

Strengthening and Restoration of Historical Structures— Mirahor Ilyas Beg Mosque in Korça*

Enea Mustafaraj

Epoka University, Tirana, Albania

Yavuz Yardım

Epoka University, Tirana, Albania

The Mirahor Ilyas Beg Mosque, built in 1496 in Korça, is one of a few Ottoman mosques still existing in Albania and the only Ottoman monument in the city. The mosque was built using cut stone and brick. It has a strong image; a cubic mass rising over a square plan. Inside there are found pictures of the mosque in the past and different famous mosques. During its existence, it was damaged from many earthquakes occurring at this area. Due to amortization, the mosque's structural properties were weakened and architectural values were dimmed. Proper strengthening methods need to be applied, not only to improve structural conditions, but also to preserve architectural features of the mosque. In this paper assessment of existing conditions of the structure is carried out. Based on the obtained results, solutions for the structural problems are investigated. As for restoration, the repair methods to be applied were examined taking into consideration at what extent the historical values of the building will be preserved. The proposed strengthening methods are the ones which would affect the least the mosque's historical values.

Keywords: heritage, masonry buildings, structural assessment, mosque retrofit, restoration

Introduction

History

The Mirahor Ilyas Beg Mosque, built in 1496 in Korça, is one of a few Ottoman mosques still existing in Albania and the only Ottoman monument in the city of Korça (see Figure 1), it is located near the city center.

This mosque has a significant importance for the city of Korça as it is strongly associated with the development of the city as an urban center. The mosque holds the name of its founder, Mirahor Ilyas Beg.

Architectural Features

The mosque of Mirahor Ilyas Beg has a strong image; a cubic mass rising over a square plan. It consists of two parts: the prayer hall having a square schemed plan of 11.75 m long and the last prayer hall having a rectangular schemed plan with three piers (see Figure 2).

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Enea Mustafaraj, MSc, Department of Civil Engineering, Epoka University.

Yavuz Yardım, Ph. D., associate professor, Department of Civil Engineering, Epoka University.

The transition from the cubic mass to the dome in this building is done by using pendentives which are divided into 10 melon ribs. The triangular shoulders are covered by leaden plates and they prepare the octagonal drum for the dome. The main dome raises 14.6 meters above the ground. It has a semicircular shape and is covered with a leaden layer. The main dome and three semi domes which cover the last prayer hall constitute the main roofing system of the mosque.



Figure 1. Mirahor Ilyas Beg Mosque in Korça.

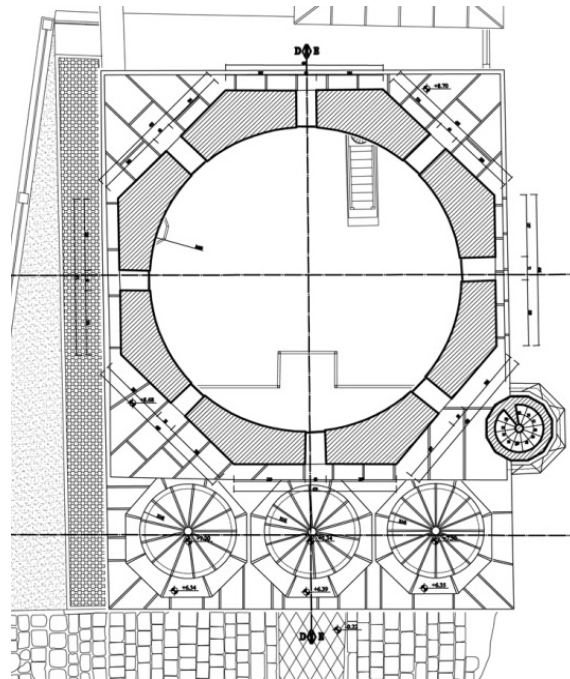


Figure 2. Plan view of the mosque.

Neatly cut stone and bricks are used for building of the mosque. Every stone is surrounded by two layers of horizontal and vertical bricks. The pendentives and the dome are constructed with bricks. Pointed Ottoman arches made of bricks span the distance between the columns.

The interior of the mosque is painted in white. There are paintings of famous mosques. There is a big lantern hanged at the dome. The pendentives are adorned with stalactite decorations (see Figure 3).



Figure 3. Interior of the mosque.

Existing Damage/Problems

During its existence, Mirahor Ilyas Beg mosque was damaged from many earthquakes occurring at this area. The most severe earthquake recorded in this region was the one of 1960, which almost destroyed the entire minaret. Due to amortization, the mosque's structural properties were weakened and architectural values were dimmed. In order to point out the structural problems, vulnerability assessment of the mosque was carried out. The methodology used for this assessment was based on visible "symptoms" that loads and stresses have caused throughout the structure. Degrees of the distresses severity were stated based on possible causes, location and extent of the cracks.

The aim was to improve the existing capacity of the structure not only for static, but also possible earthquake loads. Soil condition and environmental effects were also taken into account in order to have a realistic solution. Based on careful inspection of every single element, it was decided that immediate action needed to be taken in order to improve performance under existing load conditions. Moreover, Korça is found in a highly earthquake active region (Aliaj, Adams et al., 2004). Some of the structural problems are listed below.

Dome and Pendentives

Dome structural conditions seem adequate to carry static load. However, structural cracks are seen throughout it. Improper connection of the lanterns hanged at the top of the ceiling after the dome was built, has caused extra distresses at the very top causing cracks around it. Other structural cracks may have been caused by earthquake loads. Improper isolation system of the roof has caused moisture problems and spall of plaster (see Figure 4).

The pendentives and arches suffer from the same problems. Thrust coming from these loads has exceeded

the pendentive load carrying capacity. Propagation of these cracks is seen until the bottom of the load bearing walls. Due to inadequate isolation, spall of plaster is seen too.



Figure 4. Cracks on the dome and spall of plaster.

Load Bearing Walls

In the load bearing walls, there have been observed serious structural cracks. The causes of those cracks are excessive stress concentrations such as: compressive stress caused by vertical load (static); shear stress caused by lateral load (earthquake); and propagation of cracks due to successive earthquakes and amortization during centuries.

Propagation of structural cracks from the pendentives to the bottom of the wall is observed in some places. Spall of plaster due to improper isolation is seen.

In load bearing walls containing openings, a different crack pattern is observed. As the maximum stresses are located at the edges of these openings, every window is cracked at the bottom corners of its frame. The cracks propagate diagonally from top windows to the lower windows in the same way. It is very dangerous for the stability of the wall (see Figure 5).

Strengthening Methods

It is crucial to recognize that strengthening and repairing of a structure are more complex than construction due to unknown factors such as continuity, load path, material properties, and locations of previous interventions which increase the complexity of the work.

Moreover, Korça is found in the most active seismic zone in Albania with a rate density of 11.4 (Aliaj,

Adams et al., 2004). Therefore, strengthening of the structure is needed to be done accordingly.



Figure 5. Cracks on the load bearing walls in the south facade of the mosque.

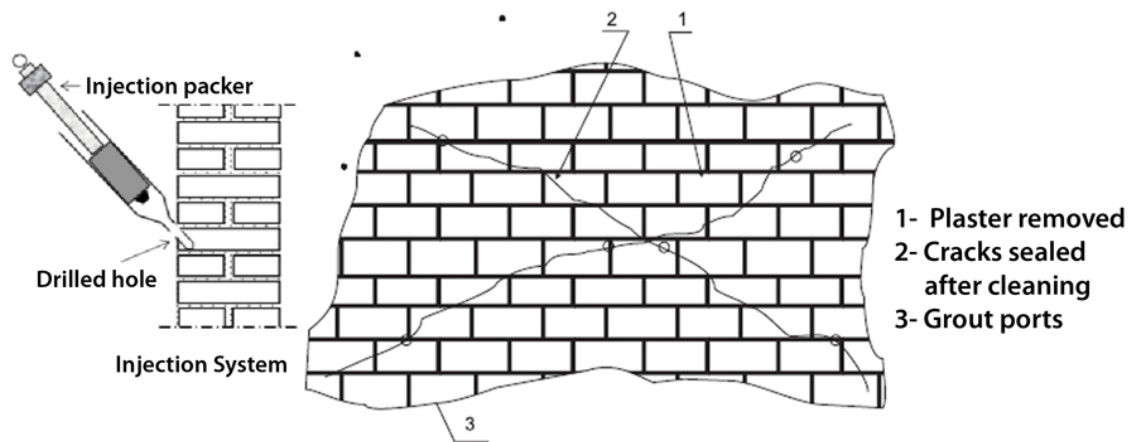
The proposed strengthening methods aim to preserve the mosque's architectural and historical values. Non-structural cracks less than 10 mm should be filled with lime mortar injection (see Figure 6). These cracks will be sealed preventing water from penetrating inside of the wall and damaging plaster. This procedure leaves no trace as it is applied inside the wall. Thus, it has no effect on architectural features of the mosque. It is widely used in restoration projects for historical constructions (e.g., Outeiro Church, Portugal).

Structural cracks wider than 10 mm should be repaired using longitudinal FRP bars (see Figure 7). This technique would provide the load bearing walls with better resistance against tensile stresses, higher shear capacity and more ductility.

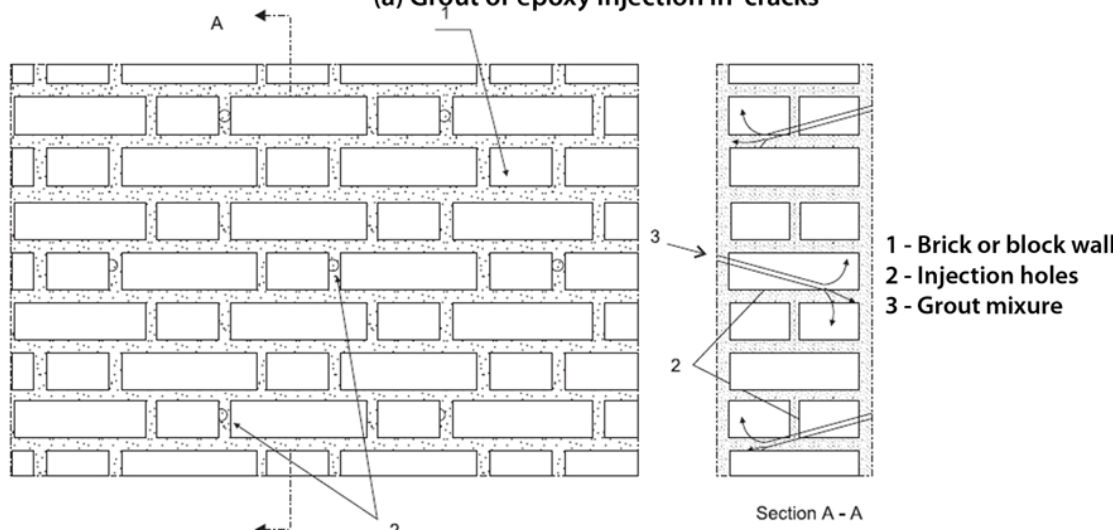
The dome is of a high importance. It encloses the maximum volume with a minimum of surface area and distributes loads to support through a doubly curved plane. Dome is to be designed to resist compressive and circumferential tensile stresses. For this reason it should be strengthened using FRP laminates along its surface.

Fiber Reinforced Polymers (FRP) provides a variety of usages and good solutions for structural problems. For example, St. Fermo Church in Verona, Italy, was strengthened by using FRP laminates.

Moreover, external and internal steel plate rings should be tied at the bottom of the dome (see Figure 8). The same procedure was applied in the leaning tower of Pisa. Pre-stressing rings were placed all along the tower.



(a) Grout or epoxy injection in cracks



(b) Grout or epoxy injection in weak walls

Figure 6. Strengthening by grout or epoxy injection in (a) cracks (b) weak walls.

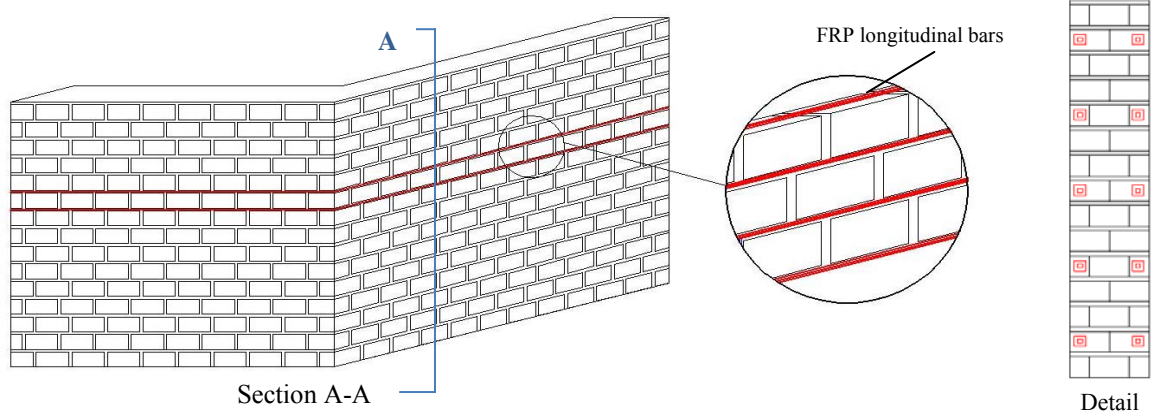


Figure7. FRP reinforcement in the load bearing wall.

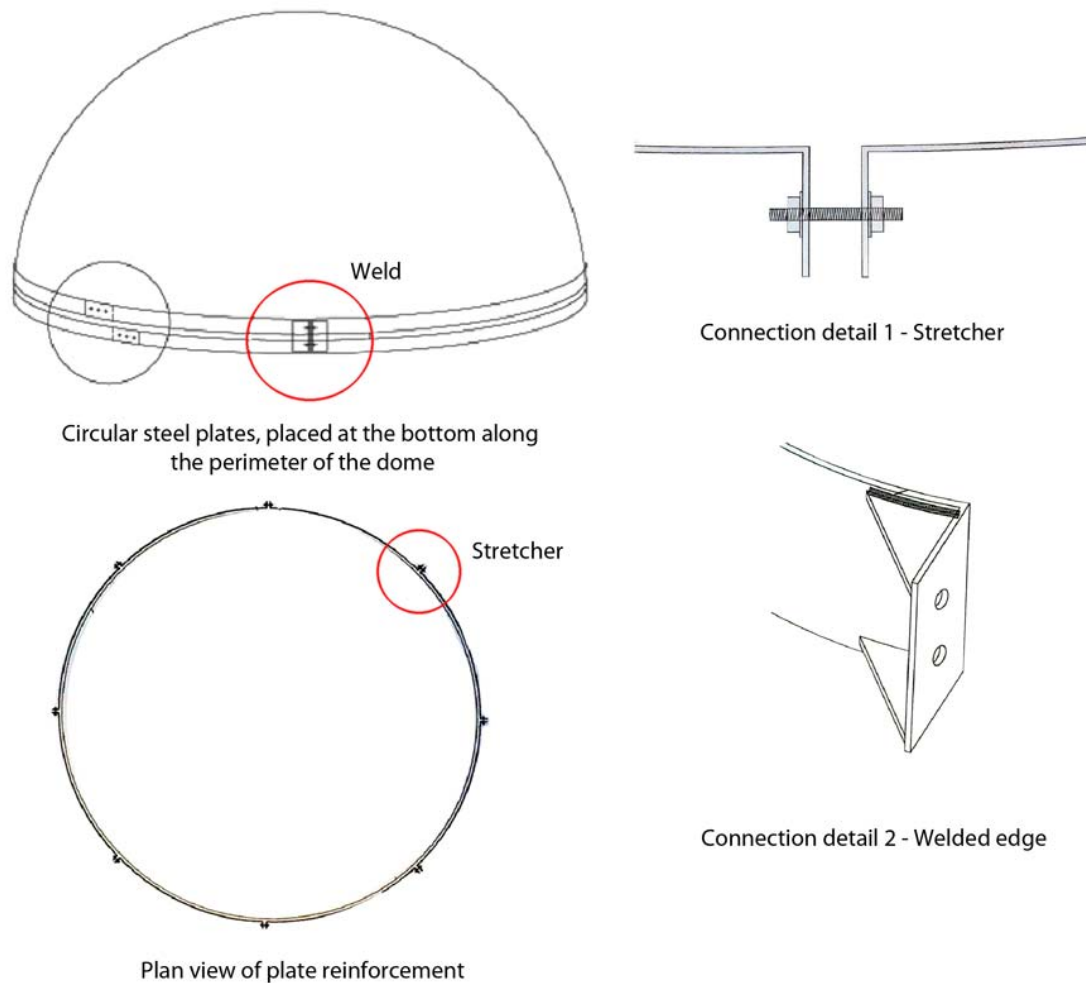


Figure 8. Strengthening with internal and external rings.

Restoration

The restoration project consists of bringing the state of the structure at a condition as it was built in 1496. This process would bring back the historical and architectural values of the mosque. As mentioned above, structural problems were found and would be solved by different methods. Moreover, esthetical interventions should be made as the mosque's elements and materials architectural values are dimmed.

Interventions Again Humidity

Humidity problems would be solved by creating a new ground water drainage system. It would cover the entire perimeter of the mosque, and would remove all surface and excess water away from the mosque (see Figure 9). Even though the leaden cap of the roof was recently replaced (in 2008), water leakage is seen in the dome which has caused spall of plaster and damage of paint and calligraphic ornaments on it.

It is suggested that the layer of lead is removed, the roof to be properly isolated and then leaden cap to be put back in place.

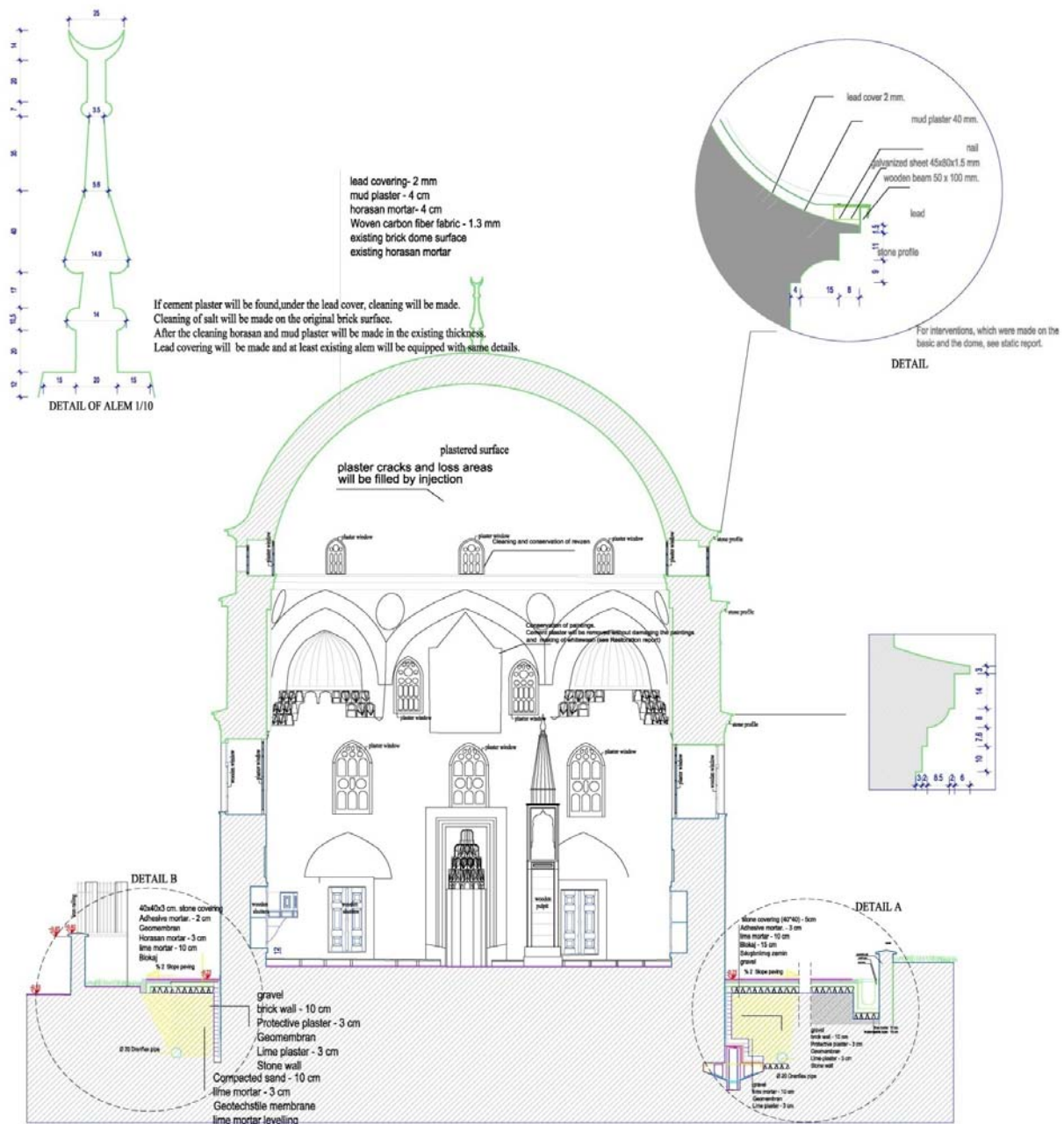


Figure 9. Proposed interventions.

Conservation and Restoration of Rocks

Missing stones in the main facades will be replaced with new ones which would be prepared using the powder of the original stone bonded with hydraulic lime repairing mortar. It will be completed in accordance with original details. Earlier interventions made to repair the stones by cement added mortar will be removed without damaging the original material (see Figure 10).

Conservation and Restoration of Render

There will be a complete observation of the areas of the walls which have gaps, swelled and cracked areas.

Lime mortar will be used to fill small gaps. In order to preserve the actual conditions of the render in the interior of the mosque, one tone lighter colors and motives completion strategies will be used using reversible paint (aquarelle, gouache paint) for decorations at areas that are filled.

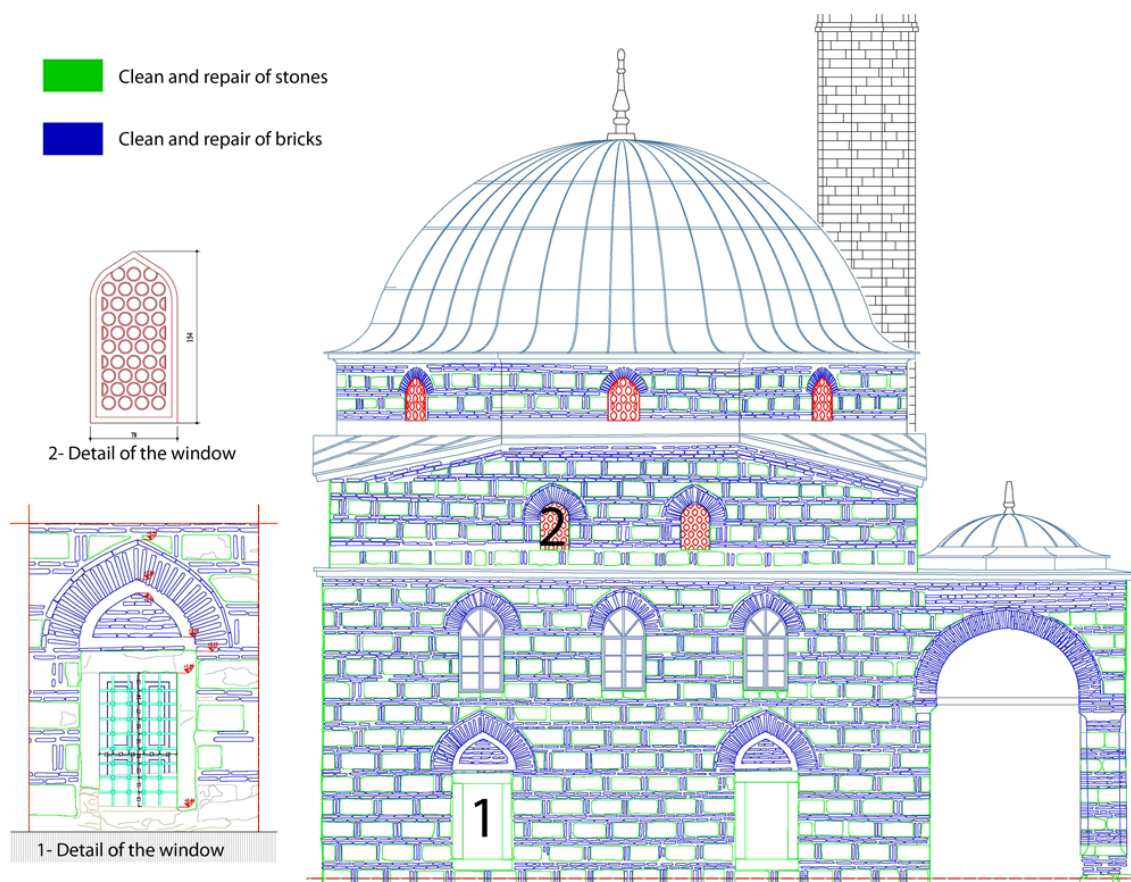


Figure 10. Proposed interventions.

Conservation of Timber Elements

From the documents in the archives, it is seen that the used timber in the mosque is original. For this reason it has great values and is to be conserved. The damaged varnish and paste layers above the entrance gate (see Figure 1), will be cleaned. Areas where there are mass losses will be filled with the same type of timber. Then, all timber elements will be varnished with a water based timber protection layer.

Deformation of the timber ceiling will be fixed by dismantling all the timber elements, replacing the damaged ones, cleaning the ones that can be reused and fixing again.

Conclusions

In this paper, structural assessment of Mirahor Ilyas Beg mosque was presented. Even though cracks are present in many places of the mosque, the assessment results have shown that Mirahor Ilyas Beg mosque's structural conditions, seem adequate to carry static loads. From this point of view, it can be stated that the current condition does not endanger the overall stability of the mosque.

However, since Korça is found in the most active seismic zone in Albania, special care should be taken in

order to immediately repair the problems stated above. By this way, structural stability and dynamic performance of the mosque would improve under the effect of any earthquake loads.

As for restoration, the suggested strengthening and repair methods mentioned above, are the ones which would affect the least mosque's historical values and which would enhance its architectural values.

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