ABSTRACT: The Holy Family Crypt under Abu-Serga church is submerged by 160 cm of water, and rising. This paper is about protecting the Crypt from the surrounding aggressive groundwater, as well as strengthening it against the effects of aging and the harsh environment.

The goal of the protection system is to bring the Crypt to a “permanent” dry state, regardless of the continuously rising groundwater in the vicinity. This is achieved by isolating the Crypt from its surrounding wet environment by enclosing it in an impervious “box”. The box is made of four vertical cutoff walls and cement based injected horizontal plug. Trench drains and floor ducts are provided inside the box and the Crypt respectively, to collect any seeping water.

The strengthening system includes structural upgrading of the walls and roof of the Crypt, as well as surrounding it with a reinforced concrete wall.

1 THE SITE

The Holy Family Crypt is one of the places where the Holy Family stayed during their flight into Egypt. It is located under the church of Abu-Serga, which lies nearly in the center of Babylon Fortress in Old Cairo (Fig.1)

1.1 The Fortress

The Fortress of Babylon (renamed later in Arabic Qasr El Shama) was established as a Roman Fortress during their rule of Egypt (Fig.1). Based on military considerations, the site of the fortress had been chosen on the eastern side of the Nile mid-way between the Delta and Upper Egypt, while the Capital remained Alexandria, as chosen before by the Ptolemy’s.

Since the Roman Emperor Constantine allowed Christianity in the year AD 330, many churches were built in the Fortress. The oldest being El-Muallaka (suspended) church and Abu-Serga church (Fig. 2).

1.2 The Church

Abu-Serga church stands among the three most prestigious churches in Egypt. The other two are the suspended (El-Muallaka) church, built on top of the south entrance of Babylon Fortress, and the Holy Virgin church at Haret Zewaila. This church gained its high prestige from the fact that it was built on top of the Crypt.

It is believed that the church was built in the late 4th -early 5th century (Simeka 1930). Yet some (Butler 1884) consider that the present building, unaltered in its main features, dates back to the 6th or even the 8th century. Fig.3 shows the church at the end of the 19th century. Nowadays its floor level is about 4.5 meters below that of, the main street of Mar Guirguis (Saint George) at the subway station.
Figure 1 : Babylon fortress (Butler 1884)

Figure 2 : View of Old Cairo at the second half of the 19th century (Jullien)
The Church is about 27m long, 17m wide and 15m high and its floor level is about 1.5m below the surrounding alleys. It has a typical Basilicas design with a narthex leading to the nave with two side aisles. These aisles are separated from the nave by twelve columns in two equal raw, with a mezzanine above the aisles. The nave leads to the choir (khoaros) then to three sanctuaries occupying the east side of the Church. In the north and south sanctuaries, there are two staircases leading down to the Crypt. Fig. 3 shows the church according to Butler (1884). Nowadays one would notice quite a change in the inner arrangement with no change in the structure of the Church.

Figure 3: The church: a) plan (Butler 1884); b) Interior

The walls of the church, in general, are built with dressed limestone blocks with bricklayers in-between. The upper roof above the nave is made of wooden trusses. The exterior walls of the sanctuary are mainly built with dressed limestone. Yet the inner walls and the apse are
constructed with limestone and burned clay bricks. Wooden beams and planks form the roofs of the south and north sanctuaries. A masonry dome mainly covers the main central sanctuary.

1.3 The Crypt

The Crypt is one of the places where the Holy Family stayed during their flight into Egypt.

The Crypt is a small low subterranean church, lying under the main Alter of Abu-Sirga church. As a matter of fact the church was built on the site of the Crypt. No doubt the Crypt was built several centuries before the church (Butler 1884). It is obvious that such a holy place must be protected, and kept as sacred, from the very beginning of Christianity in Egypt. And it is believed that a small church was built on the Crypt site, as early as the second century, for that purpose.

The Crypt is about 6.5 x 5 m x 2.5 m high with two raw of columns having a longitudinal series of arches on each raw. These two raw of columns divide the Crypt into three longitudinal shallow vaults (Fig. 4), which may be considered to form a nave with north and south aisle.

Figure 4 : The crypt; a) according to Butler 1884; b) flooded with water
Also in the Crypt there are three arched recesses, one in the eastern, one in the southern, and one in the northern wall. Undoubtedly the one in the eastern side is an alter. Yet some believe that the other two are also alters. The difficulty lies in that there are no other examples, in Coptic churches, of altars facing north and south, but the whole structure of the crypt and its interest are so exceptional. These altars may have been erected in this unusual position each to commemorate some special spot related to the stay of the Holy Family in the place (Butler 1884). The Crypt lies some 3.0 m below the sanctuary floor level, and about 4.2 m below Saint Barbara alley at the church entrance and about 7.0 m below Mar Guirguis street level at the subway station.

The Crypt is reached down from the upper north and south Alters by two flights of stairs, one on each side. Both flights lead to the west end of the Crypt. Fig. 4 shows the Crypt according to Butler (1884). The only change that occurred, since then, is that the extended wall along the north flight is not there anymore.

The Crypt floor is made of limestone overlaid by 20 cm of mortar with brick fragments then 2.5 cm marble floor then about 12 cm of concrete and cement mortar. The Crypt roof and the upper alter flooring is composed of 30 cm of burnt clay brick with lime and homra mortar overlaid by 15 cm red brick then 10 cm clay then 5 cm limestone which is the flooring of the Alter. The Crypt walls are built with red brick with isolated pockets of filling material alternating along the wall thickness. The thickness of each of the south and north walls of the Crypt is about 1.8 m.

In the mid 1980’s the crypt walls and roof were rendered by cement based, with chemical additives, impervious mortar. This was quite an unfortunate repair attempt.

1.4 The subsurface condition

The subsurface profile, under the church’s floor, consist of an upper filling cover of about 5 m thickness, under lied by soft then medium plastic silty clay layers mixed with variable percentages of sand. The fine to medium sand layers appear at depth 10-11 m below the church’s floor level. The groundwater appears at 1.4 m depth.

2 THE PROBLEM

At the present the Crypt floor is continuously submerged by about 160cm of water, seeping from the surrounding ground water. The depth of this water is reduced to 80cm when the existing project for reducing the ground water level in the church, is in continuous operation.

One would notice that the Crypt is located, geographically, between Mokatum plateau to the east and the river Nile to the west. From the “water point -of- view”, the Crypt lies, closer to the Nile, between Ein El-Sira lake to the east and the Nile to the west. (Fig. 5)

In the past, the water level of the Nile used to reach its highest level at Cairo during the month of September, while dropping to its lowest level in the month of January. The water in the crypt used to follow the Nile pattern. Hence the floor used to get flooded in late September, and then the water in the Crypt starts to recess, as the Nile water level gets lower. The Crypt floor used to be dry from January till September every year. At that time Ein El-Sira lake was maintained at its “natural” level and was contained within its surrounding limestone boundaries. So it was clear that the Crypt was mainly affected by the Nile flooding cycle.

During the late fifties to the late sixties of the 20th Century the High Aswan Dam was built. As a result the rise of the water level of the Nile at Cairo was stopped and was kept at an approximately, lower level of 16.7 m. Unfortunately since that same period, many improper interventions occurred in Ein El-Sira area, including the introduction of municipal then residential projects which started, and still continuing to be built in the area. As a result large portion of the lake was reclaimed and large amount of fill was introduced in it. Also the lake was, and still is, used as a dump place for some solid debris. As a result of these unfortunate interventions the level of water in the lake continued to rise. Hence an increasing amount of water continued to seep from the lake through the fill that overlay its natural limestone boundaries. This ground water moves westward, passing through Old Cairo, towards the Nile. An investigation done by Egy-Tech Group, in connection with the restoration of Ben Ezra
Synagogue (1989), showed that, Ein El-Sira is the main source of groundwater in the church area. A brief note (1999), prepared by the Groundwater Research Institute indicates that the level of water in Ein El-Sira Lake increased by about seven meters till 1999.

Figure 5: Old Cairo

From these developments as well as continuing environmental changes in the area, one would expect that the ground water problem in Old Cairo is bound to worsen with time. In 1988, a project to reduce the ground water effect in Abu-Serga church area was introduced. The project is composed of horizontal trench drains surrounding the church and discharging the water into a sump then forced to the sewer system. Concerning the Crypt, this project was intended to reduce the level of water in the crypt floor, but not to dry it. A small sump with a pump inside the Crypt was able to bring it to a dry state. Yet after the 1992 earthquake, the Crypt was shored, hence rendering it continuously unavailable.

From Egy-Tech observations, in the last 12 years, the ground water level in the Church area has been steadily rising. In the Crypt, when the 1988 project was continuously operational, the flooding water level used to be about 15 cm above the floor level; nowadays it is about 80 cm above the floor level.

3 THE PROTECTION SYSTEM

Diagnosis of the problem indicated that the Crypt is suffering from the rising groundwater in the vicinity, which bring the Crypt to a continuously flooded state as well as causing progressive deterioration to its structure. The appropriate remedy would be to isolate the Crypt from its immediate wet environment. The goal of bringing the Crypt to a permanent dry state could be accomplished by constructing the following elements.

3.1 The Box

A permanently impervious enclosure (box) to contain the Crypt is required to isolate the Crypt from the surrounding wet environment. Hence bringing the Crypt to a dry state without the need
for lowering the level of the groundwater in the surrounding area to such a low level as that of the crypt floor level. The box would also assure the protection of the Crypt regardless of the continuously worsening groundwater condition in the vicinity.

This box is formed by a vertical cutoff wall surrounding the crypt zone and forms the closed sides of the box. The wall would go down to penetrate the sand layer for about 2m. The cutoff wall is composed of diaphragm wall and/or overlapped injected piles or a combination of both. The wall would serve to prevent the horizontal seepage of groundwater into the crypt zone, as well as confining the horizontal plug, which forms the bottom of the box.

The plug would be done by permeation injection in the sand stratum. The type of sand requires the use of ultra fine cement. Also inclined injection is required for the zone under the Crypt to avoid causing any damage to its roof and floor. The plug top level is about 10.5 m below the church’s floor level.

In forming the box, extreme care should be exercised to maintain the continuity of the “box” elements, especially at the joints and where its walls cross under the walls of the church. The permanent impervious nature of the box should be assured.

3.2 Trench drains

Horizontal trench drains are provided in the space between the “box” walls and the Crypt. The filter lines are composed of perforated pipe surrounded by filter material. These drains would collect the small amount of water that would seep through the protective “box”. The filter lines around the Crypt should be positioned deep enough to insure that the level of the groundwater under and around the Crypt remains lower than the crypt floor level by 50cm at least. The water collected in the drainage lines is directed, by gravity, to a sump located at the end of the lines. The sump has a two cubic meters dischargeable capacity. The water in the sump is then forced by a submersible automatically operated pump, to an existing main sump located outside the church, then to the sewer system.

3.3 Inner duct

A horizontal shallow and covered duct, which already exists all along the inner side of the crypt wall would be used to collect any surface and emergency water reaching the crypt floor. The collected water is directed, by gravity, to a small sump in the crypt floor. A submersible automatically operated pump then forces the water, to the sewer system.

4 THE STRENGTHENING SYSTEM

This is mainly concerning the structural upgrading of the crypt walls and roof. Condition assessment including visual inspection, deterioration documentation, core analysis of the walls and roof, and chemical and mechanical analysis of mortars, formed the base for the strengthening strategy.

The strengthening of the walls includes surrounding the Crypt by a 25cm thick reinforced concrete wall. The continuity of this wall would be provided by bending element wherever possible, or else axially loaded elements would be provided to connect the main elements of the wall. This wall would provide some “confinement” to the crypt. As well as improving the horizontal impermeability of the walls and protecting them from the surrounding aggressive environment. Care should be taken in properly preparing the outer surface of the crypt walls before casting the reinforced concrete wall. The joints between the bricks to be cleaned and cleared, as deep as possible, from any clay and other fillings. Then filled with mortar, which is similar or compatible to the existing one. Then the surface is plastered and an insulator is laid.

The inner surface of the crypt walls, to be cleaned and the entire recent rendering removed. Also replacing broken bricks with burned clay bricks (manufactured by special permission from the Antiquity Authority). The mortar between bricks to be removed, as deep as possible, and replaced by similar or compatible mortar.
Figure 6: Groundwater protection system
Figure 7: Protection and strengthening system
Applying a low-pressure impregnation along the middle thickness of the wall to form a 50-75 cm thick wall with better bonding and porosity properties. This would include drilling test holes as well as injection holes all along the walls. No holes are allowed in the inner surfaces of the Crypt. Low pressure ascending (upstage) impregnation of the inner part is then applied. The grout material should be compatible with the existing materials. This operation should be carefully controlled and monitored to make sure that a continuous and well-bonded inner wall is formed with no adverse effect on the rest of the crypt wall.

The strengthening of the roofs, requires the removed of the alter floor and the 20 cm plus fill under it, which lies above the crypt roof. This is followed by the impregnation of the crypt vaulted roof wherever necessary. The impregnation is to be applied from the top. Then a prefab prestressed concrete slab elements, spanning over the Crypt and supported on its outer walls, are introduced to carry the alter floor. This would relief the crypt roof from carrying any load provided by the church alter.

5 CONCLUSION

The main goal of the protective system is to bring the Crypt to a Constance dry state regardless of the continuously rising groundwater level. While the strengthening system, besides upgrading the structural integrity of the Crypt, would add an extra protection against the groundwater.

REFERENCES

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