>P 4</td>
<td>2.0 to 5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>P 5</td>
<td>5.0 to 15.0</td>
<td>15.0</td>
</tr>
<tr>
<td>P 6</td>
<td>15.0 to 25.0</td>
<td>25.0</td>
</tr>
<tr>
<td>P 7</td>
<td>Greater than 25.0</td>
<td></td>
</tr>
</tbody>
</table>

A) Crack size is to be assessed in direction of movement.
B) Crack width is shortest distance between edges.

\[A = \text{Crack Size} \quad B = \text{Crack Width} \quad A = B \text{ When there is no displacement along the line of the crack; that is, there is tensile failure but no shear movement.}\]

Table 1. Pynford classification of visible damage to walls(Weaver [1]).

In the course of time, all these different kinds of cracks (even greater than 80.00 mm.) patterns have been observed on the Tomb of Ahmet Ridvan which might be due to previous earthquakes (at least five times) with the combination of different causes such as alteration, fire (in 1957), etc.
4 Restoration decisions

The collapse of a badly damaged structure happens generally very rapidly, but it may be avoided if the damage symptoms as cracks, deformation, etc. are carefully taken into account as early as possible. To this purpose the following procedures are suggested for the Tomb of Ahmet Ridvan for the structural control, stabilisation, strengthening, repair and consolidation.

4.1 Excavation

Excavation for the investigation of structural behaviours of the wall which are partly covered by the soil and cleaning of the old cemetery which is under the ground and examination of the foundation for the improvement should be done from the beginning.

4.2 The study of the structural condition of the building

Of course direct experimental investigations with non-destructive evaluation such as determination of wall morphology by video-endoscopy, using laser photography (e.g. Asmus & Marshack[3]), termography (e.g. Baratono & Cardellini & Diana[4]), borescopy (e.g. Korres & Fytos & Gregorades[5]), endoscopic and ultrasonic investigations and digital photogrammetry for the documentation etc., could provide a satisfying diagnosis but such very costly surveys can not always be afforded in developing countries like Turkey.

4.3 Monitoring

To have deeper understanding of the structure and its dynamic behaviour, monitoring of structural movement is extremely important.

5 A suggestion for the structural repair, consolidation and strengthening for the tomb of Ahmet Ridvan

Not only authenticity of the building but also using the new techniques, equipment and chemicals has an important role in the strengthening, repair and restoration of the historic buildings. In this capacity, after the preparation of the restitution project for the Tomb of Ahmet Ridvan, a preservation project is suggested without using any reconstruction of the missing part of the original structure such as dome, glass windows, wooden door, etc. (see Fig. 4).

Consolidation and preservation of the Ahmet Ridvan Tomb’s material and structural values of ancient masonry, should be previously suggested with the new reversible restoration material in capping and filling (see Fig. 4).

Steel lamas (12x10/10/2), beams and three times steel ropes (Ø2cm.) elements are suggested in this study for the strengthening of the mean cylindrical trunk and to create an earthquake resistance structure (see Fig. 4).
6 Conclusion

Conservation project for strengthening and consolidation of historic buildings has not been thought as a simple restoration project. As all historical buildings, the tomb of Ahmet Ridvan should also be considered as a world heritage and the latest technologies and interdicipliner approaches should be implemented for the strengthening and conservation.

I hope our effort to create an interdicipliner platform for the protection of the tomb of Ahmet Ridvan, will help and support the formation of the conservation project which aims at strengthening this valuable masterpiece against the risk of earthquake.

References


Figure 1: Plan (hand recording - May 1997)
Figure 2: Vertical section (hand recording – June 1997)
Figure 3: Facade (hand recording – June 1997)
Figure 4: Project for the strengthening of the Tomb of Ahmet Ridvan
Photo 1: The dome of the tomb before the last earthquake (1976).

Photo 2: Structural cracks on the façade (May 1997).