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***Study of the causes of cracks and landslides
(Collapse) of Islamic monumental buildings and
the proposed methods of treatment for the selected
monuments***

Thesis presented for the fulfillment of the masters degree in architectural
Restoration and conservation of building monuments

By

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Summary

Islamic civilization is one of the most powerful civilization which gave us a great architectural legacy, and as we know the architecture was the pages of history, which carry in its architectural elements many of subjects, and as we know who has no past has no present and is not expected to has future.

In this thesis the work modest on the study of Islamic architecture in Cairo (architectural study) with study one of the reasons affecting on Islamic architecture lead it to collapse and deteriorate, then proposed solutions to make them have the capacity to resist factors and the different manifestations of damage, so the plan of this thesis was based on six chapters as follows:-

Chapter 1

This chapter studies the emergence and development of Islamic architecture with application on the Islamic Cairo city, so in this chapter we taken up the Islamic civilization in Egypt in particular the architectural, factors, features, and the characteristic of Islamic architecture in Cairo city ,in addition to the factors affecting on it.

This chapter also includes the characteristics and properties of Islamic architecture in the following periods in Egypt in (Governors, Abbasian, Tulane. akhshedian, Fattimic, Iobian, Mamlokk, and Ottoman periods)

Chapter 2

This chapter addressed the geology of Egypt land and the soil nature of Cairo city, so we discussed the different layer that characterizes the nature of Egypt land as well as the nature of the different layers of soil in Egypt land, as study confirmed on the area of the greater Cairo.

On the other hand this chapter also includes the building materials used in the construction of Islamic archaeological buildings such as limestone and sandstone including its types and its mechanical and physical properties, also studied the fired brick, and we studied in this chapter the mortar and their types, properties, and their shapes in the different buildings.

Chapter 3

In this chapter we studied and discussed the structure analysis of Islamic architecture in Egypt by studied the construction craft which was considered one of the essential crafts were studying the lower people classes working in it in different times of Islamic ages, then we study the construction behavior of Islamic buildings under the influence of various loads then interpretation results to determine the construction balance of these buildings. Further we studied the construction analysis of ancient Islamic buildings, so it has been divided according to the study to these divisions:

- 1- Classical line structures (Beams -Arches -Frames) .
- 2- Surface Shell structures (Shells-Domes).
- 3- Statically indeterminate Structures.
- 4- Statically Determinate Structures.
- 5- Traditional masonry.
- 6- Ashlars masonry.

Then the study were studied the loads and stresses affecting on the Islamic architecture elements and it divided according to the study as these divisions: External

loads, self-loads or Vertical loads, horizontal loads or concentrated loads and distributed loads.

Also the study focused on the architectural elements of the ancient Islamic buildings (foundations walls roofs) where foundations divided into Strip foundations, Pad foundations and Raft foundations also it was divided into Shallow foundations and deep foundations. Then we studied walls where were the basic component architecture in buildings which are being built through the use of different construction materials, (stones mud brick fired brick mortars) Also we addressed the different types of walls such as simple bearing wall, double walls, and cavity walls.

In addition to foundations and walls, roofs were one of the most architectural elements where the Muslim engineer designed it very carefully, that in different Islamic ages they used two basic types of roofs, one of them was wooden roofs and the other was domed ones.

Chapter 4

In this chapter we studied and discussed the factors that led to cracking, settlement and collapsing of Islamic buildings in Egypt, where most of Islamic buildings in Cairo daily faced many serious damage factors left their marks on the buildings through cracks within an architectural elements and total or partial collapse within these buildings. In this chapter we also discussed and determined the most famous and serious reasons as follows:-

- 1- Soil Settlement and Foundations Failure.
- 2- Over Loading.
- 3- Structural defects.
- 4- Earthquakes.
- 5- Ground water.
- 6- The impact of trees and plants growth.
- 7- The false restoration.

In general it is possible to confine these factors in the following points:

- 1- Damage and deterioration of foundations.
- 2- The existence of deep cracks in architectural elements and units of the building .
- 3- Excessive increases in pressure which in turn produces a result of excessive Loads, which exceed the ability of the structural elements to endure.
- 4- Not taking into account the ratio between building height and the thickness of walls in building constructed with wall bearing system.
- 5- Land settlement under the buildings.
- 6- The presence of the buildings close to the nature tendency of the ground.
- 7- The disparity in soil effort under different rules as to the foundation of more than 25% of the maximum effort allowed .
- 8- Water leak into the dry mud soil, exposing it to be failed.
- 9- Withdrawal or reduction of ground water beneath the building.
- 10- Deficiency in the structural design and the lack of its accurate calculation.
- 11- Impact of some external loads such as wind and earthquakes.
- 12- Due to the reasons of error in construction work.
- 13- Non-vertical walls because of the decentralization of load to the foundations.
- 14- The weak on the bond between perpendicular walls or in pillars due to error in construction.
- 15- Erosion and fragmentation, which happens to the stones due to ageing.

Chapter 5

In this chapter we studied and discussed the architectural restoration process of Islamic monuments which suffer from collapsing and cracking, where we find these phenomena in the most of Islamic architectural buildings in Cairo city. Where seldom you find a building of the old Islamic buildings in Cairo city which remind several centuries doesn't need to restoration and conservation as a result of the vulnerability of the buildings over the years for many different weather factors, and the development of the environmental factors, so that these buildings in fact need to restoration and conservation immediately.

The followings are the outline steps for restoration of Islamic building monuments (Architecture and Construction Restoration):-

1- Registration, Examination and Analysis processes:-

a - Polarizing Microscope - scanning electron microscope – X Ray Diffraction (XRD)

- X-Ray Fluorescence (XRF) - Atomic

Absorption - Laser Microscope Mass Analysis "LAMMA - Raman

Microscope Analysis - Ultra Sonic pulses - Thermo vision "thermo Camera.

b- Architectural registration methods:-

- Spatial lift (spatial lift of the general location and building spatial lift) –

Monitoring and testing site – architectural documentation of the current situation.

c- The studies of soil and foundation mechanics.

d - Studies construction equilibrium:-

Optical conclusion – the use of thread balance – Tiodolit instrument - Total

Station - Finite elements" - Electronic Distance Monitoring System "E.D.M" -

Measurement Equipment - Microwave Scanning - Precision Tracking

Radars - Monitoring Static Type - Dynamic Monitoring – Mathematical

Analysis. - 3d Laser scanner.

2- Consolidation and softy works.

3- Reduce ground water level.

4- Soil Treatment.

5- Consolidating and strengthen the foundation.

6- Treatment and strengthen of bearing walls.

7- Restoration roofs suffering from cracks.

8- Building strengthens to resist earthquakes.

9- Dismantling and reconstruction.

10- Regular conservation and Rehabilitation.

Chapter 6

The practical work was applied on three architectural buildings each of them is different in design, location, and surrounding environmental, consequently, procedures and methods of required restoration and conservation will be variable.

1st--(EL-TEKIA AL SOLAIMANIA) (no- 225)

The establishment of El-tekia dates back to 950 – 1543 A.C and it lays on Sorogyah street next to the left of Bab Zewalh where it was overlooking with its main façade (north-west) On the other side its south – west façade overlooking at Atfet Allimon street and its south – east façade overlooking at Hammam Bishtak.

The planning of this Tekia was the Othmanic school system which was affected the school architecture in Cairo at sixteenth century.

It was noted that this building has been suffering from many of serious damage phenomena, but the serious ones were cracks in the walls and the collapse of many of the architectural elements of this building, also the settlement of the ground under the foundation of this building. These factors were the most visible and serious phenomena affected on this building.

To diagnosis the factors affected on this building we are follow many steps
First we studied the structural analysis of this building, then we are studied the nature, the physical and mechanical properties of the building materials, which are used to established this Tekia .

Also we studied the nature of the factors in the surrounding of this building which have been affected on it.

Then it was possible to identify the factors that led to the cracks and collapsing of the architectural elements of this building Finally we put the steps of restoration and conservation, where we can apply them on this building to become a building has been the ability to resist the surrounding damage factors.

2nd- EL-SABA BANAT DOME

It hasn't been identified the name of the constructor name and either of the constructor, because of the absence of construction texts that can be consulted to date this dome, but the most likely date which was confirmed by different authorities that this dome has been established on the mid nineteenth century of Elhejra and tracking to the Mummlukes era (784-923) A.D. As for location, this dome is located in EL-Sultan Ahmed street in (Elqarafa) in the area of ancient Cairo.

It was noted that the dome has been suffering from many of serious damage phenomena, but the serious one was cracks in the walls and the collapse of many of the architectural elements of this dome, these factors were the most visible and serious phenomena effected on this dome.

To put our hand on the factors affected on this building first we studied the structural analysis of this building , then we are studied the nature , the physical ,and mechanical properties of building materials , which are used to established this dome .

Then it was possible to identify the factors that led to the cracks and collapsing of the architectural elements of this dome

Finally we put the steps of restoration and conservation, where we can applying them on this dome to become a building has been the ability to resist the surrounding damage factors.

3rd- EL-ASHRAF BERSBAY MINARET

El-Sultan Elashraf Bersebay has been constructed his architecture compact in 835-1431A.C on the road which lead to the Khanqah of EL-sultan Barquq to

EL- Sultan Kaitbay tomb, this compact includes Khanqah, mosque, and a big buried court, which includes many buried (tomb)domes.

El-Sultan Elashraf Bersebay constructed his compact on the area which named (Sahraa EL-Mamalek) in ELDARASAH.

On the above of the main entrance of El-Sultan Elashraf Bersebay mosque there was newly minaret replaced the original one, this minaret consists of three floors, the first floor was squared shaped and it was the largest one in latitude and longitude, this floor ended with octagon shaped wooden roof.

The second floor also octagon shaped, and has a window in each side of its octagon shaped. The third one is taken the form or shape of a pencil which the minarets of ottoman era were famous of this form or shape.

It was noted that the minaret has been suffering from many of serious damage phenomena, but the serious one was the orientation or tilt and the settlement of the ground under the foundation of this minarets These factors were the most visible and serious phenomena effected on this minarets.

To diagnosis the factors affected on this minaret many steps were suggested, so in the first we have a tendency to monitor and identify the orientation or the tilt of the minaret as a magnetic deviation, and determine the tilt angle in vertical direction.

To do that we used the application of total station that it has proved to be successful on the value of tilt or orientation.

Then it was possible to identify the factors that led to orientation or tilt and the settlement of the ground under the foundation of this minaret.

Finally we put the steps of restoration and conservation, where we can apply them on this minaret to become a building has been the ability to resist the surrounding damage factors.