

REPAIR AND REHABILITATION OF THE PALACE OF AZIZA-FAHMY

BY REFAAT M. SALLAM

The Palace of Aziza-Hanem*-Fahmy sits on a wonderful site—a flat hill overlooking the Mediterranean Sea on Corniche Road in Alexandria, Egypt. The hill rises about 16 ft (5 m) above the sea water level. The area of the site, surrounded by a classical fence, is 150,700 ft² (14,000 m²).

The small palace, a summer refuge of a noble family, was built in the neoclassical style in the 1920s. The palace building occupies an area of about 10,750 ft² (1000 m²) in a nearly square shape. Figure 1(a) and (b) shows two photographs of the classical features of the building.

The building comprises three floors: the basement, used as a kitchen and for other services; the first floor, used as a reception area containing dining rooms and salons; and the second floor, with family living rooms and bedrooms.

The building suffered severe intentional damage in the 1990s in the course of a dispute between the inheritors and the government on the possession of the palace. It seemed that the objective of the damage was to cause collapse of the building in a short time.

THE STATE OF THE DAMAGE

The structural system of the building is a bearing-wall type. Hard limestone walls 24 and 31 in. (600 and 800 mm) thick carry the roof joists, which are either of beach pine wood or rolled steel I-beams and are covered with lime mortar on either timber strip grid work or steel wire mesh.

The damage included two main operations: 1) cutting the bearing walls at floor levels to nearly full length and full thickness with a height of 9.8 to 15.7 in. (250 to 400 mm), adding some small supports about every 6.5 ft (2 m) of wall length to avoid sudden collapse of the walls. The cutting operation was very severe and rough (refer to Fig. 2); and 2) completely removing the roofs, leaving the walls without any lateral horizontal support (refer to Fig. 3) for their full height of more than 46 ft (14 m). Also, the main staircase was removed by stripping the pure white Carrara marble stairs from the surrounding supporting walls.

The following features of the damage can be noted:

- Almost all of the bearing walls of the building suffered cracking in different directions, with the diagonal cracks being most notable. The diagonal cracks were wide (some of which exceeded 3/4 in. [20 mm] in width) and extended, in some cases, almost the full height of the wall.



Fig. 1(a): The palace, showing perspective of the east and the south façades



Fig. 1(b): The initials A.F. of the owner's name, engraved in a block of hard limestone

*Hanem is a royal title for ladies.

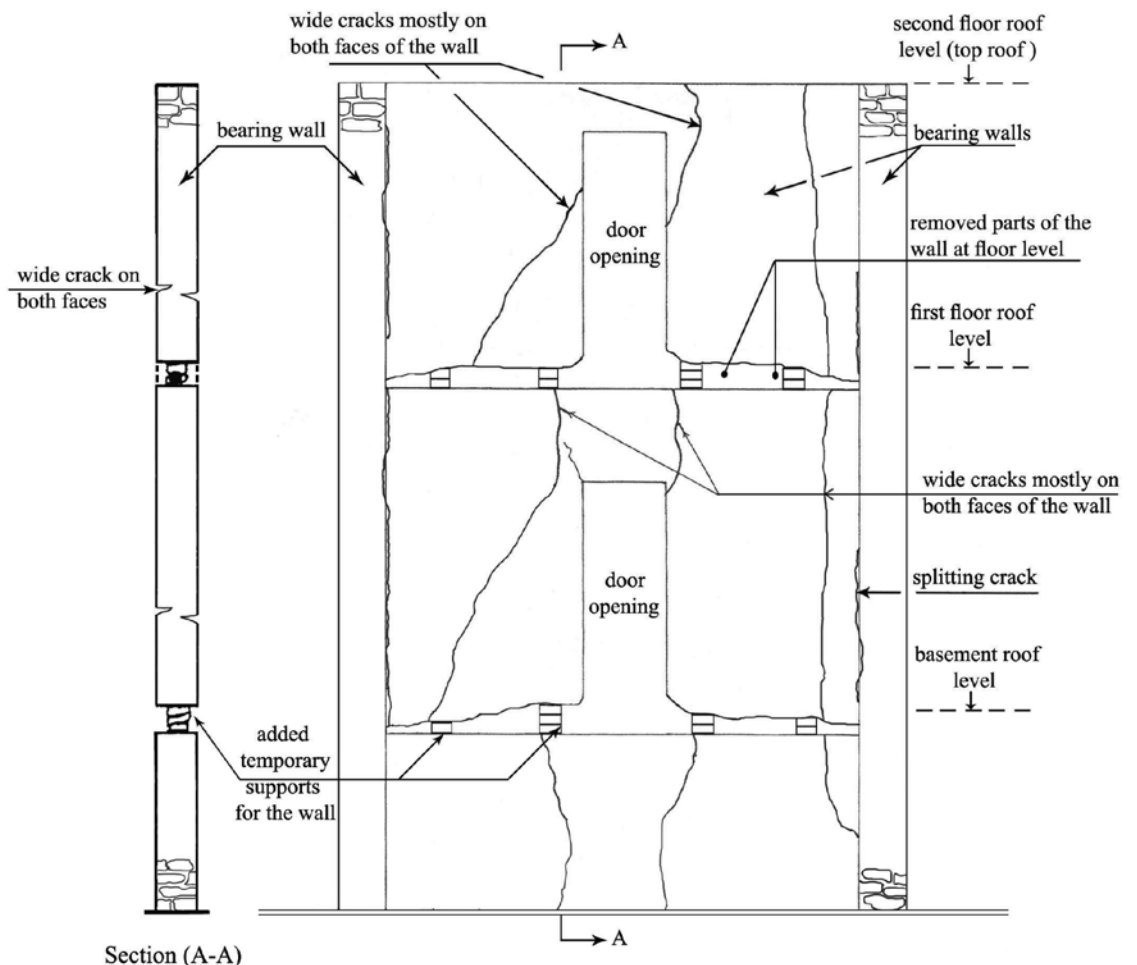


Fig. 2: Photographs showing basement roof and top roof removed harshly

Some of these cracks appeared on either side of the wall;

- At the corners where perpendicular walls meet, vertical splits of nearly full height of the wall (between two roofs) appeared, in some cases, on both sides of a corner; and
- The only unremoved parts of the roofs were the six balconies on the first floor made of reinforced

concrete slabs and surrounding beams resting on bearing walls. After 70 years from the time of construction, the concrete was in good condition in this severe marine environment. Only the bottom edges of some beams suffered from a slight corrosion of reinforcement. It is important to note that this concrete was made and cast manually.



Section (A-A)
Fig. 3: Location of damage in bearing walls

The head of the governmental company possessing the palace, on contacting a consulting engineer (the author) about the possibility of repairing and rehabilitating the building, mentioned that he has received some reports about the status of the building recommending its demolition.

The final decision to repair and rehabilitate the building was based on two important considerations: first, the building of the palace is not an ordinary modern one, but it is a building that bears historic and aesthetic values that witnessed the boom of fine classical architectural works in Egypt during the first half of the twentieth century. The second consideration is that the big development that took place in the last few decades in materials and techniques used in repair and rehabilitation, and the experience gained by engineers practicing this field, yielded a belief that any important building damaged but still standing (that is, not collapsing) can be repaired and rehabilitated.

STRUCTURAL REHABILITATION OF THE PALACE

Because of the building conditions previously discussed, the structural rehabilitation processes were designed to proceed in steps that guaranteed the stability of the fragile bearing walls against collapse until full restoration is reached.

Based on this principle, the following procedure was adopted:

1. The bearing walls were structurally restored, that is, building the missing gaps at floor levels and repairing all cracks;
2. Reshaping of the restored walls at roof levels to accommodate the new roofs; and
3. Reconstruction of the three reinforced concrete roofs.

STRUCTURAL RESTORATION OF BEARING WALLS

The first step was rebuilding the missing parts of the bearing walls at floor levels. Hard limestone blocks and smaller filling pieces from the same quarries that supplied the material for the original walls[†] were used to rebuild the missing parts of the walls. The contact surfaces between the new and the old parts of a wall were then thoroughly injected with masonry cement slurry under pressure. The guarantee of complete filling of the spaces within the full thickness of a wall at the contact surface was checked by the visual inspection of core samples drilled across this surface.

The masonry cement used was a blend of portland cement and fine limestone dust in the ratio

of 3:1 by volume. The aim of using this blend was to improve working qualities as a result of the greater plasticity obtained compared with using portland cement alone. This applied to both the slurry and the mortar used for building the missing parts of the walls. The mortar was composed of masonry cement and standard siliceous sand mixed in the ratio of 1:3 by volume.

The second step dealt with the repair of the cracks in the bearing walls and at the corners where perpendicular walls meet. At the corners, where vertical long cracks on both sides seem to indicate the possibility of separation of the two walls, thus impairing their lateral stability, precast reinforced concrete L-shaped pieces at vertical distances of about 4.9 ft (1.5 m) were imbedded at some depth from the surface of the wall (as shown in Fig. 4). These pieces were connected to the masonry all around by masonry cement slurry and mortar. This operation was executed after the repair of the cracks in the bodies of the two walls under consideration has taken place.

Repairing the cracks followed the same procedure used for repairing cracks in the reinforced concrete. The following sequence describes the main steps:

1. Cleaning the surfaces of wide cracks from small stone pieces and other contaminating materials.

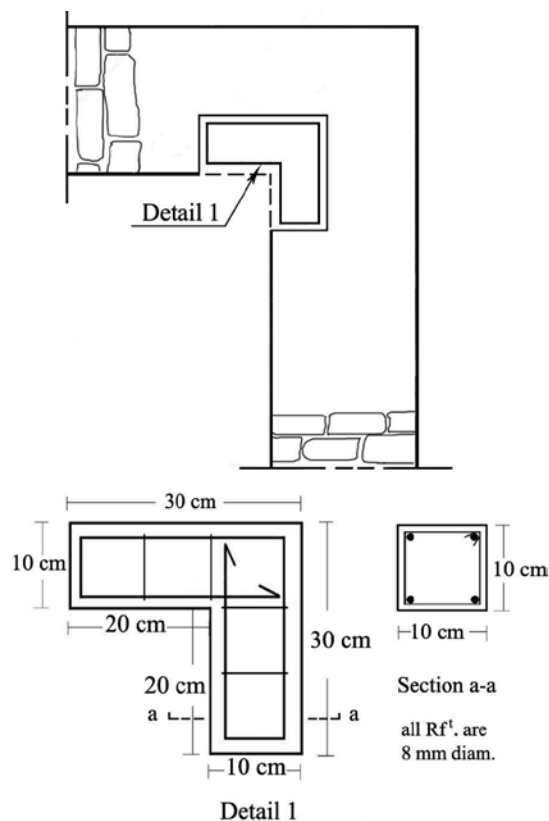
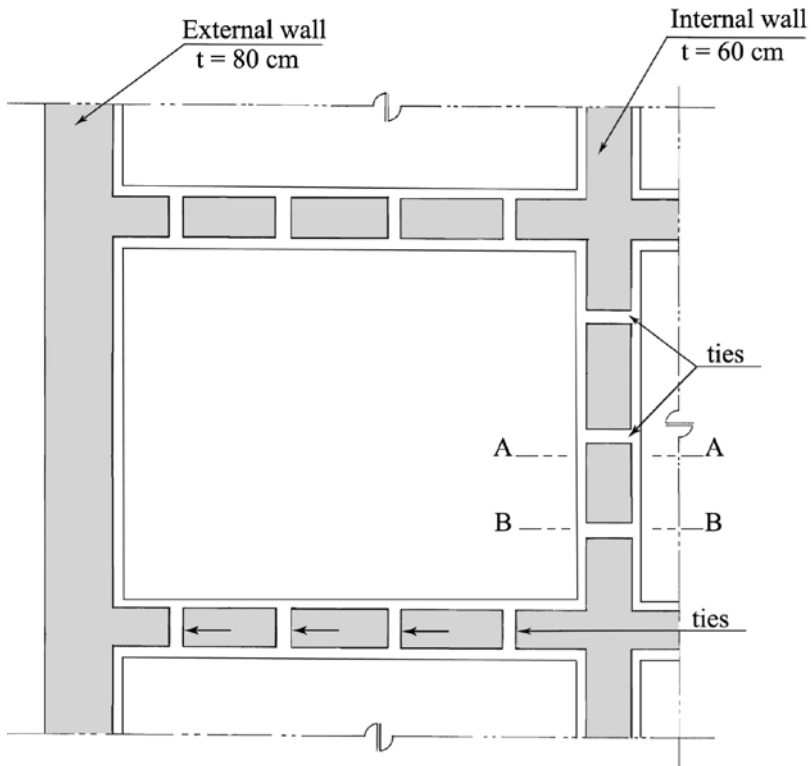


Fig. 4: Reinforced concrete corner pieces for tying perpendicular bearing walls (1 cm = 0.39 in.)

[†]A vast area of limestone quarries in the western desert adjacent to Alexandria.



Partial plan showing reshaping processes of bearing walls (1 cm = 0.39 in.)

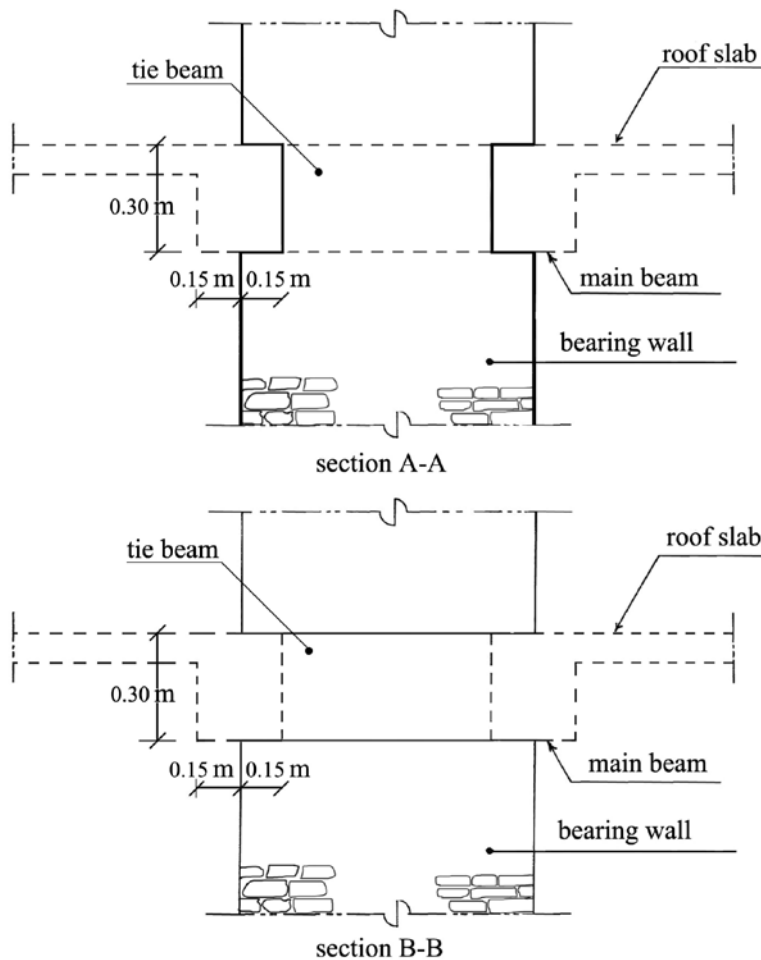


Fig. 5: Reshaping of bearing wall (cuts and drillings) (1 m = 3.3 ft)

2. Vacuuming all narrow and wide cracks to guarantee the injected cement slurry penetration and the establishment of the required bond.
3. Tightly closing the exposed crack surface on both sides of the wall with masonry cement-sand mortar sealer. Before this step, some cracks needed a V-shaped groove to be rooted along its full length when high-pressure injection was prescribed.
4. Constructing entry and venting ports along the exposed crack surface at distances of 1.6 to 3.3 ft (0.5 to 1.0 m). Drilled holes with a diameter of 0.8 in. (20 mm) and a depth of 0.6 to 1.0 in. (15 to 25 mm) beyond the V grooves were prepared and cleaned and the nipples for injection were then fixed in these holes by epoxy adhesive.
5. Injection with masonry cement slurry was then executed by a specialized firm. The pressures used varied depending on the width and shape of the crack, and on whether or not it penetrated the full thickness of the wall. The aim remained to always fill all the spaces and voids and reestablish the continuity of the wall. This was realized by core samples drilled to varying depths across crack surfaces.

RESHAPING OF RESTORED WALLS AT ROOF LEVELS

With all of the bearing walls restored, the next major step was the construction of the new roofs. Reinforced concrete was chosen as the most suitable material for construction. The restoration process yielded a system of perpendicular bearing walls parallel to the two axes of the building and dividing the area of the building into isolated compartments, each between four walls. These walls have an unsupported height of about 46 ft (14 m), without any lateral horizontal ties. The ties were going to be provided by the three new roofs on the condition that the roofs had to be continuous throughout the whole area of the building. This condition was realized by drilling holes at suitable distances through the bearing walls to pass reinforced concrete ties connecting the roof main beams abutting on either side of all bearing walls.

The reshaping process is made up of two sets of cuts in these walls at roof levels (as shown in Fig. 5). The first set is the two longitudinal grooves on either side of the interior walls and on the interior side of exterior walls. The second set of cuts is the previously-mentioned holes drilled through the bearing walls to pass the reinforced concrete ties.

Before reshaping the walls, the maximum normal stresses on horizontal planes was calculated, thus allowing the reshaping process to be done safely.

Manual diamond-bit sawing was used for cutting the longitudinal grooves in the walls. The

dimensions of the groove were 11.8 in. (300 mm) in height, exactly the height of the cross section of the abutting beam, and only 5.9 in. (150 mm) wide, that is, less than 11.8 in. (300 mm), which is the width of the abutting beam.

The two grooves on either side of a wall were not cut at the same time. The first groove was cut and, simultaneously on the other side, small holes were drilled to pass the dowels for the tie beam reinforcement. Stitch drilling of overlapping bore holes was used to make the holes with the required dimensions. The first beam and the tie beam were cast with concrete. The second beam groove was then made after casting the first beam for a period of 1 week. Local lateral supports were provided for the walls during the drilling operations.

RECONSTRUCTION OF THE THREE REINFORCED CONCRETE ROOFS

The roof of each isolated panel was formed of four main beams abutting the four walls surrounding it, the secondary beams running in the short directions at a spacing of about 4.9 ft (1.5 m), with a slab thickness of 3.2 in. (80 mm). The ties connecting the main beams on either side of a wall were spaced at about 4.9 ft (1.5 m). Details of dimensions and reinforcement are shown in Fig. 6.

The concrete mixture was designed to satisfy the main requirement for a concrete skeleton constructed in a marine environment—a concrete of low permeability. This was achieved by reducing the water-cement ratio (w/c) to be about 0.38. To keep a suitable workability—at a slump of 5 in. (120 mm)—with this reduced w/c ratio, a high-range water-reducing admixture was used.

Laboratory and field tests gave the following mixture proportions:

Cement, lb (kg)	Sand, lb (kg)	Gravel, lb (kg)	Water, gal. (L)	w/c ratio	High-range water-reducing admixture, gal. (L)
771.6 (350)	1289.7 (585)	2866 (1300)	35.1 (133)	0.38	1.9 (7)

Trial batches of the chosen mixture proved to be cohesive—with no segregation—and with high workability. The 7-day cube strength was in the range of 5000 psi (350 kg/cm²), whereas the 28-day strength exceeded 6400 psi (450 kg/cm²).

RECONSTRUCTION OF MAIN STAIRCASE

The new staircase was constructed in reinforced concrete, covered with white Carrara marble to simulate the removed one. Figure 7(a) represents the architectural configuration of the staircase, as detected from the marks of the old solid marble stairs on the three surrounding walls. Figure 7(b)

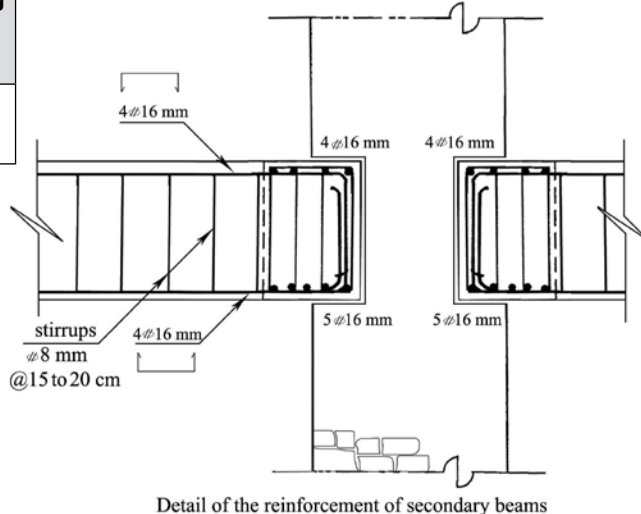
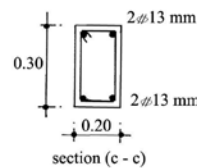
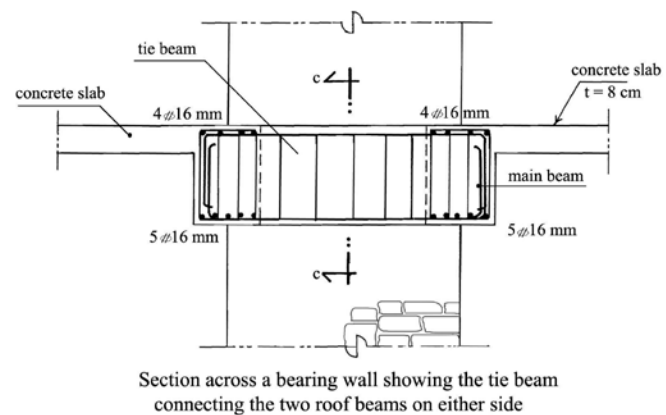
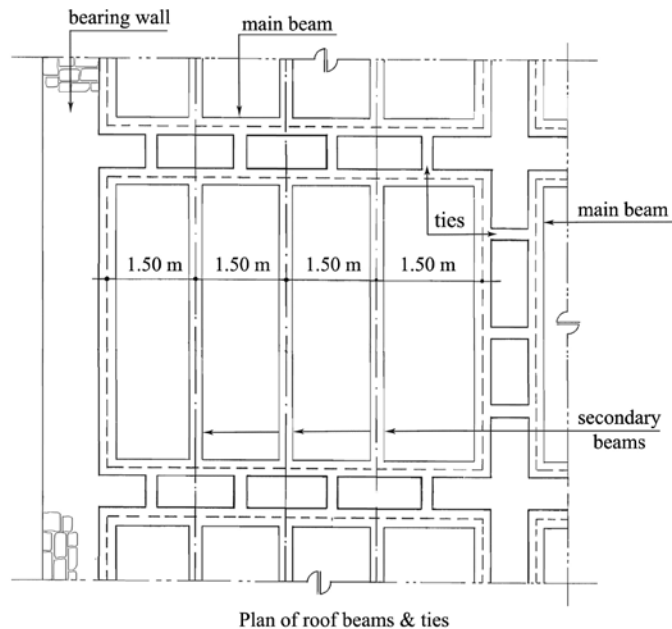


Fig. 6: Details of reinforcement of abutting main beams and ties (1 m = 39 in.; 1 cm = 0.39 in.; 1 mm = 0.039 in.)

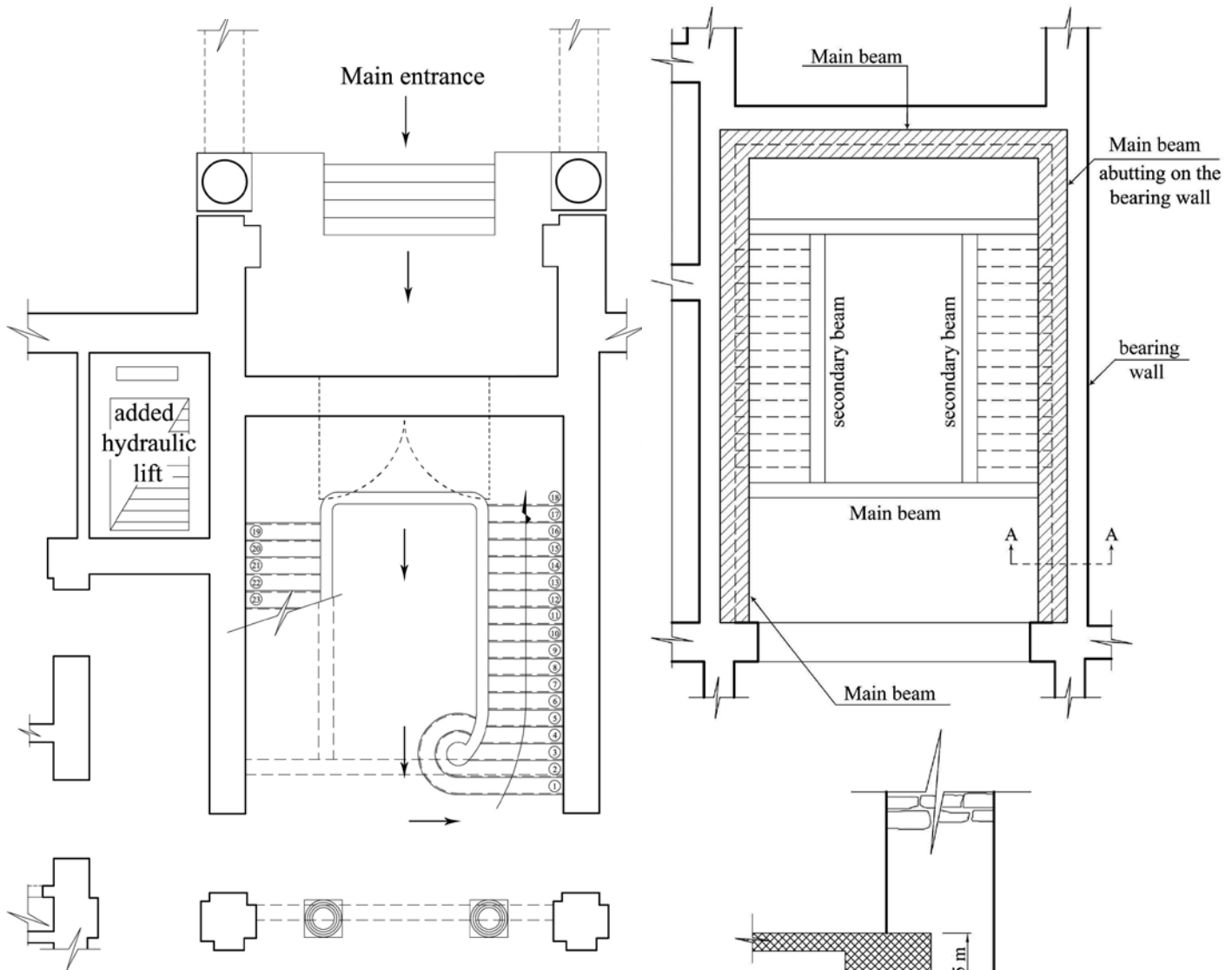


Fig. 7(a): Architectural plan of the main staircase

shows the structural system as consisting of three main beams abutting the three walls and following the shapes of the staircase flights and landing. These main beams also help distribute the load received from the system of secondary beams on longer lengths of the walls.

AFTER 8 YEARS

The repair and reconstruction works of the skeleton (bearing walls, reinforced concrete roofs, and main staircase) ended in mid-May 1998, after 6 months from the beginning of field work. Finishing work, including the elaborate interior and exterior ornaments, and other façade elements, required another 12 months and ended in mid-May 1999.

Inspection of the building was carried out periodically nearly every year from the date of finishing field work, and continued for the next 4 years. The building had no defects, either in the skeleton, such as cracks in the bearing walls and excessive

Fig. 7(b): Structural system of beams for the staircase

deflections in the roofs, or in the relief façade elements, such as cracking and edge spalling.

By mid-2006, another inspection of the building was carried out upon the request of the owner. The skeleton was intact, but some façade elements, especially cornices with big projections, suffered from edge spalling and cracks. Figure 8 shows details of façade cornices and relief elements with their sophisticated outlines. The reasons and proposed solutions for this problem are now under assessment.

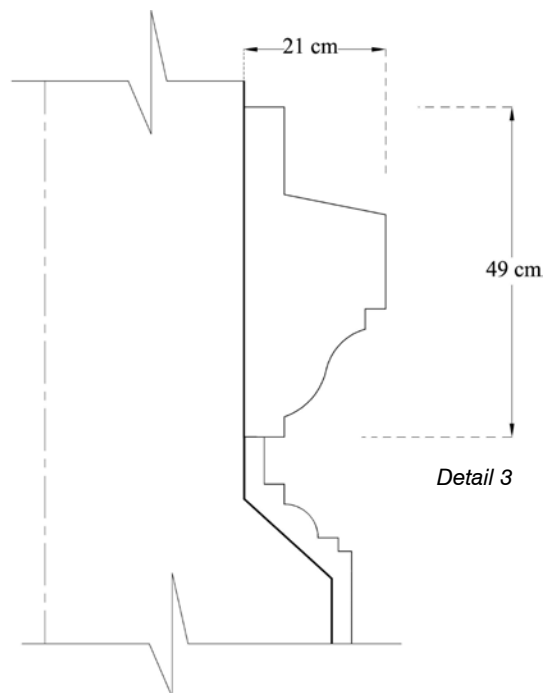
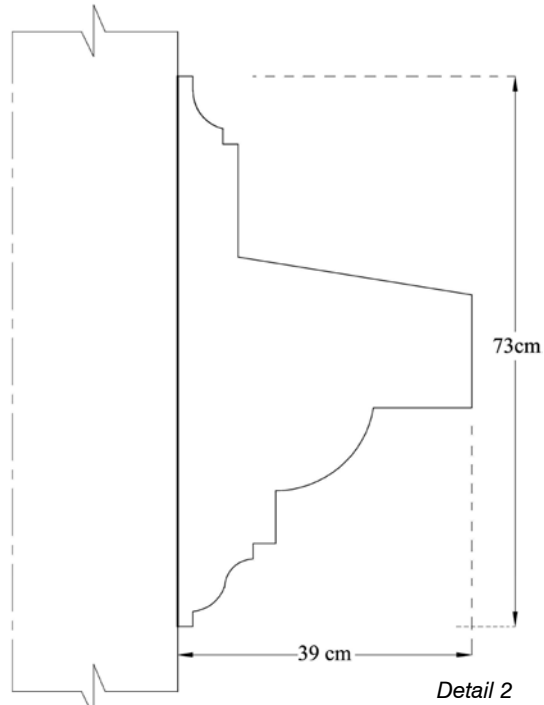
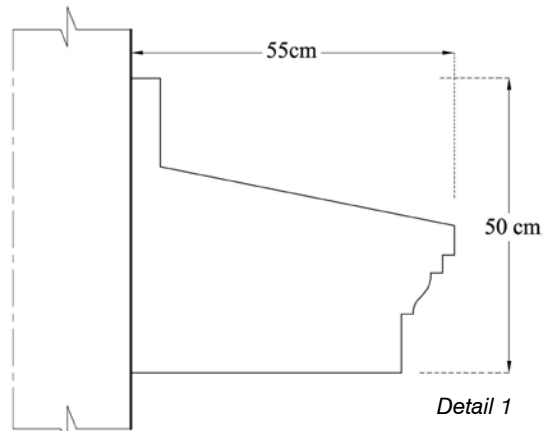
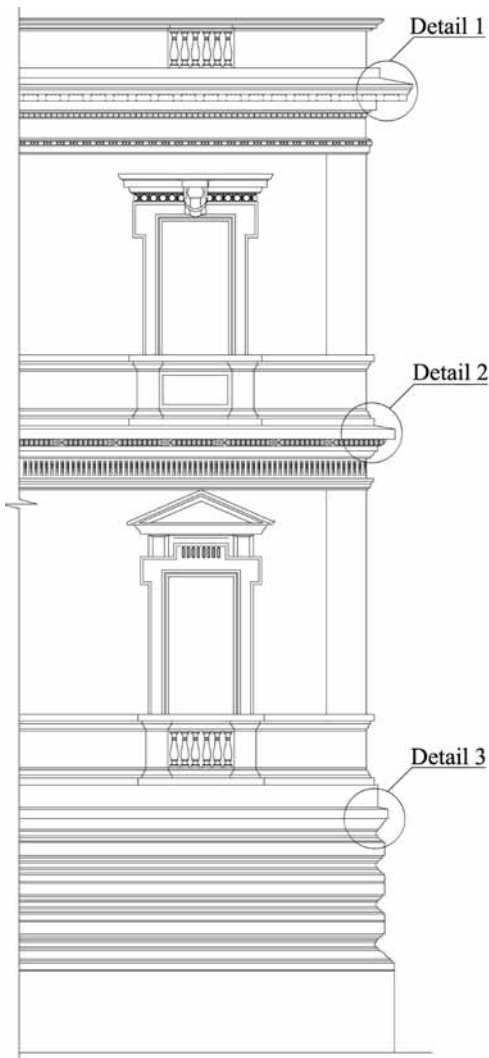


Fig. 8: Section elevation showing typical relief ornaments in the façades of the palace (1 cm = 0.39 in.)



Refaat M. Sallam is a Consulting Engineer and has his own consulting firm that he founded in the early 1970s. Since then, he has been practicing design and supervision in the field of structural engineering. Previously, he had 15 years of experience in the design of reinforced concrete structures, especially for industrial buildings where large spans were dominant. Shell roofs were of concern to him and became the subject of his Masters of Science degree. Since the late 1980s, Sallam has been intensively involved in the field of repair of reinforced concrete structures, as many buildings in his hometown of Alexandria, Egypt, suffered from corrosion of reinforcement. He has successfully conducted the repair and rehabilitation of several royal palaces, hotels, residential high-rise buildings, and more. Sallam is a member of the American Concrete Institute and is the author of a textbook that addresses the causes of concrete deterioration and methods of repair and protection.