STRUCTURE REPORT

"Conservation of the Mosque of Aslam al-Silahdar in Darb al Ahmar, Cairo"

Aga Khan Cultural Services
(Arab Consulting Engineers)

Sub-grant No. EAC-03-2006

The Egyptian Antiquities Conservation Project (EAC)
USAID Agreement No. 263-A-00-04-00018-00

Awarded to

THE AMERICAN RESEARCH CENTER IN EGYPT (ARCE)

Address: 8700 Crownhill Blvd. Suite 507, San Antonio, TX 78209 Tel: (210) 821-7000

by the

USAID Program Office of Productive Sector Development / Office of the Environment
USAID / Egypt

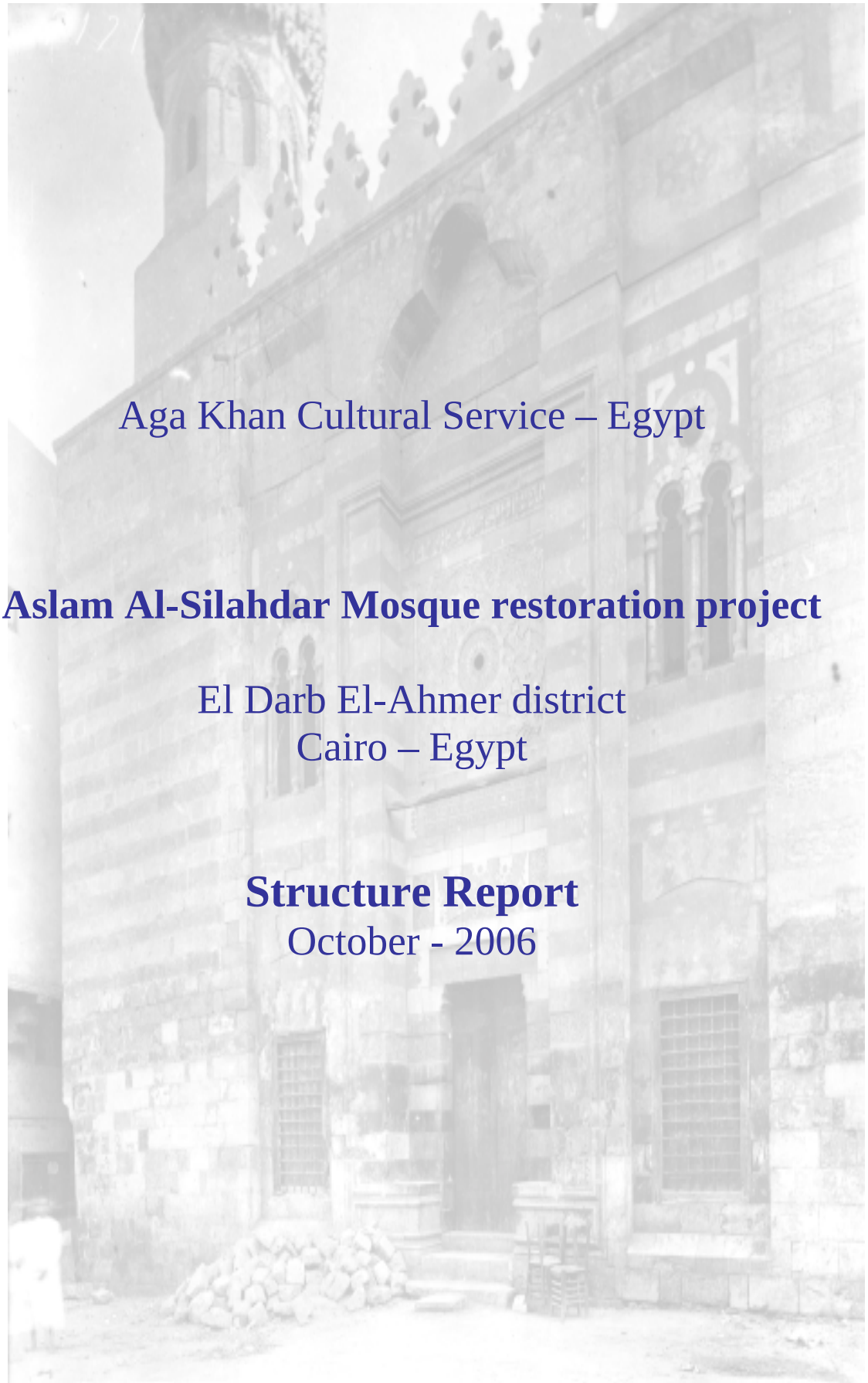
October 2006

In collaboration with the United States Agency for International Development and the
Egyptian Ministry of State for Antiquities

USAID
FROM THE AMERICAN PEOPLE

A R C E
AMERICAN RESEARCH
CENTER IN EGYPT

وزارة الدولة لشئون الآثار



Aga Khan Cultural Service – Egypt

Aslam Al-Silahdar Mosque restoration project

El Darb El-Ahmer district
Cairo – Egypt

Structure Report

October - 2006

ACE CONSULTING ENGINEERS
MOHARRAM.BAKHOUM

Table of contents

Abstract

Based upon the agreement between AKCS-E & ACE concerning restoration project of Aslam Al-Silahdar mosque restoration project .& to the available drawings.

This technical report is prepared to address the structural problems in correlation with the techniques & the materials susceptible to be used in the restoration interventions.

Historical background

The mosque of Amir Baha' al-Din Aslam al-Silahdar was built by the amir in 1344-5. Baha al-Din Aslam was a Kipchak Mamluk who rose to the rank of silahdar (sword bearer) of Sultan al-Nasir Muhammad. As a victim of vicious slander he was imprisoned for six and a half years and was not reinstated until the end of al-Nasir's reign. The historian al-Maqrizi describes him as a kind man, known for his good deeds, and a pious man who sat at the head of halqas (circles of students).

This mosque was built in stages, each segment of which was dictated by the preexisting structure and by the desire to achieve a unified and coherent scheme. The mausoleum, which predates the mosque, is integrated into the

cruciform configuration of the complex following the Madrasa-Mausoleum of Ahmad al-Mihmandar as a prototype. Among the new variations that the plan of the mosque introduces on the four-iwan theme is the inclusion of an entrance that opens directly onto one of the iwans in addition to one that leads to the sahn through a bent passageway. This direct entrance on the south was probably the one through which the amir entered his mosque. The iwans, which are of different heights, exhibit novel features both horizontally and vertically. Over the south and north iwans, which open onto the sahn through a tripartite portico, are rooms for the users of the complex. The room over the south iwan was most likely a reception room for the amir, who was also a shaykh in the madrasa, since it is also positioned above the princely (southern) entrance to the mosque. The opposite room, which has a separate staircase, was probably related to the rab' (no longer extant) on that side of the complex, and served, along with the iwan underneath it, as a madrasa for the Shafi'is. The facades of these rooms on the courtyard are pierced with triple windows and are adorned with striking carved stucco medallions and lozenges. The west side of the sahn is unique in its vertical volumetric organization, for it houses two balconies along with an iwan. The first balcony, which is made of wood and hangs across the iwan, probably functioned as a dikkat al-muballigh (for the call for prayer). The second, above the iwan, is a rare feature in Mamluk mosques and becomes popular only in Ottoman mosques. It was most likely used for theological discussions.

The ribbed brick dome of Aslam is adorned, at the base of the ribs, with fleurs-de-lis cresting in green, white and blue faience mosaic. The crenellations around the base of a dome are unusual for Mamluk Cairo. The Qur'anic verse running around the drum of the dome is also executed in polychrome faience mosaic, otherwise seen only on Cairene buildings with royal patrons. The inscription is the Throne Verse (2:255).

During the Burji period, the more traditional techniques of marble mosaic and glass paste, which were introduced for the first time in Cairo in the complex of Qalawun (1284-85), were employed to achieve polychromy. The panel of marble mosaic surrounding the oculus above the south portal clearly belongs to the same workshop that produced the marble mosaic framing the mihrab of the mosque of al-Bakri (1345). This complex is representative of the constantly evolving Bahri Mamluk religious architecture, with its rejection of fixed formulas and modules. New configurations of iwans, halls, portals, and courtyards were developed in response to the challenges of the land available and the new functional requirements of the project. Similarly, there are no fixed patterns for surface decoration; scattered elements were put together to form an ensemble for a specific surface area.

Building description & materials used :-

The monument includes the main prayer hall , mausoleum, modern ablution area & the minaret.

It is also includes several rooms distributed in three levels above the ground floor level.

prayer hall

- The main prayer hall has its traditional Mamluk four Iwans & middle court yard covered with timber ceiling stilted on steel beams in a formation of "Shokshika". Stone arches takes place at the entrance of each Iwan two of the supported on four marble columns with timber beams fastening at the level of the crown.

The Iwans walls has been built using dressed lime stone blocks until the level of the stone arches,

the rest of the walls consist of plastered brick constructions.

Colored wooden ceilings located at the level of the stone arches crest covers.

Mausoleum Facade

- The Mausoleum takes place at square area toward the street side. The Mausoleum walls has been built using bricks & mortars covered with

plaster. It is including vaulted ceiling built with bricks & plastered from the inner side & molded from the outer side.

- The Minaret starts above the mosque ceiling ,it is noticed that it is not following definite architecture type all along its height.

Its lower part following the Mamlouk architecture motive while the upper part has been rebuilt following different architecture type.

In general the minaret loses major part of its height during the reconstruction which affects its beauty & integrity aspects.

Minaret

- Two main staircases still exist in the building accessing the upper rooms & the roof.

The first started from the prayer hall serving the minaret & a part of the upper levels rooms ,it is consist of stone slabs stilted from one side at the stone walls & central pillar at the middle.

The other staircase started from the area of the ablution serving the upper rooms in the other side of the building. It has been built following the conventional manners by means of arched flights & landings using stone segments , in addition to stone trade & risers forming the steps.

Minaret Staircase

The minaret embrace in its inner shaft lime stone spiral staircase leads to the existing stone balcony started from the ceiling level coinciding with all other Mamlouk building, while at the upper timber part includes timber staircase

- The building includes two integrated facades , the entrance façade towered the "Aslan" square while the other located at the side ally containing some five shops.

The Quibla Iwan façade is partially obliterated by the nearby house while the fourth façade is totally missing.

Main Facade

All the façade walls were built using dressed lime stone blocks , enhanced at its upper part with crenellations.

- The building having two main timber gates , the first or the present main entrance which located to the side opened directly to the middle of the prayer hall ,while the other located in the side façade generating bent entrance to the prayer area.

Side entrance gate

- Modern ablution area located at the back side of the existing building bounders.

Ablution area

It has its new walls & ceilings in addition to terrazzo tiling covers the floors.

- Lime stone tiles covers the ground all over the mosque , on the other hand the upper floor rooms covered with lime stone tiles following smaller dimensions.

Upper room walls

Building materials:-

Different building materials had used in the construction of the monument

- Lime stones stone blocks has been used extensively in the building construction it has several types distributed al over the building.

Rubble stone blocks has been used in the foundations & in some places in the upper floor rooms .

Different stone types

The superstructure rubble walls has been plastered using lime base plaster mortar.

According to the visual inspections the construction mortar joint used in the foundations areas was based on lime & fly-ash in addition to sand.

While for walls above the ground level it is noticed that the mortar did not include fly-ash.

Facing lime stone blocks also accommodated in the monument walls especially at the ground floor levels & at the facades , some has been used in the first floor level rooms . The building is following the conventional building concept of having stone facing stones from the outer sides & rubble with lime patching mortar in the core.

The type of finish shows minor differences between the façade stones & the ones used in the rooms.

It is noticed that thicker mortar joints used in the room walls while in the façade & the Iwans it is thin ones.

The lime stone blocks also used in the Arches , crenellations & the minaret base .

Marble Column

- White marble columns were used in the side Iwans , the columns consists of base & main body & the crown , according to visual aspects the columns were all in good shape & will fastened together at the level of the crown using wooden horizontal studs , the columns shows different motifs which proof that they have been recycled from other older buildings.

Other marble & Bazalt stone blocks were used in correlations at the mosque entrance.

- Timber also used extensively in the building ceilings by means of beams & shingles.

Also timber studs were inserted in the brick walls & used in the openings lentils. Doors , cabinet shutters & turned wooden handrails , in addition to the turned grilled windows illustrate the non structure type of wood used in the building

Courtyard ceiling

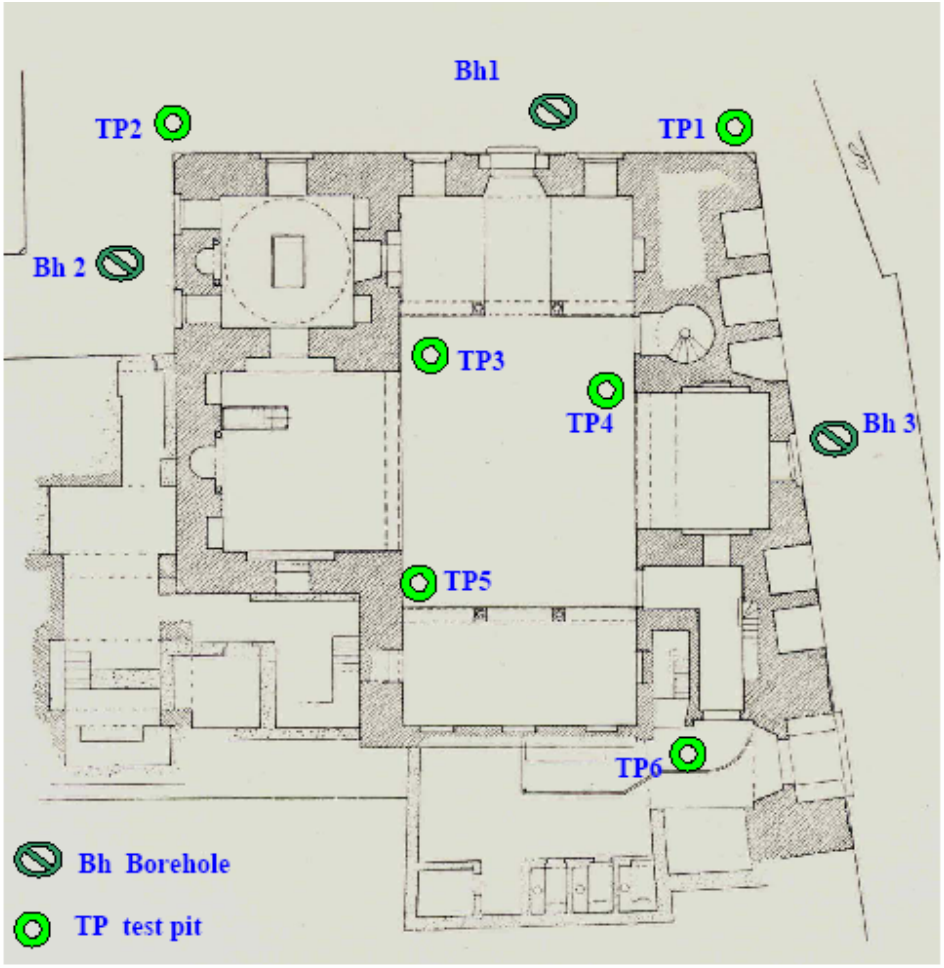
According to the visual inspection different types of wood has been used in the monument .

- Steel is used mainly in the windows metal grills sealing the openings in at the façade in the ground level in addition to the others used in the upper rooms.

Decorative Ceiling

- Red mud bricks is used in the building, it is exists in the foundations with & at the upper walls , more than one type is used in the building , following the building manner & the type of finish, it direct to recognize that the bricks used in the foundation bricks differs from those in the upper part of the walls. The building mortar used also could meet in its main components but different proportions & Potzolanic materials has been used in the foundations & walls .

Geotechnical Studies



Boreholes & test pits lay out

Reference to the geotechnical investigations report prepared by (MAFEC) dated September 2006 Integrated Geotechnical analyses through three boreholes , 12 meters depth located at the street close to the structures boundary.

Soil samples has been extracted by means of manual drilling.

Field test such as S.P.T. as well as laboratory testing program has been carried out .

Underground sort of walls and foundation have been studied through seven test pits distributed inside & outside the complex with depths varies between 0.5 up to 2.8 m .

Under ground Investigations revealed the following : -

The under ground soil stratifications consist of

- Surface non homogeneous fill layer consists of red bricks & limestone fragments, clayey silt, sand, calcareous materials and some gravel. This layer extends up to 6.5 m.

A soil formation consists of brown mixture of silt , sand , and mud. In addition to medium gravel and calcareous materials. Extends till the end of the boreholes located & in the front of the entrance & the side ally , While the one located near the mausoleum consists of yellowish light brown, graded sand. It contains traces of silt, fine gravel and calcareous materials.

No ground water has been reached through the boreholes.

Foundation walls & test pits revealed the following : -

Seven test pits has been performed in order to investigate the foundation walls quality & foundation level.

The foundation level did not reached during any of the performed test pits

Generally different type of foundation constructions arose.

According to building materials , in some places the foundation construction consists of lime stone rubble with patching lime base mortar walls stepped larger than the upper walls (test pit No. 1).

At the location of test pits (No. 4 & 5) old red brick construction with lime base mortars as binding materials has been used.

At the location of test pits (No. 2) facing lime stone walls takes place below the building wall.

At the location of test pits (No.3) two types of construction exists , rubble walls above brick construction.

At the location of test pits (No.6) earth fill combined with mud representing the foundation shown, probably the construction hides the real foundation walls , especially it is exists in the location of ablution area more over it is directly in front of the entrance of the staircase.

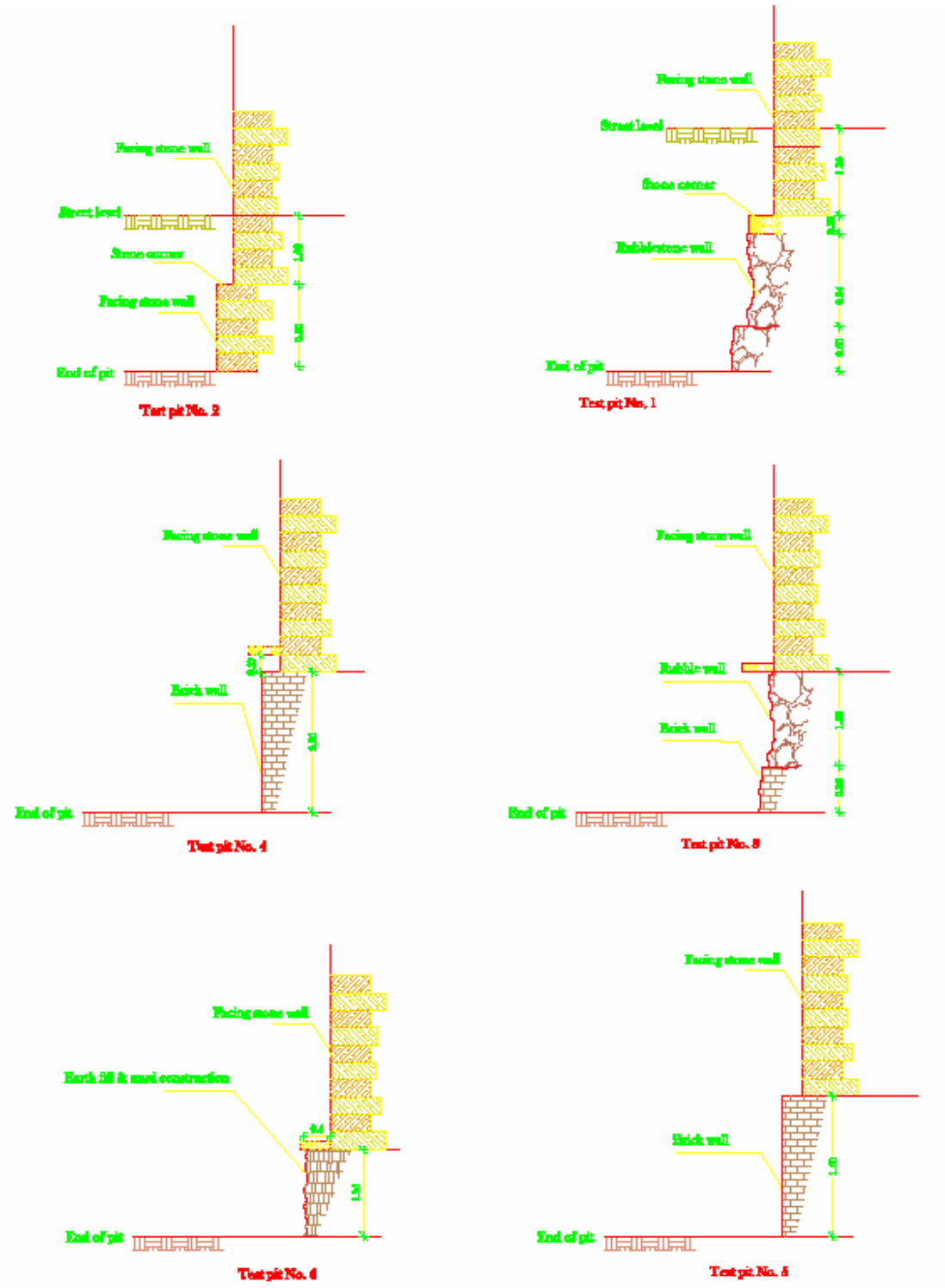
As a principle the walls rested on it did not shown any type of deteriorated related to foundation problems, consequently specific foundation treatment is not required at the moment.

Further data will be available during the extensive excavations & after removing the ablution area new tiling.

The type of intervention (if needed) will be defined according to the collected data.

With accordance to the foundation types diversity in the building, it revealed that the building probably has been built in different phases or built above remains of older buildings.

Generally the building walls did not show evidences of any problems in need for heavy interventions related to the soil or to the building foundation, local stiffening works could be done for the bared walls below the flooring level if needed .


Facing stone wall
Street level
Stone corner
Facing stone wall
End of pit
Test pit No. 2
Facing stone wall
Street level
Stone corner
Rubble stone wall
End of pit
Test pit No. 1
Facing stone wall
Brick wall
End of pit
Test pit No. 4
Facing stone wall
Rubble wall
Brick wall
End of pit
Test pit No. 3
Facing stone wall
Earth fill & mud construction
End of pit
Test pit No. 6
Facing stone wall
Brick wall
End of pit
Test pit No. 5

General aspects and causes of deterioration

The mosque located in a crowded and populated area at AL Darb el Ahmer district. It was built in the 14th century.

The main causes of deterioration summarized as follows:-

-The natural aging process.

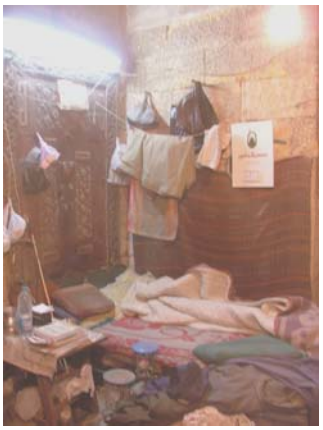
-Surrounding environment.

-Earthquakes.

-Miss use and deficient of maintenance.

Mosque Urban Area

All of the above items imprint different deterioration aspects on the vulnerable monument elements. Cracks on the facades and rooms, salt efflorescence, eroded mortar joint, stone patina corrosion, wood boring insects infection, fungus, wooden beams and shingles exhibit cracks are all deterioration symptoms.



Monument miss use

Salt is one of the main reasons of deterioration. It crystallizes inside the stone in collaboration with ambient humidity impose internal pressure harming the stone exposed surfaces.

Hydrocarbons and dust provide a nutrient media for microorganism, which produce acids, invade the mineral components of stones and wood.

Drip rain water with absence of rain water drainage system & roof insulation aggravates the moisture effect.

Dust, vehicles exhaust gases and population activities produced together black hard crust covered the façades and walls .

Different materials cracks

Cracks :-

Different cracks distributed all over the building in the rooms & the façades , most of the cracks considered as non influential cracks , which they were the influence of peeling of the mortars ,Some other cracks could be as a result of the earth quakes or bad previous restoration works.

Cracks around openings

Some old openings has been blocked resent interventions , missing interlock between the walls & the opining new brick works , provides non influential cracks.

The direct resting of beams in the brick walls also engendered local cracks.

Different building construction materials in the same wall provides cracks parallel to the

Cracks under the beams

seam between the two constructions.

The main façade including vertical crack passing between the stones at the upper part of the wall, it is passing through the stone mortar joints .

Bad construction technique also causes cracks.

Broken beams :-

Broken beams & some shingles located at the ceiling of the upper rooms , direct load & bad wood quality could be the reasons of this deterioration.

Ceiling broken beams

Missing of roofing system

The rain rater leaking affecting all the timber elements on these ceilings by increasing the amount of humidity , which allow the microorganism's & termites to invade the wood .

All colors & decorations also are missing at the upper ceilings due to the same reason.

Missing of roofing system

Deterioration of plaster layer

It is noticed in many places that the plaster layer is decayed partially or totally in some places.

The plaster layer works as a binding render protecting the inner bricks & mortars , missing plaster accelerate of daring & eroding the patching mortars.

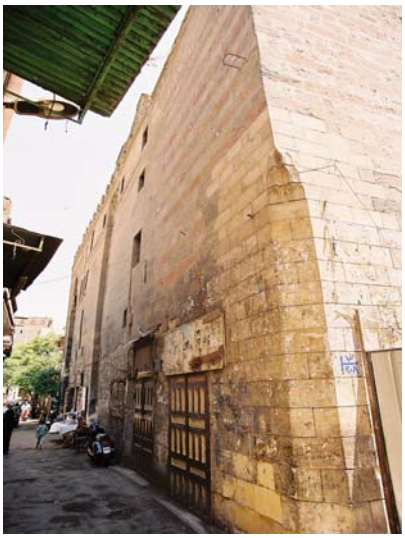
Miss use

It is noticed in many places at the rooms soot covers the ceilings, it is indicated that the monument was not used in a proper way.

Façade bulging

At the side façade bulging located the upper part of the wall

Monitoring system in addition to vertical & horizontal observations is needed to define the out of plain bulging amount, the wall did not show any aspects of instability ,but it will be clear out during the monitoring period .



Façade bulging

Ceiling covered with soot

Conclusion & recommendations

- Generally the building did not show particular structural problems.

Conventional restoration manners, are the adequate solutions for the most deteriorated building constituents'.

- No foundation intervention is needed according to what is revealed from the investigation test pets.

Proper documentation drawings in sort of planes , elevations & sections are required for better understanding of the building geometry & loads distributions.

Monitoring system for the cracks should be applied prior the commencement the works, particular importance has to be giving for the façade crack above the entrance , side façade bulging , mausoleum domes cracks.

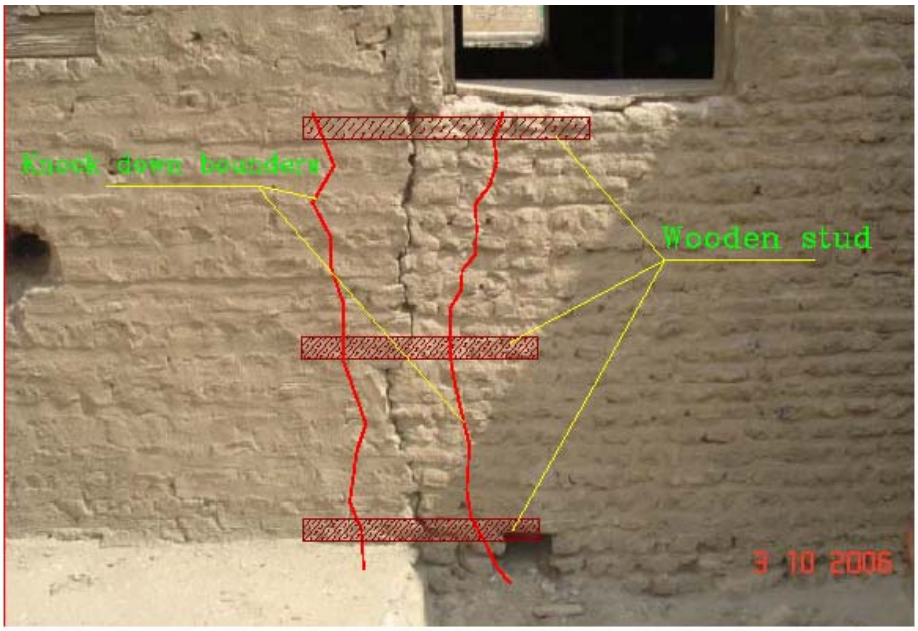
Extensive care should betaken to the ablution area walls , especially for the wall above test pit No. 6.

- At the ablution area it is not recommended to demolish the modern brick walls , which were built sticking to the historical walls in a way of strengthening them, except if the historical walls are thick enough to be treated from inside .

Modern brick walls

- Based on the typology of brick construction above stone walls ,the restoration processes should proceed from bottom to top , starting form the ground level. It is preferable to replace the deteriorated stones starting from the ground floor prior commencement of the restoration interventions at the brick works in the upper levels in order to avoid having additional cracks in the vulnerable brick walls after handing over the restoration process.

- The street level in front of the monument could be lowered if it is found crucial for historical or archeological reasons, but it should not exceed on meter ,more over the lowering activates should be fulfilled prior any restoration works in the façade walls or the rooms located towards the lowering area.



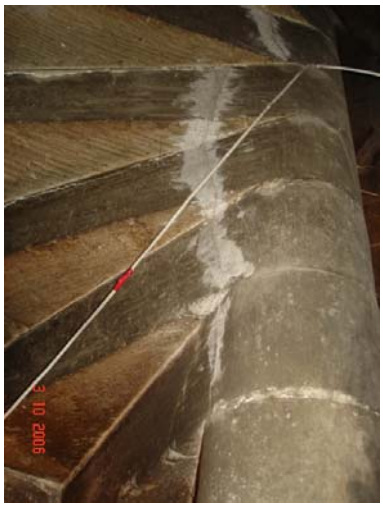
Crack restoration from outside

- It is recognized that the plaster works inside the monument embellished with several moldings & decoration elements. The brick walls restoration works will harm all the old plaster & moldings in the working areas , consequently it is visible to work from the outer sides using light tools .more over gypsum pads above fiberglass mesh has to be used to conserve the plaster & decorations during the restoration process.

- Roofing system using water proof membrane of 4 mm thickness in addition to final tiling using blue lime stone tiles of 3-4 cm according to the attached detail is recommended to protect the roofs & the walls.

The existing roof

- It is noticed that the staircase leads to the minaret at the religious area is in very bad shape , a lot of its steps were broken in addition to different cracks exists at the surrounding walls consequently the staircase has to be closed totally until the remedy works start. Independent staircase should be provided to accommodate the working traffic.



Staircase leads to the minaret

- Regarding to the importance of fairly identifying the properties, characteristics and behavior of the monument.

Investigation of the monuments materials is the most important step in clarifying the deteriorations & assessing the remedy procedures' & techniques.

Modern methods of investigation are lately used to give an idea about building materials such as stone, brick, mortar, plaster layer, pigments, marble, metal and wood.

Modern equipment's are used now a days to determine the causes of deterioration methods and equipment's used in the monument under investigation are :

- X-Ray diffraction (XRD) to identify the compounds of stone, mortar, plaster layer, bricks and salts.
- Scanning electron microscope (SEM) to get the morphology of the sample, it is also used to study the deterioration forms of building materials.
- A study of temperature and humidity or moisture level (RH) by using Protimeter
- Infra red (IR) to distinguish the media which is used with pigments.
- Chemical analysis for binding media.
- Biological investigation
- Petrography study on stone.
- Pressure and bending tests on wood.

The results of all these investigation will be of a great use to determine the causes of deterioration and the methods of conservation.

Preliminary restoration activities & precautions:

- Water supply & sewage network should be totally disconnected from all part of the historic complex in order to stop the main humidity resources, allow walls to dry & avoid extra salts contamination.
- Temporary passageways , staircases should erect to accommodate the traffic of the materials using in the restoration & the circulation of work ,especially to protect the main staircase & to conserve its condition until the restoration activates started.
- Building scaffolding around the monument concern facades to provide the required accessibility for the restoration works without using the ceilings & openings.
- Necessary shoring for imminent danger rupture & deteriorated areas has to be placed according to the project specification & standards .
- All wooden doors & delicate items should document, removed & stored in a ventilated safe place. They should be kept in the right bed direction above wooden platform.
- All materials proposed to be used in the project should be from the reversible type , without affecting the old & surrounding elements
- All chemicals & row materials has to be from known origin & they should be supplied in their original
- The new wooden peace's has to be treated against , micro organisms, insects & it should be selected with sufficient dimensions susceptible to work in a good manner .

- Documentation via photographs, drawings & reports describing the restoration concept & procedures case by case has to be prepared prior the commencement of the work.
- monitoring via fiberglass string strain gauges or5 similar for the cracks while restoration is needed .

Stones restoration processes:-

Stone replacement :- disintegrated & cracked blocks of stones could be removed and replaced by new ones similar to the old stone in the chemical & material composition more over it should match in color with the surrounding stones. The pointing works could be done simultaneously while building the stones. The building & the pointing mortar has to be lime base mortar consist of Lime, sand (free from salts), stone powder in proportions of 1:2:1 , 10 of white cement could be added to improve the mortar sitting time.

Injection:- It is proposed to be the treatment method in the cracked places . The technique helps to fill deeply inside the wall using floodable grout injected inside the walls core through distributed holes distributed around the crack . The proposed grout is a lime base grout consist of lime , fly-ash ,stone powder & 10 of white cement. Working under pressure between 1-3 bars is quit enough to get the required result. Finishes could be applied after fulfilled the injection works to unify the new joints colors with the old ones, using Ocra diluted in water with the required color.

Masonry restoration:-

Brick walls existing condition

The crack treatment :- Brick walls cracks could be repaired if they are local , but incase of family of crack other alternatives could be better. The following technique could be applied in order to restore the walls single or double cracks.

A- Removing the unconsolidated bricks through and around the crack, all crumbling and loose materials in the core should be removed.

B- Strengthening the core using bricks patched with lime mortar (free from salts) consist of, lime , fly ash , sand in the proportion of 1:1:2.& 10 of white cement.

C - Wooden treated studs with suitable sections in the horizontal levels and in the corners to be placed to connect & redistribute the loads.

Knock down & rebuilt :- this alternative is the most convenient solution for the totally deteriorated walls & for the walls which affected by family of cracks.

Shoring should be placed in advanced to carry the ceilings load then dismantle the walls , store & sort the intact bricks to reuse them.

Rebuilt them using the old bricks after washing the properly in flooded water.

The rebuilt walls has to be built with the old & some added new bricks & fortified with wooden studs every now & then or as it was in the original state if their was a timber studs. The mortar used will be lime base mortar

consist of, lime , fly ash , sand (free from salts) in the proportion of 1:1:2. & 10 of white cement .

Plaster Works:-

All deteriorated & hollow sound plasters should be flaked in advance to access the walls conditions & to apply the new plaster layers , sticking well with the walls after restoring them

Brick walls & vaulted ceilings should be plastered using lime base mortar consist of sand with different grain sizes ,lime , stone powder. According to the following procedures:-

a- Preparing the surfaces to apply the plaster layer.

b- Apply the Initial Undercoat (touting layer).

c- Second undercoat (Float Coat).

d- Finishing or Setting Coat

The smoothness of the & colors of the surfaces will be the same as the old plastered walls in phase one , modifications should be done if needed to match the new plasters & the old.

Brick vaulted ceiling restoration:-

In the ground floor bricks plastered vaulted ceilings is notices in the corridor leads to the ablution area.

- In order to define the goodness of the ceilings & their building materials flaking plaster should be the first step in the way of treating them.

- Proper shoring through timber moldings stilted on steel shoring members has to be placed when it required.
- Rebuilt using better masonry techniques to fortify the week & deteriorated parts using a combination of old & new bricks & lime base mortar.
- Injecting using strong lime base mortar to insure filling all the voids & invisible cracks.
- The injection could be done from the bottom or the top of the vault " if accessible " considering that the injection points & processors has to be according to the specification.
- Apply plaster layer as a final treatment task to consolidate & protect the building material.

The wooden ceilings

All ceilings which shows highly rates of deteriorations or broken beams should be replaced according the following :-

Dismantling the old ceilings.

Install new beams form old pitch bine wood with the right section dimensions not less than the old.

Install wooden cushion in the walls in recess 5 cm to allow the plaster works.

Connect the beams to the cushions using nailed timber wedges ,

Install the new pitch bine shingles of 1 inches thickness with width 12 -15 cm ,taking the consideration no to have small peaces.

In case pf having limited number of broken beams exists , they could be only replaced from below conserving the ceiling shingles.

The steel beams carrying the Shokshaka should be cleaned from the rust & painted with Epoxy paints to protect it from corrosion.

Timber Cushions could be placed below it to prevent having concentration of stress directly below which produce cracks in the walls .

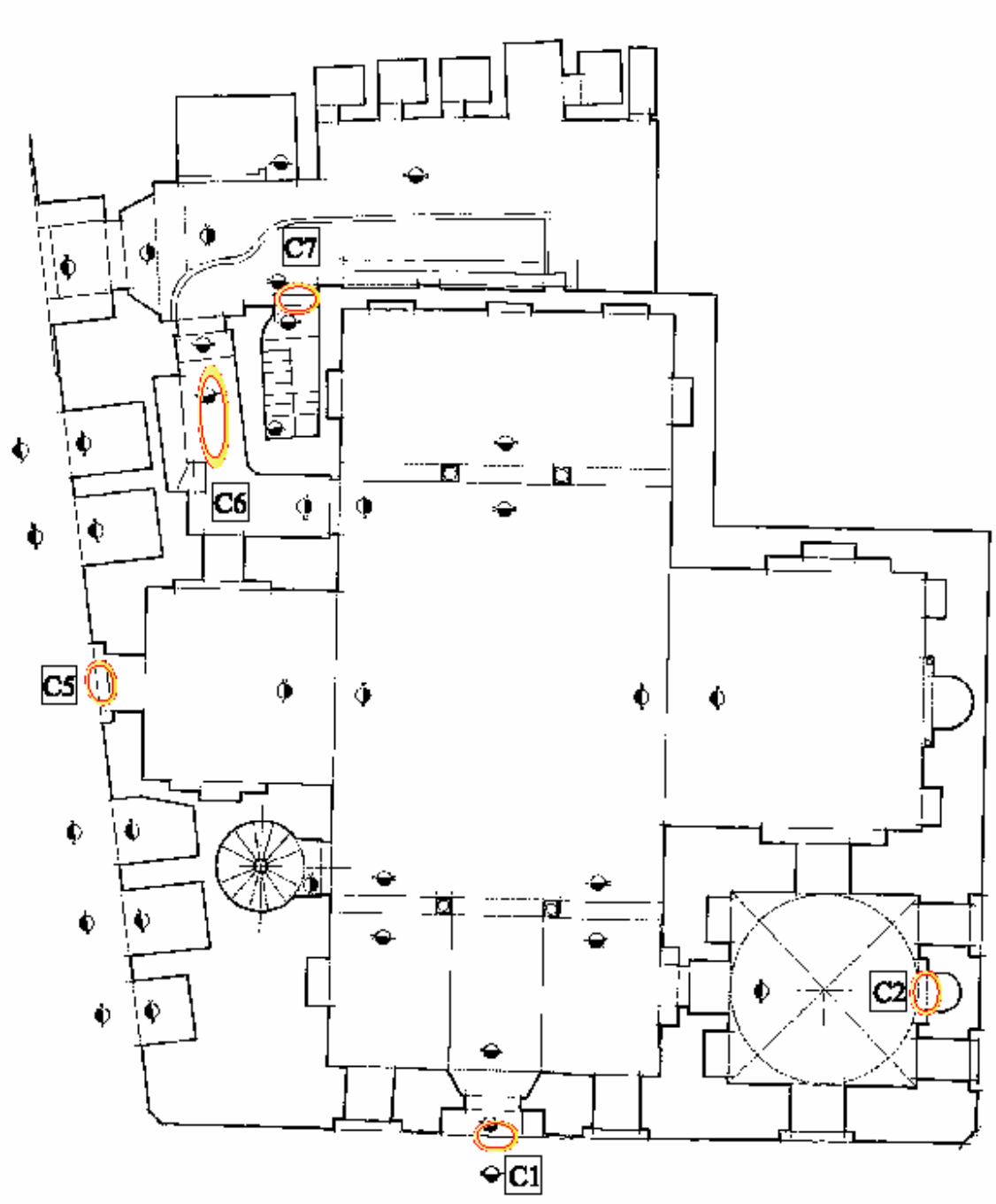
Roofing & insulations :-

There is no sort of roofing or tiling systems covering the madras & the mosque ceilings .

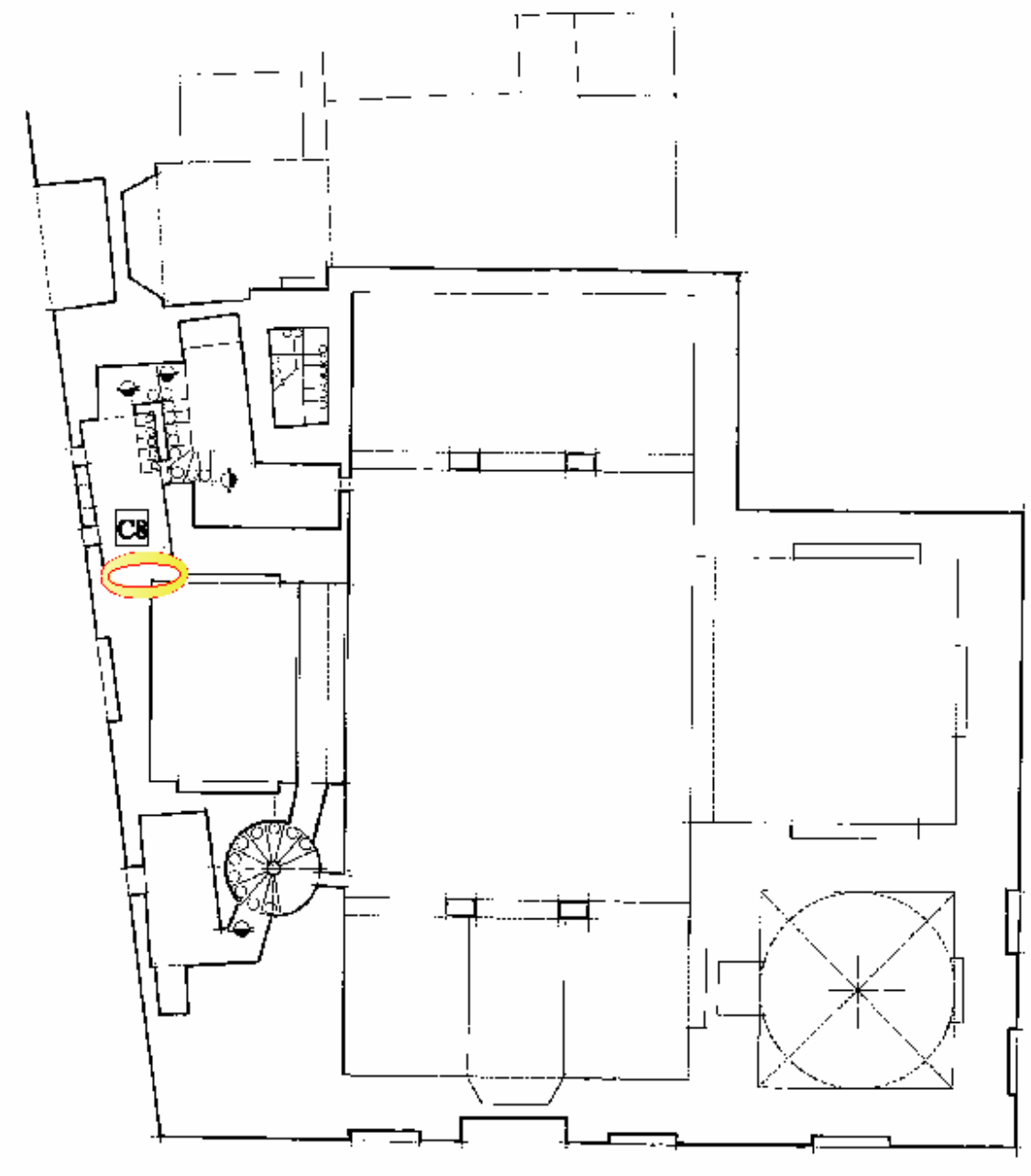
One of the important targets has to provide good roofing system to protect the madras upper floors from the raining water & the other withering conditions.

Bituminous polymers water proof membrane 4 mm thickness is proposed to cover the ceilings above the wood , it will be protected with special light weight sand screed which will sustain as the final exposed surface .

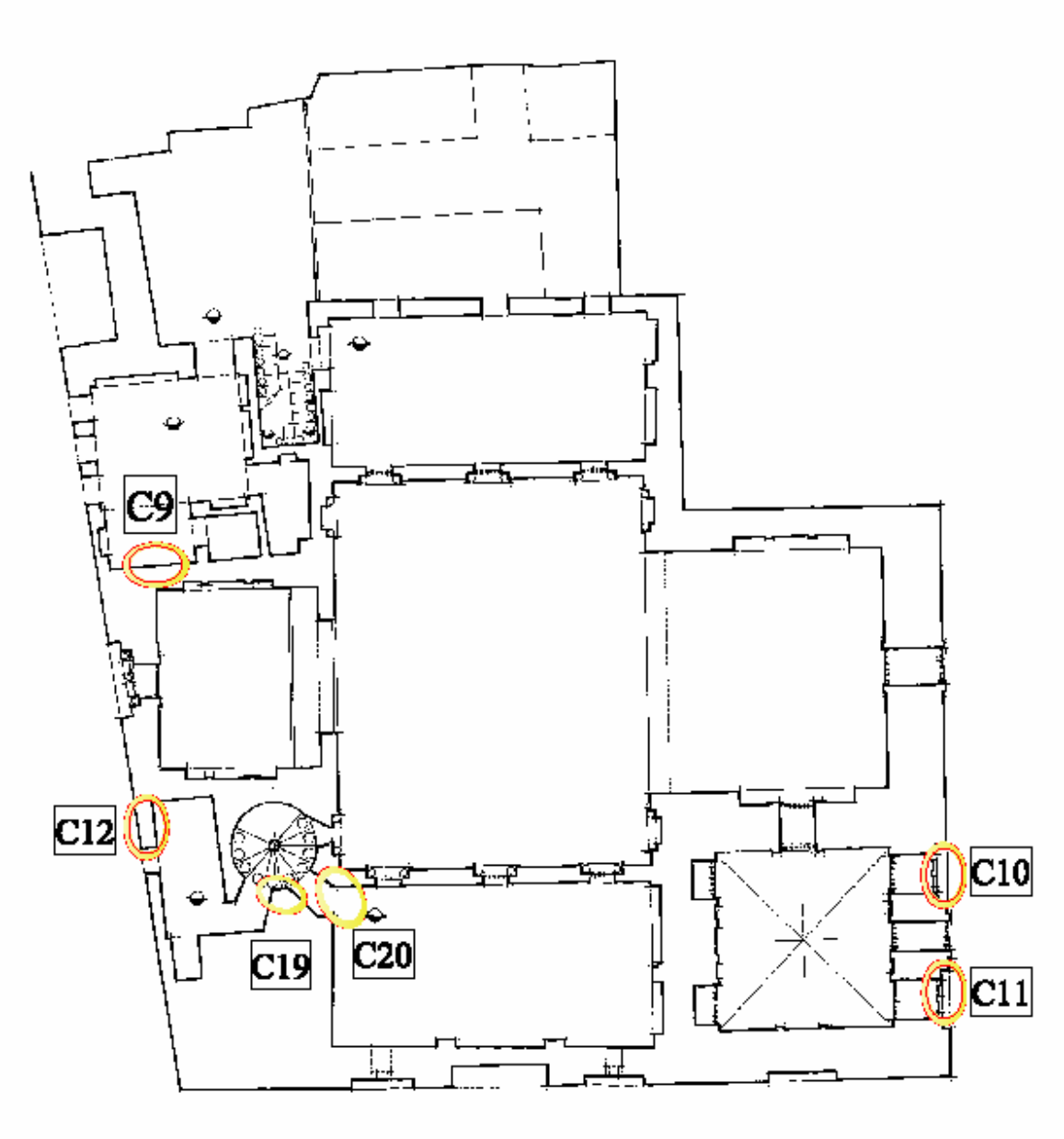
While all wooden final surfaces such as sheds & Shoksheka will be protected & insulated using lead sheets of 2 mm thickness



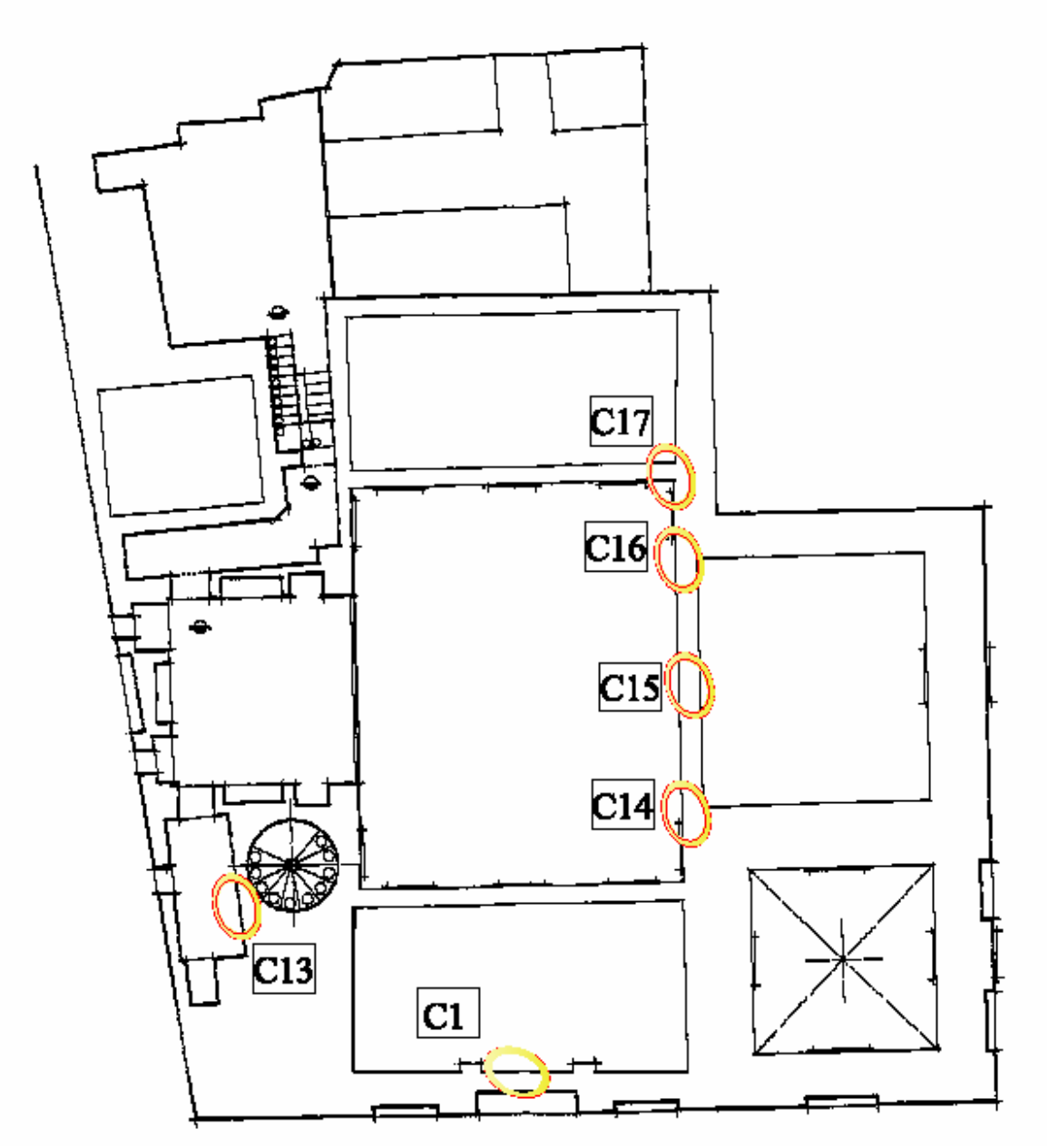
Ground floor plan main cracks locations



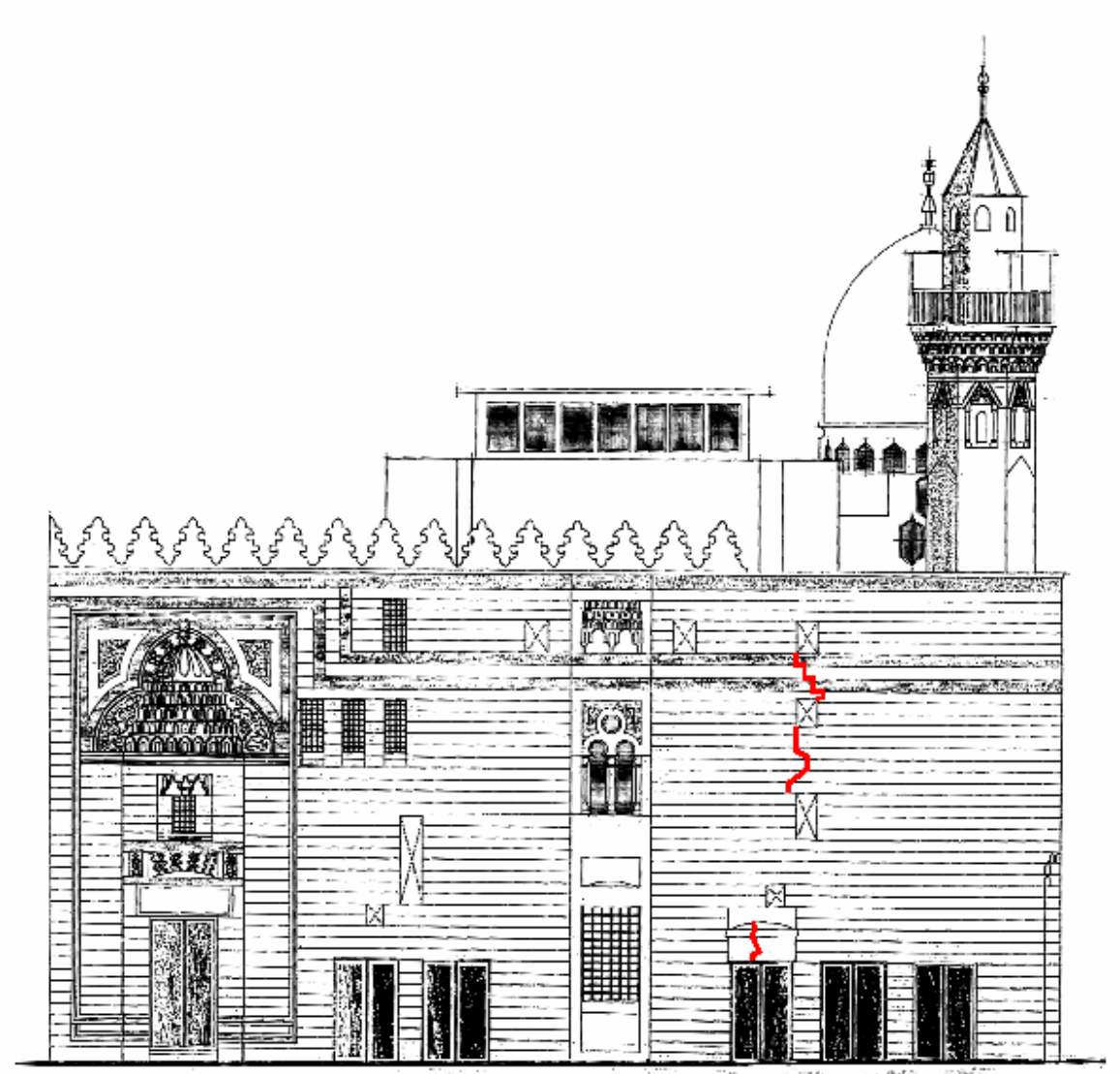
First level main cracks locations



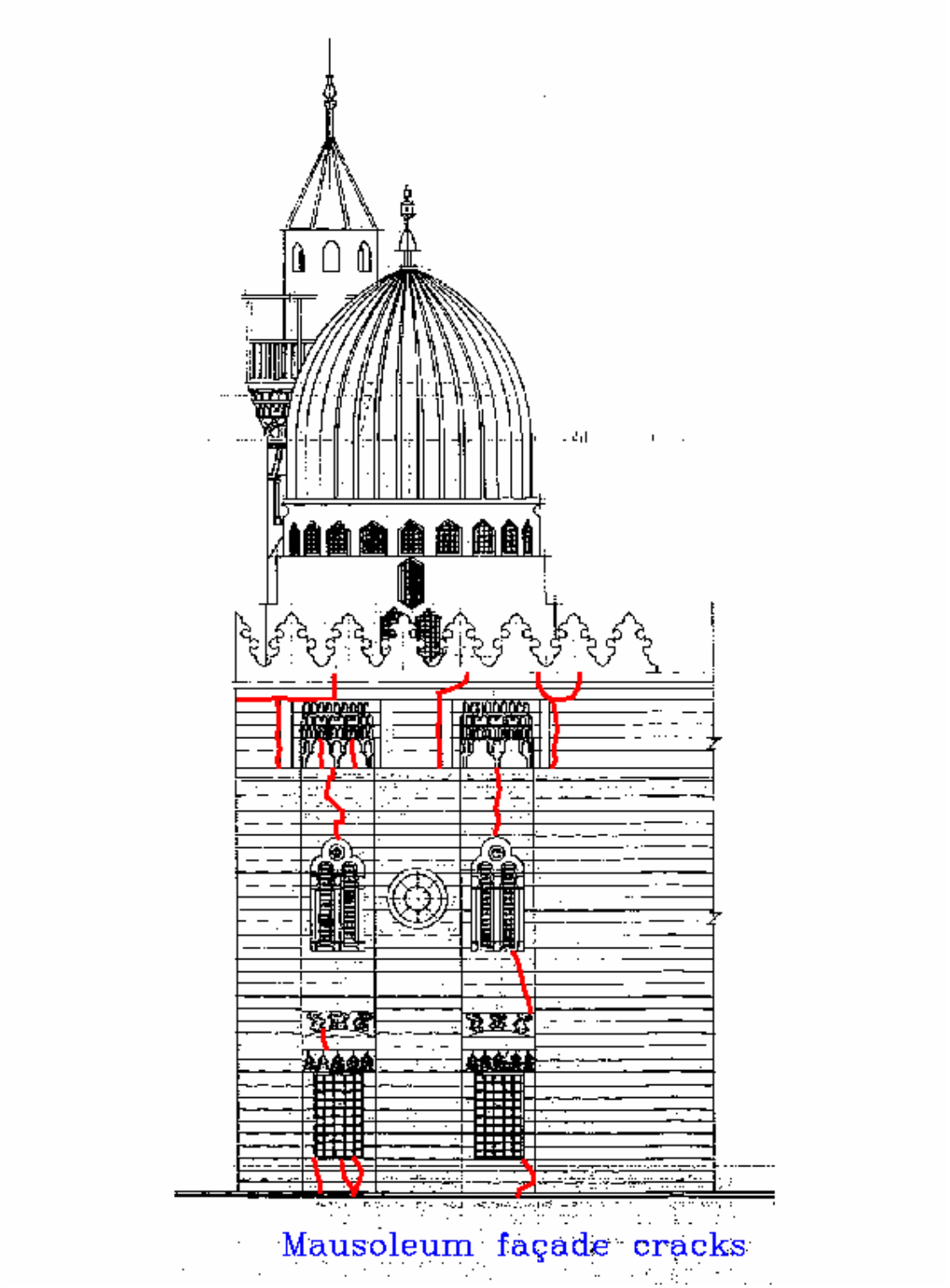
Second level main cracks locations



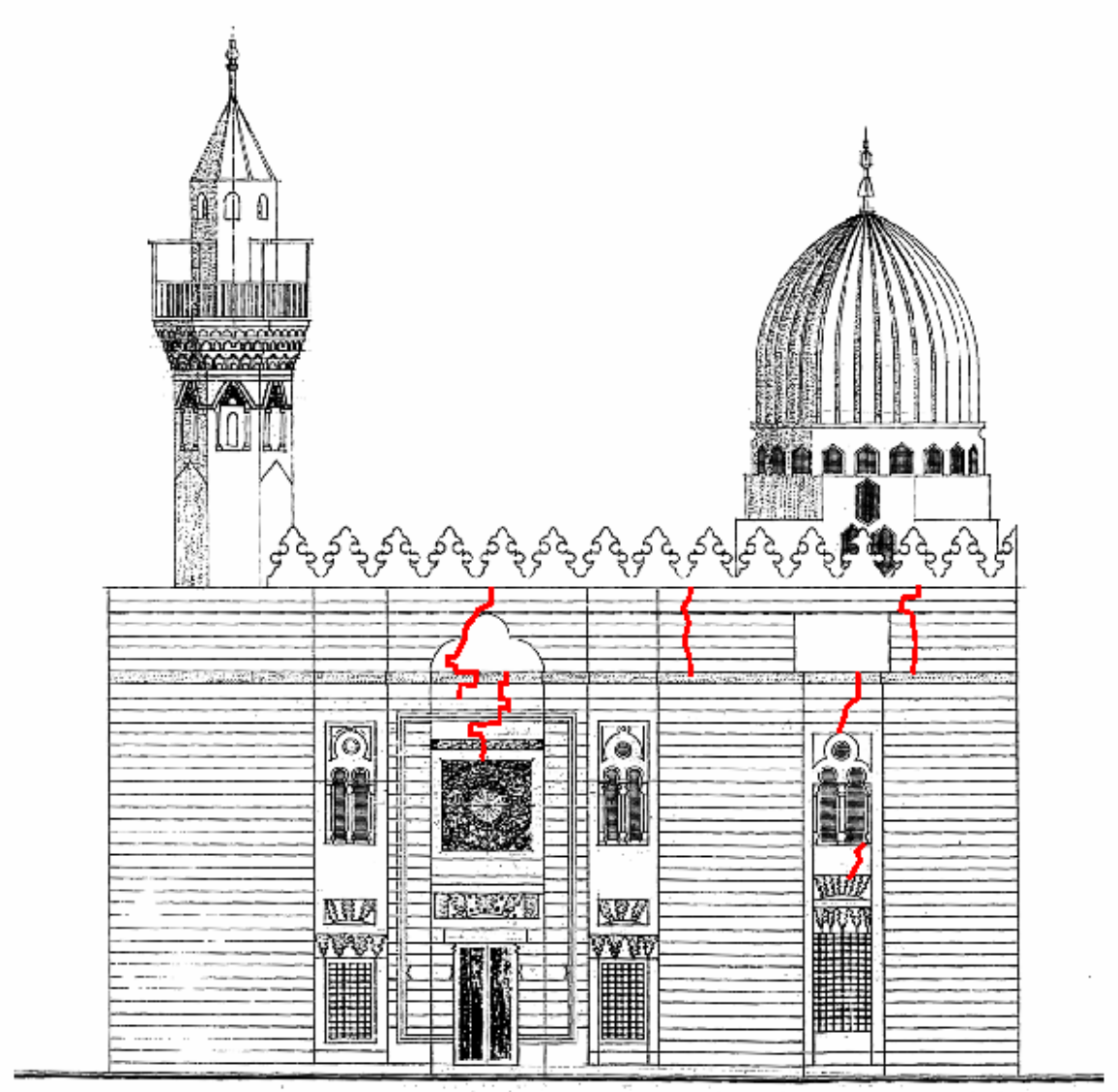
Third level main cracks locations



Western façade cracks



Mausoleum façade cracks



Front façade cracks

Cracks evaluation & restoration techniques :-

It is known that the cracks is the main deterioration aspect imprint on the building walls & ceilings.

Most of the cracks takes place in the monument are due to the deterioration of the building materials or mortar powdering as an influence of the aging process.

Crack **C1 - Strong**

The cracks could be classified according to its effect on the building stability in addition to its inactivity.

According to the visual inspection & to the available data four types of cracks could be distinguished following their structure effects:-

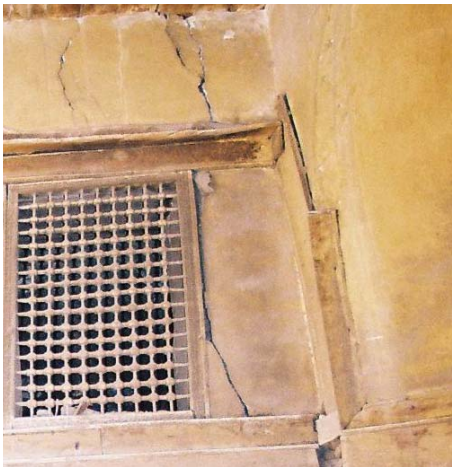
a- Negligible cracks :-

This type of cracks has no effect on the building stability or any of its structure elements, all plaster hair cracks or hollow sound or decorative moldings cracks could be considered following this type.

Crack **C1 – Strong**
Inside the room

Visually these cracks appears as hair cracks not more than 3 mm thickness & 2 mm in width , propagating in all directions , it could be single crack but most of the cases they are integrated in family of cracks, almost parallel or intersected.

This type of crack has no influence in the structure of the building , but it has its disadvantages on the building architecture beauty.



Crack **C**7 - **Serious**

b- Minor cracks:-

It is the crack which has been produced due to local weakness in the building materials as a result of mortar deterioration or peeling of the building stuffing elements.

Visually these cracks are not more than 2- 4 mm thickness & 3 – 4 mm in width , they could be horizontal or vertical , in most of the cases they are following the line of joints between the bricks .

Crack **C**2 - **Minor**

This type of crack has no risk influence at the present time but restoration interventions has to be planned to stiffen the deteriorated elements & mortars.

Crack **C**10-11 - Moderate

c- Moderate cracks:-

It is the crack which has been produced due to local movement or sliding in a particular building constituent of the walls during a period of its life & stopped without affecting the building stability or integrity.

Crack **C8** - **Serious**

The local movement could be due to previous earthquakes or local movement during previous restoration or as a any other similar impacts.

Generally this type of cracks can be distinguished passing through the stone walls joints ,vertically or horizontally , it is around 7-8 mm thickness & 5 mm wide.

Crack **C5** - **Moderate**

This type of crack has no immanent risk influence but sooner interventions should be applied to rectify the defects in order to add more stiffness to the integrity of the building.

Crack **C12** - **Serious**

d- Serious cracks:-

Crack **C**13- **Serious**

It is the crack which has been produced due to local movement or sliding in a particular building constituent of the walls or ceilings during a period of its life & stopped with limited effect on the walls stability or limited effect on the stone courses regularity & continuity. Totally the crack did not affect the total stability of the wall The local movement could be due to previous earthquakes or limited movement during previous restoration or any other similar effects .

Crack **C**17- **Serious**

The crack can be directly recognized with its width of around 1-2 cm & depth around to 4-5 cm.

Generally it is located horizontally or vertically following the line of joints in the stone walls & it could be or inclined in the brick walls.

In many cases it is located between two

Crack **C**16 - **Serious**

building materials (stone & brick construction) or it is located at the upper part of the building in the corners between the walls. This type of crack has higher risk value in addition that negative effect is expected on the defected places.

Crack **C**15 - **Moderate**

e- Strong cracks

It is the crack which has been produced due to movement or sliding in a particular building wall or element or it is a result of settlements. It could be located in walls or ceilings. it is produces during a period of the building life & the source of it could be stopped or still functioning. It could affect the building or walls stability.

Crack **C**14 - **Serious**

The source which produce this type of crack is giving its appearance it could be vertically or horizontally or family of crakes giving star or parallel shape. Generally its width not less than 1.5 cm & its depth not less than 2-3 cm. This type of crack influence

immanent rupture for the cracked parts of the building especially if the building is still functioning.

Fortunately this type of crack dose not exit in the monument.

Crack **C**9 - Serious

In general we could categorize the previous types of cracks in two main major types

Non influential cracks:-

Which includes the types of minor & moderate cracks in addition to, non-continuity and sagging of the horizontal joints appears in several places in the faced as other respected aspects of deteriorations.

Crack **C6- Serious**

Adequate pointing will be a sufficient remedy for this type of cracks.

Whereby mortars of lime (free from salts) stone powder and sand in the proportion of 1:2:1. The surface of the new pointing should be equated with the original Joints. It has also to take the same form of the restored part (the curvatures and the circulation).

Influential cracks

This category includes the serious & strong crack types.

Extensive precautions should be taken prior the commencement of the interventions in the strong type of cracks .

Proper shoring in addition to gypsum pads has to be used to consolidate temporarily all the defected parts to secure the areas during the restoration process.

Generally the restoration process for this type of heavily deteriorated & fragile can be applied according to the following steps , more over adaptation in the technique & processors can take place based on the case of each crack & the area of work.

In order to strengthening the walls in the cracked areas & increase its capacity ,the crack treatment method will be according to the following procedures:-

A - Proper documentation through photographs and drawings (by the contractor) for the stone arrangement on the crack portion has to be done. Required shoring should be placed.

Crack **C19- Minor**

Crack **C20- Minor**
Arch key stone missing

B - Removing the unconsolidated stones through and around the crack, more over all crumbling and loose materials in the ruble core should be removed.

C - Strengthening the ruble core using lime mortar (free from salts) consist of, stone powder , sand in the proportion of 1:2:1.

D - Wooden treated studs with suitable sections in the horizontal levels and in the corners to be placed.

E - Historical facing stones will re-fixed on its original location and deteriorated ones should be replaced with others similar to the old according to the "XRD" results as much as possible .

F - After complete consolidation of the crack joint pointing with lime grout 'similar to the above' will be the final process in the crack restoration method .

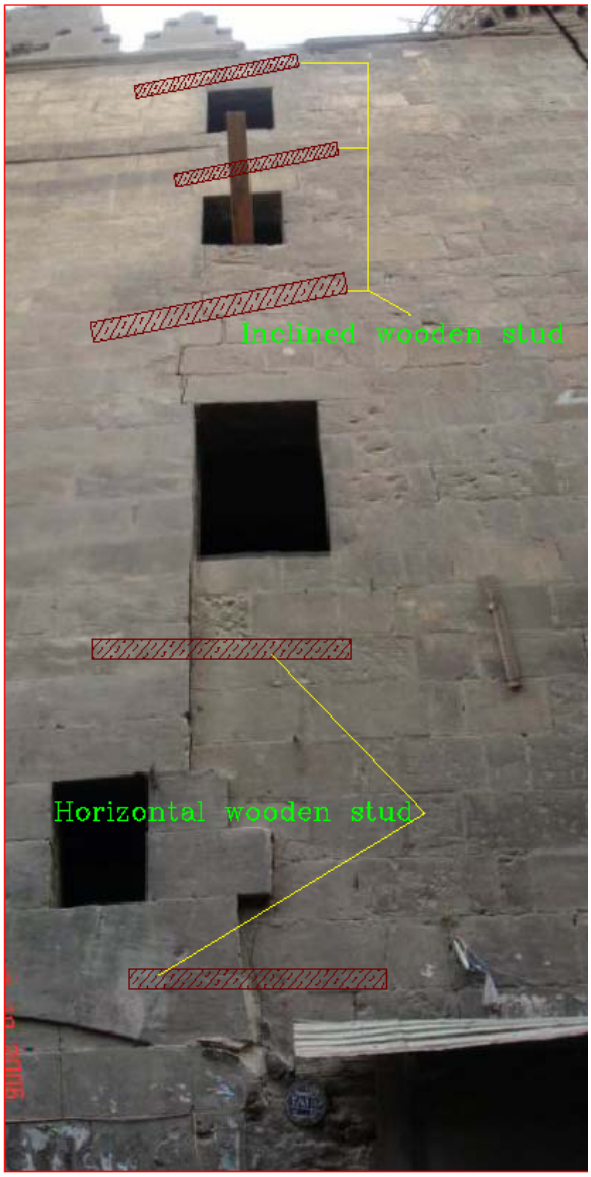
The side façade crack C12

The illustrated crack extended all along the façade in the vertical direction ,It is propagating in the a fragile area of the faced due to the existence of four openings distributed vertically in deferent levels.

The wall thickness in this area is about 40 cm which is not the adequate thickness for such a wall of about 12 m height.

Particular restoration technique is proposed in order to return back the wall stiffness & the horizontal continuity according to the following :-

Timber treated studs can be inserted in the seam of the crack from the inside the rooms to conserve the façade facing stones, the timber elements should be installed inclined with not less than 15 degrees as show in the figure , while the lower timber studs can be inserted horizontally.



The side façade crack C12 timber Studs proposal

Generally all the wooden studs should be placed in the middle of the wall.

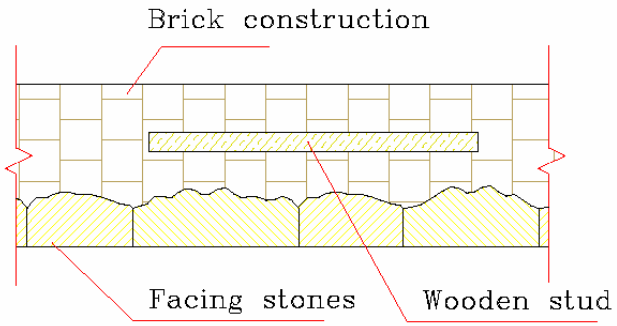
Strong Lime base mortar is recommended by increasing the white cement content to be 20 % or more .

The plaster layer for the brick side of the walls (inside the rooms) will increase the confinement of the wall thus it is recommended to increase the white cement in the plaster inner portion while the final render surface could be done following the conventional manners .

Extensive care has to be taken during the restoration works to protect the wall form having more other cracks in other places .

The restoration works should extend from bottom to top further more no stone replacement should be applied before finishing all the restoration works.

Crack C12 from inside the room



Staircase at the prayer hall :-

Staircase at the prayer hall

The staircase leads to the minaret at the religious area is a spiral staircase, built using stone slabs rested on the middle pillar & the walls at the sides.

It is recognized that stone wall has been built at the ground floor level extended to the first level floor in order to stiffen the steps at the level between the ground & the first .

Generally most of the stair slabs are in very bad shape , a lot of them were broken in addition to different cracks exists at the surrounding walls.

The staircase existing condition can not sustain the labor traffic & the material transportation.

It is highly recommended to provide other independent possibility to access the upper rooms without using the considered staircase.

Steps cracks near the pillar

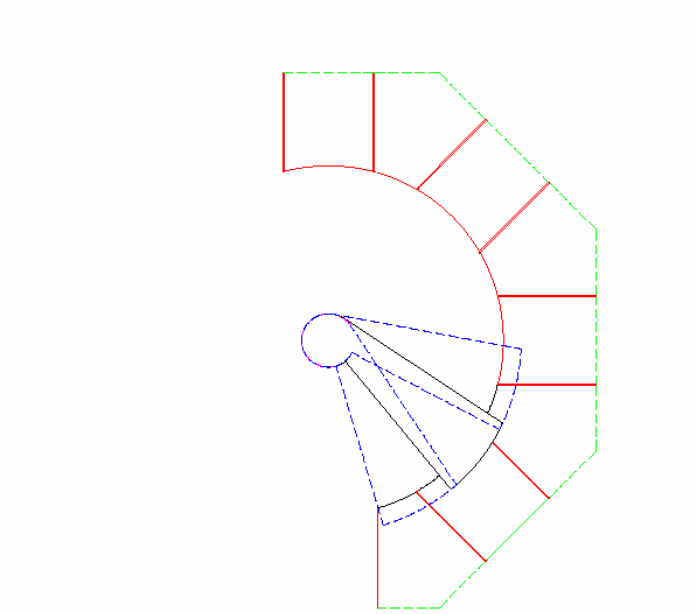
' staircase has to be closed totally until the remedy works start. Independent staircase should be provided to accommodate the working traffic.

Blue lime stone slabs can be installed replacing the old broken ones.

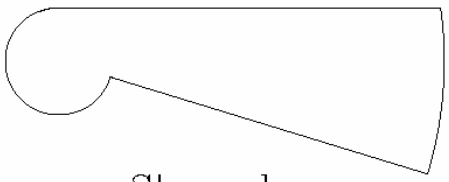
Each stone slabs has to be molded forming the step & the pillar segment, it has to be expended inside the wall with length not les than 15 cm.

Usually the stair construction should work from bottom to top , consequently the old staircase has to dismantled totally in advance.

Proper documentation is needed prior the commencement of the work to define the levels & orientation of each step.

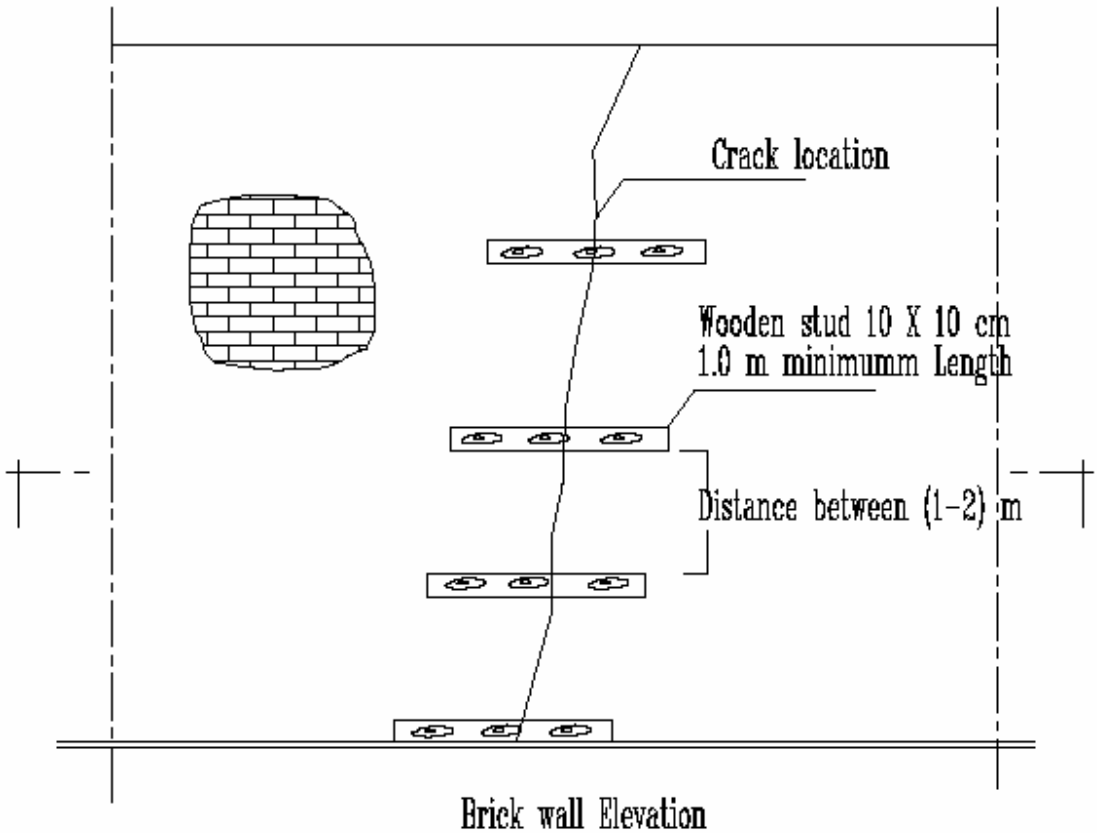


steps plan

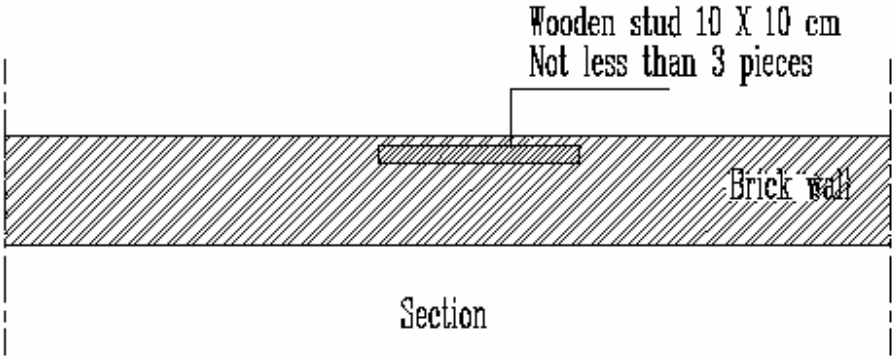


Step shape

Staircase steps proposal

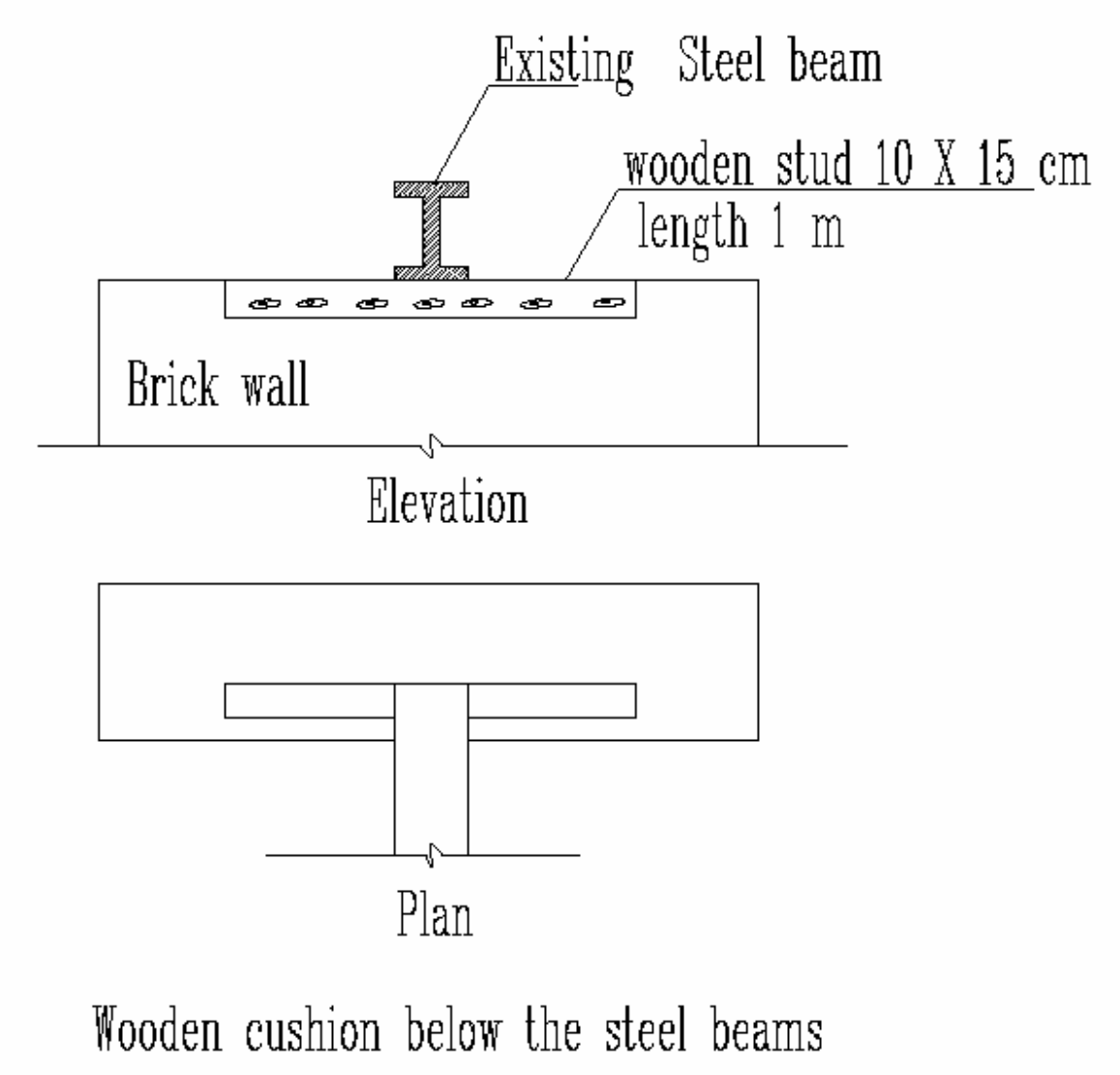


Brick wall Elevation

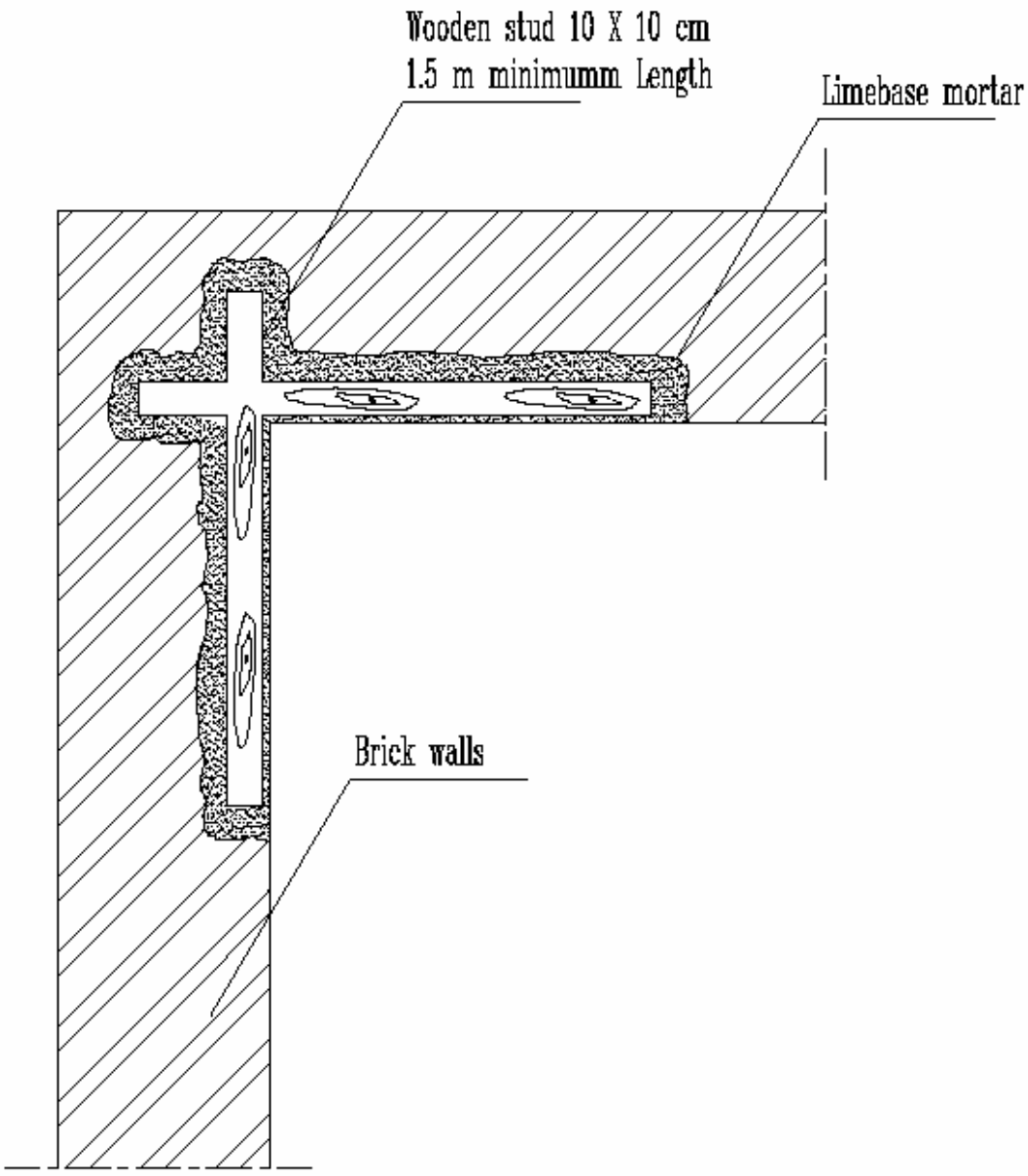


Section

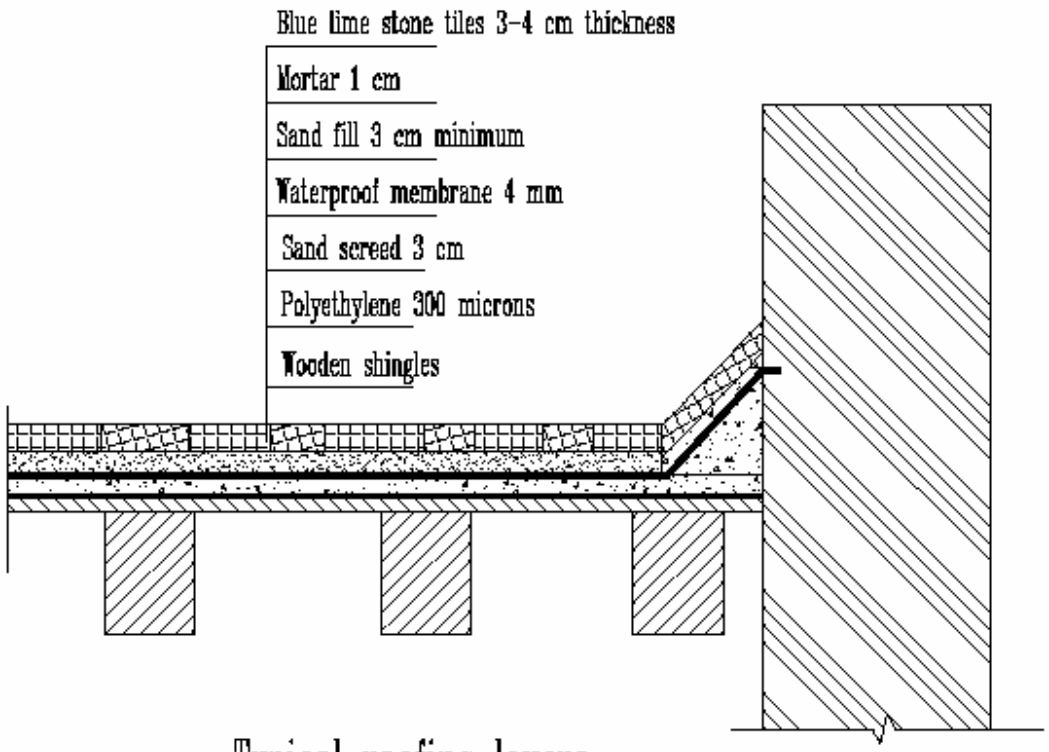
Typical brick wall crack restoration using wooden studs



Wooden cushion below the steel beams



Walls Corners stiffening using wooden studs



Typical roofing layers

General Technical Specification

1) The works in this chapter consists of the supply and implementation of all the works required for support, restoration, dismantling and reconstruction of all the critical structural areas and those areas liable to failure. This should be done according to the drawings given in the tender or the areas where the site supervising Engineer specifies.
2) The Egyptian Code of Standards should be achieved (Egyptian code of practice 1994). Published from the Housing & building research centre for the implementation and testing of all the works that are executed. The specifications and charters for restoration works should be followed, in addition to what is mentioned in the booklet for special conditions.
3) Before the commencement of any works in this project, performing all the scaffoldings & shoring required and prepare safe pathways which are to be used for transporting the materials and the circulation of the workers. The scaffoldings used during the implementation stage must be new metal ones.
4) continuous and periodical monitoring system for the walls & elevations through telltales. It has to be put perpendicular to the crack direction. , listed according to their numbers in a tabulated form , including its locations , date of inspecting . It has to be followed weekly or in case of demolishing in the nearby area or earthquake or deep cracks takes place. a monitoring report each three weeks has to be produces in order to compare the observations & ensure the stability of the building.

5) The minaret has to be monitored to ensure its stability using total station to observe points on its body defining the verticality & ensure that their is no bulging or sagging in its centre line.

6) Special care should be taken into consideration when there is any knock down works in the masonry , stones, arches, ceilings and all elements of the building, no mechanical methods should be used. In case any harm occurs during the knock down works of any structural elements.

7) All depress due to the knock down works needs to be removed immediately and disposed in areas approved by local authority ,

8) Prior to the commencement of work, several samples of all the types of mortar that planed to be used in the restoration process has to be tested to ensure its validity for the required works. Tests to ensure that these materials are suitable for the required purpose should be preformed on these samples. The results of these tests should show all the engineering properties such as fracture resistance , acidity, porosity, penetration, abrasion and the initial and final setting time.

9) Prior to the commencement of the restoration process, it is recommended to dismantle all antique elements that are liable to be damaged during the restoration process.

10) Generally all the materials, additives and chemicals used in the restoration process must comply with Egyptian or American or British or German International Standards.

11) In case of partial dismantling of a wall, it should be dismantled at several stages and each dismantling stage should be rebuilt before dismantling the next stage, leaving the necessary interlocking in the masonry for the binding of each stage.

The extension of the wooden studs is also left to assist in the binding between stages. All precautions must be taken to ensure that the wall or any adjacent walls do not collapse or crack.

12) Prior to the commencement of work, a steel bench mark should be fixed , protected by concrete, and the level of this bench mark must be connected to all the different levels of the monument and this should be shown on detailed drawings on a scale of 1:50.

13) In cases of dismantling of stone masonry or arches, the stones should be numbered with clear reversible colours and these numbers must be documented on the architectural drawings for these elements. These numbered stones should be registered in files stating the right bedding direction of these stones and they should be stored properly, so as not to be affected by environmental conditions.

14) Mechanical stone tests should be performed on the lime stone, in a specialized laboratory, to specify its apparent porosity, percentage of absorption, density, abrasion and shear stress & X ray analysis .

15) Specific samples of the woods used, having statements of their technical properties, should be submitted and the following test should be performed: compression test in the direction of the grains and also in the direction of cross grains ; direct shear in the direction of the grains ; humidity and factor of elasticity.

16) It is strongly not recommended to store any waste inside or outside the monument except in storage containers outside the monument and these wastes should be removed periodically once the container gets full.

Specification of Materials:

Water:

The water used in mixing the mortar for the masonry works must be clear and free of any impurities such as salts, acids, lime matter, organic matter and others. The use of sewage water, stagnate water and seepage water is not allowed.

Fill:

The fill used for any filling purpose either being excavated materials, knock down remains or fill supply from outside the site, must be smooth and free of solids, wastes, organic matter, salts, alkaline, swelling soils.

Sand:

The sand should be natural desert sand composed of silicate, and should be free of solid lumps, smooth materials, silt, salts, alkaline matter, organic matter, wastes and swelling soil.

The particles of the sand should be gradual in size and should not have more than 20 of fine particles which is less than 1mm and not more than 5 of coarse particles which is more than 5mm. The sand used in plaster should be sieved with a sieve size 2mm to remove the coarse particles.

Aggregates

The aggregates should be of the finest quality of natural aggregates & free of foreign matter, weak particles, long particles, alkaline matter, organic matter and pollution due to clay.

The aggregate should be gradual in size, between 0.05cm to 2cm for reinforced concrete and between 0.5cm to 3cm for plain concrete.

Lime:

1) Lime is a result of slaking recently burnt live lime with filtered watered. The lime should be slaked before it reaches the site, but should not be used before three months after being slaked, and should pass through a sieve size 3mm to free it of solid matter.
2) The typical slaked lime used for building mortar should not consist of less than 80 Calcium and Magnesium oxides.
3) Highly dense slaked lime used in plaster should not consist of less than 95 Calcium and Magnesium oxides, and 20 of this should be Magnesium oxide.
4) The Sultan lime used in the rough coat plaster " toothing" and the "maseis" coating should be bright white and previously burnt mildly.

Slaked Lime:

Before using the live lime in mortar or plaster works, it must be slaked by water to change it to Calcium hydroxide. The amount of water required for this purpose is 1/3 the weight of the live lime. This will result in high heat and increase in its volume from 2 to 3 times more.

Slaking of Lime to obtain Lime Putty:

Water is added more than usual for the slaking process, while mixing it to achieve a workable paste. To achieve 1m3 of lime paste,300-400kgm of live lime are required.

Lime Characteristics:

It is compulsory that the lime in the building works must be suitable to withhold the sand and amount of mortar to give it strength. The lime used for painting must be suitable with respect to; rate of reaction with water, smoothness, colour, hardness, hardening time and shrinkage rate .

Lime Mortar:

Lime is usual used in mortar for structural and architectural work, where it is mixed with sand to reach the required mortar, additives may be added to reduce shrinkage according . If high calcium lime is used for mortars 5 of white cement can be used to make the mortar hydraulic. Lime should be yeast through lay it in water for at least one day , some of "Kazaeen " material or yoghourt should added to the water.

Live Lime:

It is bought in a solid form or sometimes as smooth particles packed in sacks. It must be slaked when it is fresh before it could be used. It should be sieved to remove all foreign matter. If the amount of water is exceeded and the a lime paste is formed, it should be left for about three months to get slacked lime before use, to obtain suitable workability texture.

Hydraulic Lime:

This is prepared by crystallisation of limestone containing small amounts of clay and burning at a temperature of 1000-1200C and then slaked with the required amount of water. It is then sieved and packed in sacks in smooth powder form. The slacking process should be at the factory, by spreading a thin layer and sprinkling water and mixing it, then it is left for 10 days. This is why Hydraulic water is very hard under water, even though its setting time is slow.

Storage of Lime:

Lime must be stored in a dry environment, so that it is not slaked by the air. To test for this, add water to a sample to ensure that it is still fresh live lime or add dilute hydrochloric acid to a sample, efflorescence will occur if the lime changes to calcium carbonate due to the carbon dioxide in the air during storage.

Gypsum used in Restoration:

The gypsum used is a crystalline combination of calcium sulphate and water (CaSO4 2H2O). If the powdered gypsum is heated to about 200C it loses about three quarters of its combined water and the resultant is described as hemi-hydrate gypsum plaster CaSO4 0.5H2O. This material is better known as plaster of Paris. The crystalline forms gives strength and solidity to the plaster. To prepare a workable plaster, water equivalent to 75 of the weight of the gypsum is added. The plaster of Paris is used in making models, moulds, forms and plaster and its setting time is between 5-15 minutes. The artificial gypsum can be classified according to the percentage of calcium sulphate content into the following:

a-Plain gypsum:

Also known as 'Balady' gypsum, has a percentage of CaSO4 2H2O is not less than 60 and its colour is yellowish gray. It is divided into two types according to the setting time:

2- Plain gypsum with average setting time; setting time not less than 15 minutes.

3- Fast setting plain gypsum; setting time is not less than 5 minutes and not more than 8 minutes.

b) Massees, (siratite) gypsum:

The percentage of CaSO4 0.5H2O is not less than 80 and is divided into two types according to setting time:

1- Slow setting massis gypsum

2- Average setting massis gypsum

c) Sculptural gypsum:

The percentage of CaSO4 0.5H2O is not less than 90 and the setting time is not less than 15 minutes and not more than 40 minutes.

The Strength of Structural Gypsum

Structural gypsum can withstand stress between 50-200 kg/cm2 and this resistance depends on the following:

1) Additives added to the gypsum to reduce its setting time.
2) The temperature of crystallisation.
3) The amount of water needed to make a workable paste of gypsum; the resistance of gypsum to stress increases as the water used is decreased.

The Degree of Dryness of the Gypsum

The gypsum reaches half of its strength 24 hours after being placed in its location. The plaster gypsum which contains gypsum and sand at a ratio of 1:2, is 60 of the strength of gypsum that doesn't contain sand.

Additives included to control setting time reduces the resistance of gypsum after solidification. The resistance of gypsum to strain is weak. There is a linear relationship between stress and strain in gypsum. The best type of gypsum is from Beni swef and the weight of 1m3 of this type of gypsum equals between 1257 kg to 1367 kg.

Brick Powder (red clay powder):

It should be made from the best and purist type of clay that does not have the property of swelling or being lightly burnt. If the case requires, the clay is placed in moulds to make bricks, then lightly burnt so that it turns yellowish red in

colour. After burning the clay or brick it is crushed to powder and filtered by a sieve sized 2mm. The brick powder should be free of dust, sand, ash, organic matter, lime matter and any foreign matter.

Stone Powder & Stone chips :

The stone powder used should be free of any impurities and it is obtained by crushing limestone to powder consisting of a high percentage of kaolin. The kaolin plays the role of the liquid and binding material and it should be free of lumps and impurities. The powder is filtered through a sieve of size 2mm.While the stone chips is a lime stone chips with rough, bigger grains restrained above 2 mm sieve .

Fly Ash (qusromil):

It is the result of remains obtained from the kilns using wood as their fuel power. The remains obtained from kilns using wastes and sugarcane as their fuel should not be used.

Cement:

The cement should be of the finest quality of Portland cement which fulfil the specifications stated in the latest certified standards specifications published. A storage area on site has to be prepared to protected against rain and humidity having wooden flooring to store the cement in. Each batch of cement placed in the storage must be easily accessible for easy inspection and use. The cement can be tested at any time and during working procedures according to the requests of the Engineer to ensure that the specifications of the cement have not been harmfully affected.

Brick Fragments:

This should be the resultants of completely burnt solid red bricks, free of pieces of stone, lime matter, foreign matter or dust and it should be gradual in size.

Stones:

All types of stones must be of solid characteristics and free of fossil remains, soft spots, clay streaks, organic matter, foreign matter and should have a uniform outer appearance, with no variation in colour. The stones should come from the quarries mentioned in the specifications or bill of quantity.

The size of the stone rubble should be according to the needs and in case the size is not mentioned, the sizes of the stones, after being dressed, should allow to form a stone course equal to three courses of uniform brick. It should have one clear cut face and its sides should be rough in texture before placing for building (50 x 30 x 15cm). If the size of the stone blocks is not mentioned (50 x 35 x 30cm), then it should allow for the size of the stone after being dressed to make one course equal to six brick courses .In all cases it is not recommended to use stones less than 25 cm or using stones cladding .

Red Bricks:

The bricks must be of the finest quality, they should be homogenous, uniform in shape, have a levelled surface, parallel and sharp edges, perpendicular corners, and should be free of cracks, protrudes, foreign matter, vacant air pockets and lime matter. The bricks should be burnt completely and when you bang the bricks together you should hear a ringing sound.

When the red bricks are immersed in water for five hours, they should not absorb more than 1/8 of their own weight . The red bricks should withstand stress not less

than 50 kg/cm2. The bricks should be packed in stacks not higher than 2m and of 50cm width, in a way to allow for easy circulation between them.

Stone Tiles:

They should be from the finest quality of blue limestone, they should be strong and free of spots, pockets, soft and clay streaks. After being dressed to the finished state they should reach the thickness and size.

Marble:

The marble should be free of cracks, vacant pockets, scratches and other defects. The marble should be of the required color, thickness and size. The white marble should be of the No.1 quality.

1- White marble with color spots and grey streaks comes from the Edfu quarries.
2- Red marble comes from the Sinai Govern ate
3- Green marble comes from the Qena Govern ate
4- Black marble comes from the Sinai Govern ate

Reinforcing Steel bars:

The steel bars should be clean and free of rust, paints, cracks, protrudes, grease matters , and other defeats. The bars should be uniform in dimension and should not be bent. The bars used should be mild steel and withstand tensile stress not less than 37kg/mm2 and the coefficient of linear elongation should not be less than 24 for bars with diameter of 1 inch or more, and not less than 20 for bars with diameter between 12mm-15mm, and not less than 16 for bars less than 10mm diameter. In general the reinforced steel bars should fulfil the specifications of the latest published certified standard specifications for this type of steel.

Wood:

There is two types of wood; soft wood and hard wood. In both cases they should be of No.1 quality found in the local markets. The wood should be completely dry, straight and free of decay, termite infection, harmful knots, cracks and fractures. Their dimensions should be clear and uniform.

Soft Wood:

White Pine Wood:

The weight of 1m3 should not be less than 400kg. Its color is slightly yellowish white. This wood may be used for shingles, planks, beams and other uses. This type of wood is imported to Egypt from the Balkan states, Turkey, and Russia.

Yellow Pine Wood:

It is yellow in color and its grains are alike and it consists of glutinous materials. It is imported to Egypt from the Scandinavian countries and the Baltic shores. This wood is used for shingles, planks, beams and other uses. Its weight is not less than 450kg/m3.

Turkish Wood:

Its colour is dark yellow and its weight is not less than 650kg/m3. It is imported to Egypt from the Far East.

Pino Wood:

Its colour is dark yellow and contains a suitable amount of glutinous materials and it is imported to Egypt from Yugoslavia and Russia and its weight is not less than 600 kg/m3.

Pitch Pine:

Its colour is dark yellow and contains a suitable amount of glutinous materials its grains are very noticeable and its weight is not less than 700 kg/m3.

Hard Wood:

Oak Wood

The specific weight is 750 Kg , its has dark yellow to dark black colour with visible grains with silver colour It is imported from USA , AUSTARIA

Beech Wood

The specific weight is 750 Kg , It is imported from Japan m Europe & some times USA its colour varies from white to yellow.

Mahogany Wood

The specific weight is 600 Kg , It is in red or black or yellow colour .

1 Excavations & backfilling

1.1 Scope of work

1.1.1 This section covers excavation up to the required levels , fill, removal of excavated soils to destination approved by the local authorities, or reusing the excavated materials.

2.1 Excavation works conditions

2.1.1 Excavation work shall be executed in a regular and controlled manner. The the excavation sides should be preserved during the work ,they could be formed vertical, stepped or with special slopes.

2.1.2 In case of old foundation which obstacle the excavation works , the excavations has to be extended to with depth not less than 25 cm in below the findings .

2.1.3 It is needed to secure all services " electrical , sewage, telephone " located in the excavation area, inside or outside the monument .All the time during the restoration project .

2.1.4 It is preferable to sign bench mark inside the monument , protect it & use it as a levels reference in the excavation & back filling activities

2.1.5 All required precautions should be taken to protect the monument, nearby structures ,pedestrians & workers during the process .

2.1.6 Any old foundations ,walls , or any other historical remains encountered during excavation . should be document properly via existing condition photographs taken just after discovering them , drawn them with sufficient drawing scale .Inform the SCA representative immediately.

2.1.7 The walls or any monumental elements should be protect & covered in order to conserve them & keep them clean. Using polyethylene sheets thickens not less than 150 micron before start excavation near them.

2.1.8 all precautions should be taken to avoid water leaking inside the excavation locations .The trenches should be kept desiccated all the time.

2.1.9 The excavated materials should be placed temporarily away from the trenches. It should stored in a safe manner & in a safe place which do not disturb the work , fare at least two meters away from the trenches edges .

2.1.10 In case of having precious or meaning materials & equipment's.
They should be stored in different places , classify

2.1.11 The required precautions has to taken to avoid pedestrian falling in the trenches .Warning tape & fences should be used for the same propose . The fences has to be lighted at least each 5 meters .The fences should be watched all the night.

2.1.12 The excavations should be performed using resourceful workers in a manual manner.

3.1 Back filling works conditions

2.3.1 The trenches & excavated areas should be cleaned from the analysed materials .Back fill using material free from harmful components , Impurities, tree roots , buildings deposits , agricultural surface soil , lime material & swilling components & metal material which could engender oxides .

2.3.2 The back filling should apply in layers , not exceed than 20 cm in case of using normal filling materials while it should not exceed than 25 cm in case of using coarse sand. Sprayed water & manual compactors " Mendala" or other surface compactors should be used to reach a compaction ratio not less than 95 from the maximum dry density calculated from the standard proctor test .

2.3.3 The base surface should be compacted before adding the back filling material. It is recommended to perform the required testes to proof the material goodness & applicability prior the commencement of the works.

2.3.4 In case of recycling the excavated materials , it should be stored a regular shape & in the places that not affecting the traffic in the site & far away from any sources of impurities or salts .

2- CONCRETE WORKS

2.1 GENERAL

2.1.1 This section of specifications covers the plain & reinforced concrete works for the Project.

2.1.2 all required sleeves for utilities passing through the concrete areas has to be placed before poring the concrete .

3.1.2 Reference shall be made to the specification of concrete works reinforced in Egypt "The Egyptian Code for Reinforced Concrete Construction 1995".

2.2 MATERIALS

2.2.1 *CEMENT*

3.2.1.1 Cement shall be delivered from approved sources and shall conform to one of the following Specifications:

a. Egyptian Standards (ES 371) (Portland Cement Ordinary and Rapid Hardening).

b. Egyptian Standard (ES 583) (Sulphate Resistant Cement).

c. British Standards (BS-12) (Portland Cement-Ordinary and Rapid Hardening).

3.2.1.2 Cement shall be delivered in the original sealed, sound secured sacks. All bags shall be stored on a raised wooden floor in properly constructed sound, dry, weatherproof covered place. Any cement affected by damp or otherwise imperfect shall be removed from site.

3.2.1.3 There should be adequate quantity of Cement in the site to avoid stop the work .

2.2.2 *STEEL REINFORCEMENT*

2.2.2.1 Steel reinforcement shall conform to the Egyptian Standards 262 (steel bars for concrete reinforcement) with the following characteristics:

	Yield Stress Kg/mm^2	Tensile Stress Kg/mm^2	Minimum Elongation
Steel 24/35 (Normal Mild Steel)	24	35	20
Steel 36/52 (Ribed High Tensile Steel)	36	52	12
Steel 40/60 (Ribed High Tensile Steel)	40	60	10

2.2.2.2 All reinforcement, at the time concrete is placed, shall be free of mud, oil, grease, loose rust, mill scale or other materials which may adversely affect or reduce the bond. The steel reinforcement shall be brushed with steel brushes and cleaned with air jets if required by the Engineer.

2.2.3 *AGGREGATES*

2.2.3.1 Aggregates for concrete shall be materials from natural sources and shall conform to E.S. 1109 (concrete aggregates from natural sources).

2.2.3.2 The nominal maximum size of the aggregate shall not be more than one fifth of the narrowest dimension between sides of forms, one third of the depth of slabs nor three fourth of the minimum clear spacing between reinforcing bars, bundless of bars cover or between reinforcing bars and cover.

3.2.3.3 The grading limits of coarse and fine aggregates shall conform to the requirements of the specifications & able to produce concrete with applicable workability.

2.2.4 *WATER*

Mixing water shall be potable water, clean and Free from harmful materials like oils , acids ,alkaline & organic matters .It should coincide with the Egyptian Code of practise .

2.2.5 *ADMIXTURES*

Suitable admixtures may be used to modify certain properties of concrete. However, as they may at the same time adversely affect other important properties of concrete. It should be used according to the manufacture recommendations & it should be compatible with international standards. Test has to be done on samples to check the admixture gains & disadvantages.

2.3 DESIGN OF MIX AND CONCRETE PROPORTIONS

2.3.1 Proportions of ingredients for concrete shall be established to provide:

a. Conformance with the strength test requirements.

b. Adequate workability and proper consistency to permit the concrete to be worked readily into the forms and around reinforcement under the conditions of placement to be employed without excessive segregations.

2.3.2 The mixes design shall be designed to give higher compression strength than the required by 50 kg/cm2

2.3.3 The following are the concrete mixes used in the project and the corresponding minimum cement requirements:

	Minimum Strength (Kg/cm2) cube - 28 days	Minimum cement requirement (kg/m3)
Mix B	250	350

The concrete shall be mixed in a batch mixer capable of thoroughly combining the aggregates, cement and water into a uniform mass within the specified mixing time and of discharging the concrete without harmful segregation. The mixer shall bear a manufacturer's rating plate indicating the rated capacity and the recommended revolutions per minute and shall be operated in accordance therewith. In no case shall the numbers of revolutions be less than 20 revolutions per minute.

2.4 BATCHING, MIXING AND PLACING OF CONCRETE

2.4.1 Concrete ingredients shall be measured by weight. Scales for the ingredients shall be accurate when in use within (0.4) percent of their total capacities. Standard test weights shall be available to permit checking scales accuracy.

2.4.2 The interior of the mixer shall be free of accumulations which may interfere with the mixing action Mixer blades shall be replaced when they have lost 10 percent of their original height.

2.4.3 Concrete shall be conveyed from the mixer to the place of final deposit by methods which prevent the separation or loss of materials and without interruptions sufficient to permit loss of plasticity between successive increments. Truck agitators or truck mixer operating at agitating speed (refer to Item 3.4.8) shall be used for transportation of ready mixed concrete unless a special permission is given for using non-agitating trucks having proper body proportions so that concrete is delivered without segregation.

2.4.4 Truck agitators or truck mixers operating as agitators shall be operated at an average speed ranging between (2) to (6) r.p.m. provided that the concrete shall be delivered and discharged to the site within one hour from the introduction of aggregate and cement to the mixing water or the cement to the aggregate.

2.4.5 In case non agitating trucks are permitted for transportation of concrete, the time prescribed in (Item 3.4.6) shall be reduced to 20 minuits.

2.4.6 In all cases the concrete shall be delivered and discharged within one and half hour or before the drum has revolved 300 times after introduction of water to the cement and aggregates or the cement to the aggregates.

2.4.7 Mixing and transportation of Ready Mixed Concrete shall conform to ASTM - C 94.

2.4.8 Concrete shall be carefully handled, transported and placed to minimise segregation of concrete components. Or water deficient .Concrete should not be permitted to drop freely for more than 1.5 ms, otherwise metal chutes or pipes shall be provided. The concrete casting time must not exceed than 20 mints from the time of adding the water .

2.4.9 Before concrete is placed, forms, reinforcement and other embedded parts shall be rigidly secured in proper position. All dirt, mud, water and debris shall be removed from the space to be occupied by the concrete. All surfaces which may have incrusted with dried mortar or concrete from previous placement operations shall be cleaned and the entire installation shall be completely ready for casting concrete.

2.4.10 Before placement of plain concrete (lean concrete)on excavated surfaces, remove from the surfaces all oil, loose fragment of rock, rubbish, timber and other deleterious matter and any standing water.

3.4.11 Concrete shall be deposited as near as practicable in its final position to avoid segregation due to re-handling or flowing, the use of vibrators for transportation of concrete is completely prohibited.

3.4.13 All concrete shall be consolidated by vibration so that the concrete is thoroughly worked around the reinforcement, around embedded items and into corners of forms, eliminating all air or stone pockets which

may cause honey-combing and planes of weakness Internal vibrators shall have a minimum frequency of 6000 cycles of vibrations per minute and sufficient amplitude to consolidate the concrete effectively External vibrator's (rigidly clamped to the form-work) shall be used especially in places where internal vibrators cannot be sufficiently used. The external vibrators shall have a minimum frequency of 6000 CYCLES of vibrations per minute. The form-work has also to be strong and tight so as to prevent distortion and leakage of grout.

2.5 CURING OF CONCRETE

2.5.1 Concrete shall be maintained with minimal moisture loss at a relatively constant temperature for the period necessary for hydration of cement and hardening of concrete. Curing shall be continued for at least 10 days after placement of concrete. Curing for surfaces placed against wooden forms or metal forms shall be done by keeping the forms wet until they can be safely removed. For concrete surfaces not in contact with forms curing shall be made either by continuous sprinkling or by application of sand kept continuously wet.

2.5.2 Curing compounds, if used, shall be of the types conforming to British, German or American Specifications, approved, before delivery, by the Engineer. Tests on cubes cured by the compounds, under the same conditions shall be conducted to ascertain the efficiency of the compounds. In all cases the compounds shall not adversely affect the concrete properties or the adherence of plaster or paint coats to the concrete surfaces (where applied).

2.6 PLACING AND SHAPING OF REINFORCEMENT BARS

All bar reinforcement shall be bent cold, before the bars are placed in position. All reinforcement shall be supported and fastened together to prevent displacement by construction loads or placing of concrete. Supporting concrete blocks shall be used between the steel reinforcement and the forms. Bare metal supports shall not be used in contact with forms for exposed surfaces.

2.7 FORMS

2.7.1 Forms shall be designed to produce hardened concrete having the shape, lines, levels and dimensions indicated on the drawings. They shall be also able to withstand, without displacement or vibrations, movement of men, weight of materials and all other loads to which they may be subjected. It should be tight & sealed to avoid concrete water leaking.

2.7.2 Form-work shall be of sound timber or other approved material and shall be substantial and sufficiently tight to prevent leakage of mortar. They shall be properly braced or tied so that they will maintain the required position, shape and alignment during and after placing concrete therein. Vertical studs, internal ties and other form supports shall be of sufficient size and number and shall be located and spaced such that all acting loads are safely resisted It should be wetted with water prior casting the concrete

2.7.3 Forms shall not be re-used unless they are well maintained and repaired so as to produce the same surface produced by the first time use. Special attention shall be paid to the water tightness and surface smoothness of the

re-used forms. Forms which are unsatisfactory in any respect shall not be re-used.

2.8 PATCHING FORMED SURFACES OF CONCRETE

2.8.1 After the forms removal, all concrete surfaces shall be inspected and all poor joints, voids, air pockets or other defective areas permitted by the Engineer to be patched, shall be patched before the concrete is thoroughly dry. Defective areas shall be chipped to a depth of not less than 25 mm with the patched edges perpendicular or the surface. The area to be patched together with a space of at least 15 cm wide surrounding shall be wetted to prevent absorption of water from the patching mortar.

2.8.2 A grout of equal parts of Portland cement and sand with sufficient water to produce a suitable consistency shall then be well applied into the surface, followed immediately by the patching mortar. The patch shall be made of the same material and of the same proportions as used for the concrete, except that the coarse aggregate shall be omitted. The amount of mixing water shall be as little as consistent with the requirements of handling and placing. The mortar shall be retempered, to be used within a maximum of one hour, by continuous mixing. without the addition of water.

2.8.3 The mortar shall be thoroughly compacted into place and screeded off so as to leave the patch slightly higher than the surrounding surface. It shall then be left undisturbed for a period of one to two hours to permit initial shrinkage before being finally finished. The patch shall be

finished in such a manner as to match with the adjoining surface. The holes left by withdrawal or rods shall be filled solid with mortar after first being thoroughly wetted. For holes passing entirely through the wall, a plunger-type grease gun or other approved device shall be used to force the mortar through the wall.

2.9 QUALITY ASSURANCE AND QUALITY CONTROL

2.9.1 The following tests for quality control of concrete and steel could be done. Tests which are not performed in the site laboratory, shall be conducted in well recognized approved laboratories. Test shall conform to relevant Egyptian or American or British standards.

1st. SLUMP TEST:

A slump test shall be made from each of the first three batches mixed each day. An additional slump test shall be made for every 40 (forty) cubic meters of concrete in any day or whenever requested by the Engineer. The slump test shall be conforming to the provisions of B.S. 1881 "Method of Testing Concrete".

2nd. COMPRESSION TEST:

Test cubes shall be prepared, cured and tested in accordance with B.S. 1881 "Method of Testing Concrete". Two sets of compression test cubes shall be made each day when 80 cubic meters or less of concrete are placed. Two additional sets shall be made for each additional 80 cubic meters or major fraction thereof placed in any one day. A set of test specimen shall consist of six cubes all made from the same batch. Three cubes of each

test shall be tested after 7 (seven) days and other three cubes at 28 (twenty eight) days

3- Shoring and Dismantling Works

3/1- General

3/1/2- Usually the restoration works require shoring, retaining. This shoring assists in the restoration and straightens the stone arches or returning a column to its vertical upright position.

3/1/3- Arches and walls will be shored throughout the entire restoration process.

3/1/4- In cases where there is total or partial dismantling and reconstruction, all precautionary measures should be taken into consideration to ensure that the masonry is restored to its original state. Total dismantling should only be done when there is no other applicable solution for restoration proposes.

3/2- Shoring & Scaffolding Works:

Before the commencement of any shoring works, the following procedures should be followed:

3/2/1- A precise structural study should be made showing the design of the shoring required. which should not effect the walls , ceilings & other antique or architectural elements .

3/2/2- All members of the shoring should be designed, to be strong enough to withstand the loads they are expected to bear.

3/2/4- All precautions must be taken to ensure that the shoring is placed in the required location easily and safely.

3/2/5- Holes should not be made in the walls of the monument to assist in fixing the shoring. The shoring should not touch decorative architectural elements. Ties passing through windows could be applied .

3/2/6- When designing and implementing the shoring works, all the site conditions of the monument must be taken into consideration, such as the location of the supports, the traffic around the monument, etc…

During the shoring works all the precautions must be taken to protect all the decorative and antique elements. Using new metal scaffoldings, wood scaffolding for form-works, castings, sponge materials or any protective covering may do this.

The structural stability of the monument must be taken into consideration during setting or dismantling the shoring. The shoring must not cause any variation or increase in the load bearing on the monument.

3/2/11 The structural stability of the minaret must also be taken into consideration. During the entire shoring process, it must be carefully monitored with the proper equipment for this purpose.

3/2/12 The scaffolding consist of steel vertical painted side panels supplied from reputable manufacturing companies , it is almost two meters height. It should be erected away from the monument wall for 20-30 cm . The scaffolding system should have the independent ladder extended for the full height.

The scaffolding should have wooden skirting not less than 20 cm all around to avoid equipment's falling .

The scaffolding should have minimum 90 cm handrail to insure labor & workers maneuver.

3/2/14 protection fabric " made from artificial materials " is recommended to be installed covering the scaffolding vertical frames .

3/3 Special Conditions for Dismantling & Reconstruction Works

3/3/1 Introduction

The monument is built using the wall bearing system. There are several building techniques, which have been used in monuments, such as circular and flat stone arches. Wooden beams are used for the ceiling. Therefore the following precautions must be taken during work:

3/3/1/1 The drawings and reports of the current status of the architectural elements of the monument must be revised and carefully studied so as to understand how to restore them to their original conditions.

3/3/1/2 A numbering system should be made for all the architectural elements that require dismantling.

The numbers should be carefully placed on the elements and also documented on the work drawings, having at least a set of two copies. The materials used for numbering must be of a type that can be easily removed so that they do not cause any scratch marks or other damages to the elements.

3/3/1/3 A descriptive list is made for all the numbered elements before dismantling. This should state the No. of the element, its location, its architectural properties such as form, name, direction, and dimensions. In addition to this, the natural and chemical properties of the materials of the numbered elements must be stated in the descriptive list. It is preferable that the

elements being dismantled be divided into different categories in the list, but without giving the same number to more than one element.

3/3/1/4 During the dismantling of any element, light, manual tools should be used, so as not to harm the stone or elements being dismantled. When dismantling a masonry, the stones must be loosened from behind while carefully hammering it so that it may be preserved.

3/3/1/5 All the measures and precautions must be taken during transporting, storing, wrapping and protecting of the architectural elements being dismantled so that no harm or decay reaches it. The elements must be stored on wooden platform in an area, which has proper ventilation and is away from the circulation of work. The elements should not be exposed to any environmental conditions different to what it is used to, example wind, dust, rain, and pollution resulting from car exhaust, humidity, etc.

3/3/1/6 The elements being stored must not be bared with any additional loads more than it can with stand. This should be the same for the elements which will not be dismantled.

3/3/1/7 The structural stability of all the elements during dismantling must be considered.

3/3/1/8 Form works and gypsum casting must be made for all the decorative elements such as stalactites and moldings. The facing of the elements should be padded with a certified, approved material to protect it from harm. The gypsum and padding materials should be strong and highly sensitive. The form works and castings should be reinforced and they should be treated like the monumental elements during transport and storage.

3/3/2 General Conditions:

3/3/2/1 Before the commencement of any dismantling or knock down works, it is needed to prepare drawings showing the current status of the architectural elements that will be dismantled for restoration purposes. The drawings should be on a scale of 1:50, 1:20 or 1:1 or according to the working conditions

3/3/2/2 Before the commencement of any dismantling works, it is needed to document the elements by photographs.

All precautions must be taken to protect all structural, architectural, decorative and other elements which are to be dismantled, throughout all work processes.

3/3/2/10 When dismantling any architectural or structural element, the element which is being carried should be removed first, then the supporting element is removed. Dismantling should be horizontally from the upward direction. It should be performed with great care until the elements are protected and stored.

3/3/3 Special Conditions for Dismantling Arches, Domes and Vaults

When dismantling these elements for restoration work, the following precautions should be taken:

3/3/3/1The arches, the domes and vaults should be completely shored before and during dismantling, using wooden and metal supports.

3/3/3/2 Formwork and template must be made for the arches, domes and vaults. these should have the same original form of the different openings .

3/3/3/3 The outer facing of the arches, domes and vaults should be numbered. These numbers should be documented on detailed working drawings, stating all dimensions and exact locations. The elements should also be completely documented by photographs.

3/3/3/4 The keystone of the arch must be numbered from its upper surface after being cleaned from dust particles and old mortar remains using a plastic brush. The materials used for numbering should be clear, but should be easily removed without causing any harm to the stone. The numbers must be documented on drawings and placed in schedules, each arch separately, stating the number, size of keystone and average thickness of the joints.

3/3/3/5 The keystone and the rest of the stones of the arch should be placed in their right bed direction above a wooden platform which is protected from any harmful environmental conditions.

3/3/4 Special Conditions for Dismantling Stone Masonry (Wall Bearing):

During the dismantling of the stone masonry for restoration works, the following precautions should be taken.

3/3/4/1 The stone facing is dismantled from front and back for each wall. The rubble core, may be knocked down if necessary.

3/3/4/2 After cleaning the stone wall from dust particles and old mortar remains, using a plastic brush, the stone facing should be numbered clearly with material that do not harm the stone and that can be easily removed. The numbers must be documented on drawings and placed in schedules stating the specific dimensions and exact locations; i.e. front or back.

3/3/4/3 The stone of the masonry should be placed in their right order, each course separately, on a sand strata above wooden platform which is protected from any harmful environmental conditions. The stones should be protected during dismantling and storage.

3/3/4/4 The structural stability of the masonry must be taken into consideration before and during dismantling. All the elements that require supporting must be shored before dismantling begins.

3/3/4/5 A numbering system should be made for all the stone blocks that require dismantling. The numbers should be carefully placed on the blocks and also documented on the work drawings, having at least a set of two copies. The materials used for numbering must be of a type that can be easily removed so that they do not cause any scratch marks or other damages to the elements.

3/3/4/6 A descriptive list is made for all the numbered stone blocks before dismantling. This should state the No. of the element, its location, its architectural properties such as form, name, direction, and dimensions. In addition to this, the natural and chemical properties of the materials of the numbered elements must be stated in the descriptive list.

It is preferable that the stone blocks being dismantled be divided into different categories in the list, but without giving the same number to more than one element.

3/3/4/7 The elements being stored must not be bared with any additional loads more than it can with stand.

3/3/4/8 The elements being stored must not be bared with any additional loads more than it can with stand. This should be the same for the elements which will not be dismantled.

3/3/4/9 The first element in the numbering series must be connected to constant bench mark and its coordinates are taken so as to ensure that the stone blocks or elements are returned to their exact direction and location, especially the circular, curved and other similar elements.

3/3/4/10 The relationship of the dismantled stone block to what is adjacent to it must be specified, such as what is to its right, left, below, above, etc.. The thickness of the mortar of the joints surrounding the stone block must be specified. If there are any stone pieces which will require replacement, this must be mentioned and their exact dimensions taken.

4-Injection Works and Restoration of Cracks

4/1 The Field:

4/1/1- This chapter will concentrate on injection works in walls, either for the consolidation of the walls or injecting cracks in the walls.

4/1/3- The component percentage of the injection mortar mentioned in this chapter is the basis for designing the injection mixture. Samples of this mixture should be made with different component percentages and tested in one of the certified labs.

4/2- Injection of Cracks in Stone Masonry:

4/2/1- This item will concentrate on injecting some cracks depending on the width of the crack and type of wall, either external, internal or an arch. In some cases the crack may be only stitched.

4/2/2- The crack must be thoroughly cleaned from any dust particles and impure residues. The old mortar must be removed and then the crack is washed with water but using as little amounts of water as possible. It is preferable to use compressed air in walls cleaning instead of using water.

4/2/3- All the points which may allow for seepage of mortar must be blocked off. The distribution of the mortar must be noticed, especially in walls and ceilings, so as to make sure the mortar does not spread and reach the shingles of the ceiling or to areas which does not require injection.

4/2/4- The method of injection is performed by fixing metal piping or plastic hoses having an opening of 19mm diameter. These are placed into the crack at a depth of 30-35cm and the spacing between each pipe should be between 25-30cm from axis to axis.

4/2/5- The pipes are fixed at a slanted angle 15°-20° toward the bottom direction.

4/2/6- All the horizontal (bed) and vertical joints should be blocked off from the outside before the injection process begins.

4/2/7- Injection is performed using a lime mortar consisting of (1 part lime: 1 part fly-ash or cool powder : 0.5 part of brick powder : 25 white cement) . Mortar samples should be applied prior the commencement of the work .. When injecting, a distance of 2 cm should be left from the face of the surface of the masonry and this should be filled with the same building mortar.

4/2/8- The injection process is applied upwards under suitable pressure of about 2 bar and becomes gradual depending on the case. It must be guaranteed that the mortar is distributed properly and enters all the required areas in between the stone.

4/2/9- After finishing the injection process, the joints are cleaned thoroughly and are then pointed with the building mortar according to the specifications.

4/2/10-In the visible places or in the top of the walls or any other places defined by the engineer gravity injection could be applied , via straight pointed waterspout which allow the mortar to fill inside the walls. From a suitable height the mortar could dissipate inside walls voids , considering to seal off all points which could cause mortar leakage .

5- Damp-proofing Works

5/1- The Field of Work:

5/1/1- The works required to be implemented in this chapter consists of all the Damp-proofing works specified in the detailed work shop drawings and the technical sections.

5/1/3- The works or layers which are to following the damp-proofing course must preformed as quickly as possible, so that no defects are caused to the DPC.

5/2- Materials:

5/2/1- The materials used for implementing the damp-proofing works must be of the finest quality of the newest materials fulfilling the technical specifications for each material.

5/2/2- The different materials required for the damp-proofing should be supplied in amounts that are enough to complete each stage of work, according to the time schedule. The work process should be continuous without delaying the other works.

5/2/3- The materials should be stored in way to protect it from any decay and the environmental conditions. The felts rolls should be stored in a dry storage with adequate ventilation and protected against direct sunlight. The rolls should be stored vertical standing protect for decay and tearing.

5/2/4- Bituminous Felts:

The bituminous felts used in damp-proofing must be of the ready made type, that fulfill the British Standard Specification No. 743 for the year 1968 of class (A). These specifications are as follows:

5/2/4/1-It is manufactured using a cloth made of jute or linen fibers or combination of both that are impregnated with bitumen. Its weight is 200 gm/m2. The hot solvent of bitumen is saturated in the felt by mechanical methods so as to protect the fibers from decay during manufacturing. The surface of the felt is covered with minimum amount of bitumen so that the fabric will not stick together when it is stored in rolls after manufacturing.

5/2/4/2-The surface of the impregnated felt should be homogeneously covered with bitumen and should be free of spots of bitumen, wave formation in bitumen or any manufacturing defects. The felt should be equal in thickness throughout its surface. The bitumen felts surface should be covered with clean smooth sand at a rate of 150 gm/m2.

5/2/5- Felts with Glass fiber base:

It consists of glass fibers that are bonded together with a glutinous material. It thickness is about 0.4mm and is covered with bitumen oxide, which is set by a metal filling material of weight not more than 40 the weight of the bitumen cover. Not less than 60 of its weight should pass through a sieve size 75 micron and not less than 99 of its weight pass through a sieve size 212 micron. Both sides are covered smooth sand so that the surfaces do not stick during manufacturing and storage. The optimum weight of this felt should not be less than 1.8 kg/m2.

5/2/6- Initial Primer Coat:

The primer coat is made of a solution of bitumen oxide dissolved in a volatile solvent such as the essence of metallic petroleum, according to the Egyptian Standard specification No. KM 24-1958. The soluble material should not be more than 60 by weight. After cleaning the surface which

will receive the D.P.C., the primer coat is applied.

5/3- Horizontal Damp proofing using Polymer Bitumen Rolls:

5/3/1- The surface which is prepared to receive the horizontal D.P.C. should be even and free of pockets, wave formations, weak areas and should be completely dry. In all cases, the vertical and horizontal connections should be curved before beginning the work, using a cement mortar.

5/3/2- The primer coat should be applied according the rate and specifications given by its manufacturing company.

5/3/3- The D.P.C. made of bitumen polymer is 4mm thick. It is composed of three layers; an outer bitumen polymer layer, an intermediate unweave polyester layer, and a layer impregnated in bitumen. There must an overlap of 10cm in the longitudinal direction when placing the D.P.C. and an overlap of 15 cm at the beginning and ends of each roll.

5/4- Vertical D.P.C. for walls:

5/4/1- After completing the masonry works the areas which require damp proofing should be done with vertical D.P.C.

5/4/2- A primer coat is applied, then three coats of hot bitumen oxides are applied, the weight of each layer should not be less than 1.5 kg/m2.

5/5- Bitumen D.P.C. (sheets) applied by Heat:

The D.P.C. is made of bitumen sheets consisting of reinforcing fibers such as bitumen polymer or insuflame-n 400 and they should comply with international specifications. The basic specifications are as follows:

Thickness 4mm

Weight 3.8 kg/m2

Reinforcement 180 kg/m2

Degree of Softness 155 m (ASTM D36)

Longitudinal Tension 800 Newton/5cm

Cross Tension 650 Newton/5cm

Elongation not less 45 in both directions

Connection Resistance:

Longitudinal not less than 800 Newton/5cm

Cross not less than 650 Newton/5cm

Water Absorption not more than 0.16 according to ASTM D570

Lasting Resistance not change after 2000 hour according to ASTM G53

Tear Resistance:

One- longitudinal not less than 160 Newton

Two- laterally not less than 200 Newton

This system should be performed according to the manufacture's specification and approved by the Engineer. This system includes the primer coat and a divider layer of polyethylene 15mm.

The sheets (rolls) are welded together using a torch. There should be suitable overlapping of the sheets so that all areas of the D.P.C. are sealed completely so that no water is allowed to penetrate the D.P.C. The sheets are bonded to one another by a material specified by the manufacturer and should be applied according to their instructions.

5/6- D.P.C. for Trenches:

5/6/1- Horizontal Surfaces:

a. The surface which is to receive the D.P.C., should be well inspected so as to make sure that its surface is well leveled and evened out completely.

If required, this may be done by a cement plaster layer 3-5 cm thick and consists of 300 kg cement / m3 sand.

b. The surface should be painted with the initial primer coat, The first layer of the D.P.C. is applied. In the longitudinal direction the overlapping of the sheets should be 10cm and at the end of the roll with the beginning of the next roll the overlapping is 15cm. In the corners, an extra layer is added which should overlap 10cm in both the horizontal and vertical directions.

c. The second D.P.C. layer is applied perpendicular to the first layer and the overlapping should be as mentioned previously.

5/6/2- Vertical Surfaces:

a. The vertical surface should be prepared according, before applying a D.P.C. to a vertical masonry, it should be plastered with a cement plaster to give it a smooth leveled surface. Special additives are added to prevent shrinkage.

b. The D.P.C. layers are applied similar to the horizontal surfaces.

c. The D.P.C. layers are protected by a special protective board provided by the manufacturer known as Bihinenons impregnated fiber boards.

5/7 lead insulation

All final wooden surfaces has to be covered with lead sheets not less than 1.5 mm with own weight of 19.5 kg/m2 .

The lead is considered as a good water proof material . It cloud be affected by rust in case of imbedded inside the lime or cement media so it has to be

painted with Bitumen in such case in order to provide the required protection for it .

The lead is long-live material it can bear slightest building & walls settlement without occurring damaging on it .

10 cm overlap has to be provided between the varies sheets , vertical mechanical assembles reinforced with brass strips has to be done , nailing using stainless steel nails could be used

grove in the sides of the wood should be applied to imbed the lead edges & it has to be covered with brass stripes to avoid any water leakage in behind.

It is not allowed to bend the lead sheets or pull them strongly while lifting & transporting them.

6- Stone Masonry Works

6/1 Material

6/1/2 Stones:

A. All types of stones must be of solid characteristics and free of fossil remains, soft spots, clay streaks, organic matter, foreign matter and should have a uniform outer appearance, with no variation in color. The stones should come from the quarries mentioned in the specifications or bill of quantity.

B. White limestone are preferable if they are dolmite limestone from the Helwan Quarries. The size of the stone rubble should be according to the needs and in case the size is not mentioned, the sizes of the stones, after being dressed, should allow to form one course of stone to equal three courses of uniform brick. It should have one dressed face and its sides should be rough in texture before placing for building (50 x 30 x 15cm). If the size of the stone blocks is not mentioned (50 x 35 x 30cm), then it should allow for the size of the stone after being dressed to make one course of stone to equal to six brick courses. If the quarries are not mentioned in any documents, it is determined as follows, according to the types of stone:

Cairo governorate and Giza from "Athar Al Nabi "Quarry, "South Helwan" Quarry.

The stones should be tested; these tests include density test, dry fracture test, wet fracture test, porosity test, abrasion, and percentage of sodium chloride.

C. White limestone are preferable if they are dolmite limestone from the Helwan Quarries.

6/2 Ashlar & Rubble Stone Masonry

6/2/1 In Ashlar masonry, the construction is done using square or rectangular dressed stone blocks, according to the drawings and dimensions required in the work. The stone block should be prepared for construction on the ground. Proper bonding should be maintained, while ensuring true vertical shape of the masonry. The stone courses has to be built in horizontal tips till the end of each course using leveling tools , then apply a mortar layer not less than one cm it should be squeezed through the vertical joints filling them . Apply the second tire of stone courses above the mortar , thread should be used in the both sides in order to check the stones horizontal alignment. Finally the stone joints should be treated & cleaned.

6/2/2 All stones used in masonry must be on their natural beds. The formation of the continuous vertical joints should be avoided. The stone facing should be bond to the rest of the masonry using thorough stones.

6/2/3 In rubble masonry which is hidden, the face of the stone should be as uniform as possible. The courses should be equal in height where one stone course should equal three courses of bricks, including their joints.

6/2/4 Exposed rubble masonry should be constructed in the same method as in hidden masonry. The corners, sides and sides of openings of doors and windows should be constructed in horizontal courses using Ashlar stone blocks or square coursed rubble blocks and their joints should be well pointed and their facing well dressed.

6/2/5 Regular course rubble masonry that will be covered with plaster should be hammered to give a rough texture , before placing it in the masonry, to a surface suitable for bonding with the plaster.

6/2/6 The stone masonry should be constructed with mortar consisting of the following (unless otherwise mentioned):

1 part high density lime (Samaluty) : 2 parts clean washed coarse sand : 1 part stone powder. Different samples has to be performed to select the best

6/2/7 Manual tools should be used to dress , preparing & cutting the stones , It is essential to dress and level the stones five faces, prior commencement the work . The exposed stone surface should be treated manually to give the same appearance of the surrounding stones .

6/2/8 In case of a stone replacement inside the hole wall while the rest are not needed to be replace .The new stone should be dressed & prepared similar to the old in the dimensions , shape , composition, color. Five stone faces should be dressed giving more care to the exposed one to give the same vision of the surrounding stones .The stone joints " seams " should be not less than one cm .The new stone has to be placed in its location , adjusted using small timber wedges from the sides . The stone should be installed in its location using gypsum weak mortar closing all the joint from the outer side , two points in the top has to be left open. Mortar filling by gravity will be applied from the top point, The mortar will fill all spaces around the new stone then it will get out through the other opening hall . Finally after mortar initial setting time the gypsum mortar & timber elements should be removed .Cleaning the stones & joints. Joint treatment will takes place

.Immediately after removing the old stone from its location timber studs should be placed to support the wall stones until the new stone be placed .

6/2/9 Stone masonry is measured in cubic meter, deducting all openings.

6/3 Preparing the Mortar Mixture

- All the material used for the mortar should comply with the specifications of each material. Pure water free of impurities and salts is added to the components of this mixture and should be mixed well, preferably using modern mechanical equipment. When the mortar is tested, it should give a vertical compression strength of not less than 40 kg/cm2.
- The quality control for the mortar is achieved by taking block samples of mortar 5cm x 5cm, after the mortar hardens, to one of the specialized laboratories for testing. The results should show the components of the mortar, their properties, and the compressive, shear and tensile stress of the mortar.
- If the samples taken prove to be unsuitable, double the amount of samples are prepared and tested once again until approved results are reached, and a written report of the results should be made.

General Building Specifications

These specifications apply to the Ashlar and rubble masonry. The intact stones must reuse the stones that have been previously dismantled, if their conditions allows this, after being cleaned from the old mortar, and well prepared before reusing them. The supply of stones should only to complete the work according to the specifications.

6/4 Masonry Woks:

The stones should be in accordance with the technical specifications specified for restoration materials, with respect to its chemical composition and technical characteristics.

The stones should be supplied to site, completely prepared for work, having numbers explaining its destination place.

All the stones used either ashlar or rubble must be strong, tough, hard and well seasoned and free of pockets, soft spots, clay streaks or organic matter.

The stones should be well watered before use so that they do not absorb moisture from the mortar.

The stones has to be protected from chipping of sides and scratches on the facings during their transportation, storage and installation until the final hand-over of the works. Stone blocks with chipped sides or scratches on the facings must not be used. The external stones should be well dressed.

It has to be specified the place of origin of the stones used for replacing missing pieces or pieces that are decaying.

6/5 Natural Stones

6/5/1 Limestone

6/5/1/1 Types of Limestone

The limestone is generally known to be of a residual stone, but it is divided into two types:

6/5/1/2 Compressed Limestone:

Its color varies from white, yellow, rosy, to red and this is due to its content of some limonite or hematite. Different fossil pockets appear on its surface.

When hydrochloric acid (HCl) added to it, effervescence occurs; it is originally formed from calcites.

6/5/1/3 Fossil Limestone:

There is a wide range of colors in this type of limestone. The color may be white to light or dark yellowish brown, rosy, red or black. This type is found at different levels, ranging from millimeters to several meters thickness and the fossils are found on their surface layer.

6/5/1/4 Limestone Impurities

The term 'limestone' may be used for any residual stones which basically consists of carbonates, calcites and dolmites. Some iron carbonates may be found, example, siderite and the limestone is divided into three main formations; organic, chemical. Most of the available limestone consists of a percentage of these three groups.

The modern limestone formations consists of hexagonal calcites and aragonite and since aragonite is easily changed into calcites, it rarely is found in old limestone formations. The limestone is unique in its content of the magnesium element which improves its mechanical characteristics. Most limestone consist of a metal known as Montmorillonite, which is a clay metal that swells when placed in humid environment and is able to change ions under certain conditions, especially in the presence of cations of sodium, potassium and calcium which are in the layers of the ionic composition. Therefore, the Montmorillonite metal is not preferred in the stones used in monumental buildings and its presence in the stone should not exceed 0.05 by weight.

Another type of clay metal element present in limestone is kaolinite (Al SiO(OH)), which is affected by high temperature (more than 500 C). It is a complex compound used in the manufacturing of ceramic tiles and it does not have harmful effects on the limestone used in monuments (on condition that its percentage does not exceed 1 by weight).

6/5/1/5 Technical Specifications of the Quality of Natural Limestone

1) Color:

The limestone used in monumental buildings should be homogenous in color, and similar to what is originally available and also according to the requirements for stone replacement or for continuing stone work on site.

2) Texture:

The limestone used in monumental buildings should not have cracks or pockets of diameters of more than 2mm or the presence of residual layers.

6/5/1/6 Natural Characteristics of Limestone

The limestone used in restoration works must comply with the physical properties stated in table No. 5a.

Table No. 5a Natural Characteristics

Porosity (by Volume)	age of Absorption of Water (by Weight)	Density gm /cm3
Not more than 15	Not more than 8	Not less than 2.1

6/5/1/7 Mechanical Characteristics of limestone

The limestone used in restoration works must comply with the mechanical properties stated in table No. 5b.

Table No. 5b Mechanical Characteristics

Tensile Stress (kg/cm2)	Compression Stress (kg/cm2)
Not less than 25kg/cm2	Not less than 200 kg/cm2

6/5/1/8 Natural Characteristics of Limestone used in Floorings

The limestone used in restoration works must comply with the physical properties stated in table No. 6a.

Table No. 6a Natural Characteristics

Porosity (by Volume)	age of Absorption of Water (by Weight)	Density gm /cm3
Not more than 10	Not more than 5	Not less than 2.2

6/5/1/9 Mechanical Characteristics of Limestone used in Floorings

The limestone used in restoration works must comply with the mechanical properties stated in table No. 6b.

Table No. 6b Mechanical Characteristics

Tensile Stress Kg/cm2	Compression Stress Kg/cm2	Abrasion Resistance in mm thickness
Not more than 35 kg/cm2	Not less than 350 kg/cm2	Not more than 4mm

Each sample is tested individually under pressure equal to 15.5kg for a distance of 500m. sand is used as the abrasive material, the sand should pass through a sieve of size 0.9mm and remain on a sieve of size 0.6mm.

6/5/1/10 Quality Control

The following steps should be taken to ensure the quality control of the limestone used in restoration works:

A) Samples:

-Samples should be taken from the work site or during transportation.

-They should be stored in a dry place away from any water sources until the tests are performed. In case the samples are refused, twice the number of samples are taken and tested again; only samples which fulfill the specifications will be approved and used.

B) Methods of Testing:

The characteristics and properties are obtained by performing physical and mechanical tests, dry fracture test, wet fracture test, density, abrasion test, penetration test, porosity test and absorption test; results should be according to one of the following specifications: ASMT, D3697-92, C126-77, C170-50 or the methods used in the ISRM.

6/6 Stairs

6/6/1 General Conditions

6/6/1/1 The stone must be solid, homogenous and of the first quality and free of pockets, soft spots clay streaks and organic matter. The stones must also must meet the rest of the specifications mentioned in 'stone masonry'.

6/6/1/2 The stair steps which are cut from stone should be clean and well dressed from all sides and it should have a rough finish. To fix the steps into the wall, openings of depths not less than 25cm are made in the required position in the wall and the end of the step is placed in the opening and fixed with gypsum mortar.

6/6/1/3 When making the cladding from masonry tiles, the thread cladding should not be less than 5cm thick and the riser cladding not less than 3cm thick and they are fixed with a lime mortar similar to that used in the masonry works, unless mentioned otherwise.

6/6/1/8 The materials required for the stair works should be supplied and stored on site in a way to protect from any possible damage. This should be done in ample time prior to the commencement of work.

6/6/2 Technical Specifications for fixing the Steps:

6/6/2/1 When fixing the steps, all the step pieces which have defects should not be used. Strong precautions should be taken to protect the steps after fixation by covering them temporarily with a thick layer of gypsum or weak mortar layer and this is not removed until all the other works are completed.

6/6/2/2 The stairs are fixed with the same masonry mortar and Ocra may be added if needed.

6/6/2/3 The cantilever part of the steps should not extend out more than 1.5m after fixation and should a have rectangular longitudinal section.

6/6/2/4 The width of the thread should not be more than 30cm net. The side of the step near the riser should be a square edge or beveled or curved depending on the drawings.

6/6/2/5 After all other works are completed, the protective layer is removed and the steps are cleaned well and smoothened if necessary.

6/6/2/6 The stones used for the stair works should be solid and obtained from certified quarries.

7- Ordinary Masonry Works

7/1- Field of Work

7/1/1- The works mentioned in this chapter consists of all types of brick masonry

7/2- Clay Bricks:

The clay bricks must be supply from a reputable source and should be homogenous in form and free of fossils and lime knots. A brick should not absorb water more than 30 of its own weight kept immersed in water for 24 hours. The average absorption rate for five bricks should not be more than 27 their weight. The average resistance to compression should not be less than 35kg/cm2.

7/3- The Mortar:

The masonry is built with a lime mortar (2 parts Sand : 1 part Lime : 20 of white cement).

7/5- Masonry Implementation Conditions:

7/5/1- Bricks should be soaked in water before use and the masonry works should be sprayed with water for 3 days after its construction for curing purpose.

7/5/2- The bricks should be laid on their beds and the mortar should completely cover the bed. The joints between the courses should be filled with a uniform thickness of mortar, in both the vertical and horizontal direction, and the thickness should not be more than 12mm.

7/5/3- The masonry should be built using the English Bond (one course headers and the next course stretchers) and the bricks must be immersed in water before use.

7/5/4- The bricks should be placed in the masonry in the same form as that of the old masonry. Brick work should be raised uniformly and no part of the

masonry should be allowed to be raised more than 1m to the rest of the masonry work. If masonry work is to be constructed later on, in a continuation with the masonry work being done, the work should be raked back in successive courses. Interlocking alternate courses are left only if it is expected that the masonry to be extended in the future.

7/5/5- In order to facilitate easy and adequate bond for plastering or pointing to be done later, the facing of the mortar joints should be raked for a depth not less than 10mm. when the joints is still green. It should be kept rough to give proper bond with the blaster layers

8- Plaster Works

8/1- Field of Work:

8/1/1- The works implemented in this chapter consists of plastering elevations, walls or different types of ceilings

8/1/2- samples of all the types of plaster should be implemented to choose the colour required and the type of finishing for the final coat.

8/1/3- The materials used for the plaster works should be stored in a closed covered dry area, which is well ventilated and protected against rain, humidity and other environmental conditions. Sand should be stored in a clean place away from any water source. The lime should not be stored unless it is slaked and it should be used latest within one month of being slaked.

8/2- Conditions of Implementation of Plaster Works:

8/2/1- The proper preparation of the background for plastering plays a vital role in the durability of the plaster and its adhesion with the surface of the masonry. The surface of the background should be prepared as follows:

a- All the protrudes and dust particles should be cleared from the plastering surface.

b- All joints in the masonry should be raked for a depth of 10mm.

c- Smooth surfaces reduce the bonding between the plaster and the masonry, therefore the surface must be raked before adding the first rough coat (render).

d- The surface should be thoroughly sprayed with water to before the render coat is added. This is to ensure that all salts are removed and that the masonry surface does not absorb the water of the plaster.

e- The render coat should be sprayed with water for 5 days, once in the morning and once at night…..

8/2/2- The Initial Undercoat (Render Coat) :

This render coat is preformed after preparing the surface as mentioned previously. After the thoroughly washing the surface, the render coat is applied. The mortar is taken on the trowel and dashed against the surface, this dashing of the mortar is essential to assist in the bonding with the surface. Water may be added to the mortar to assist in this process. The surface must be completely covered with this render coat with thickness of 5 –10 mm. The mortar of this render coat consists of (by volume) 8 parts of course sand : (5-6) parts of lime : 2 parts of limestone powder

8/2/3- Second Undercoat (Float Coat):

This layer is added after fixing the frameworks for the doors and windows and all the electrical ducting. The mortar of this coat consists of (by volume) 8 parts of sand : 3 parts of lime : 2 parts of stone powder : some Hay The hay should be damp mixing it with the mixture. The average thickness of this layer is at least 15mm for walls and 10mm for ceilings, unless mentioned otherwise, to obtain a uniform leveled surface, this coat must be scratched (raked) making vertical and horizontal wave formations to assist in the binding with the final coat.

8/2/4- Finishing or Setting Coat:

The finishing layer is performed after fixing the items mentioned previously and before fixation of the architrave's, skirting, and other similar elements. All the internal and external corners, connections between walls and ceilings,

corners of openings should be slightly curved . The mortar of this coat consists (by volume) 10 parts of sand : (3-4) parts of lime : 2 parts of stone powder: some Hay ,The hay should be damp mixing it with the mixture. Ocra or red brick powder may be added but not more than 5 to adjust the coloring of the plaster. The Engineer must approve this percentage before the commencement of work. New modern poly-probalen fibers could be used instead of Hay it could be added 900 grams for each one cubic meter of mortar "sample should be approved by the engineer before supply"

Plaster should be treated by water for a week .

Manual tools has to be used , finishing the surface should be treated with different length of wooden studs to give the same touch & vision of the old plaster.

9- Flooring Works

9/1- The Field of Work:

9/1/1- The work required to b

implemented in this chapter includes supply and installation of the cladding required for the flooring works as mentioned in the drawings.

9/2- Stone Tiling Works:

9/2/1- Stone tiles

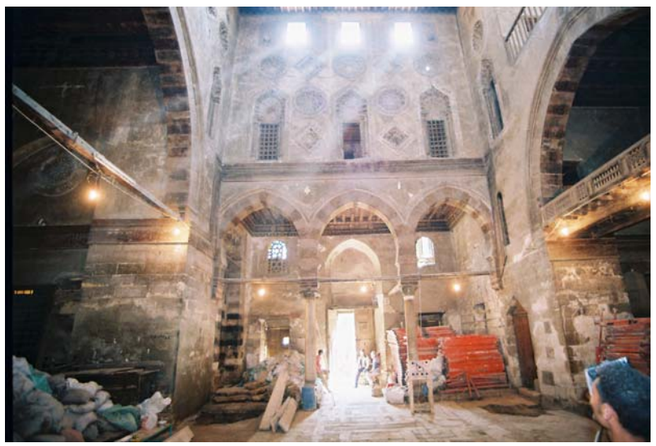
The stone must be of the finest quality of limestone and similar to the types original available in the monument. The thickness of the tiles should be between 10-15cm, it should be cut and well dressed for five faces with sharp and uniform corners and according to the drawings and dimensions required on site. The tiles are adhered with lime mortar consisting of 1.5 part slaked lime : 1 part sand : 1.5 part stone powder unless mentioned otherwise in any of the tender documents. The joints of the tiles should not be more than 1cm and should be pointed with the same mortar. The final flooring must be leveled according to requirements.

9/3- Measurements and Cost:

9/3/1- The claddings for the flooring are measured in square meters from the surface of the plaster or skirting and the thickness of the plaster or skirting will not be included.

9/3/2- The cost rate of the floor cladding should include all the materials, equipment, the worker's fee, sand layer, pointing of joints required to fulfill these works in the utmost quality.

Picture 1



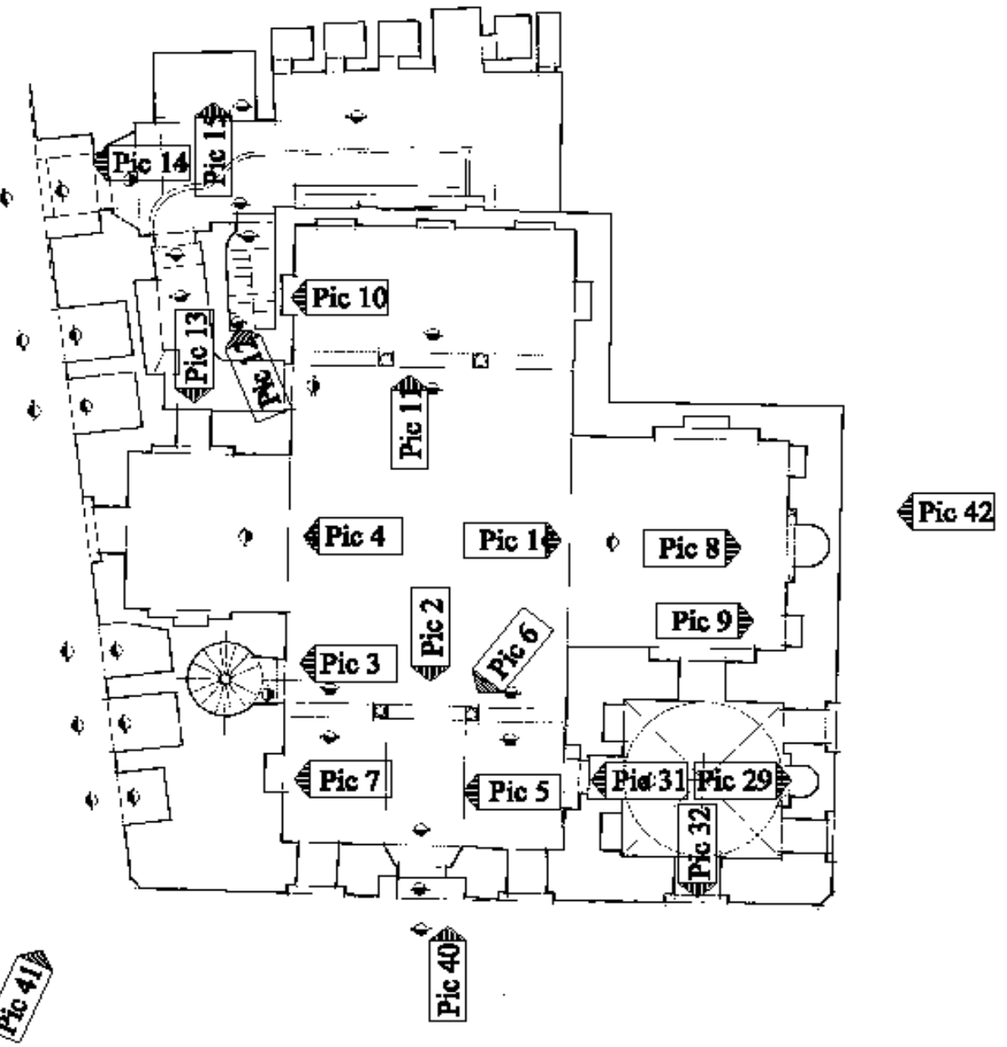
Picture 2

Picture 3

Picture 4

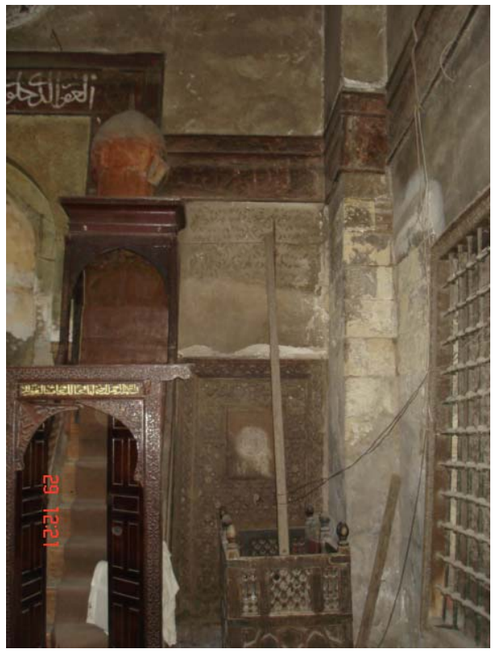
Picture 5

Picture 6



Plan of ground floor

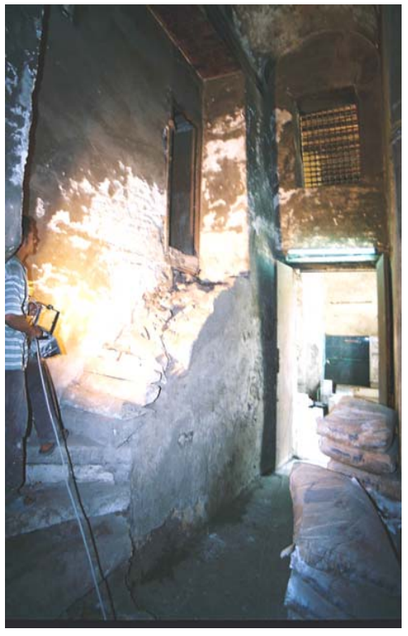
picture 8



Picture 9

picture 10

Picture 11



Picture 12

Picture 13

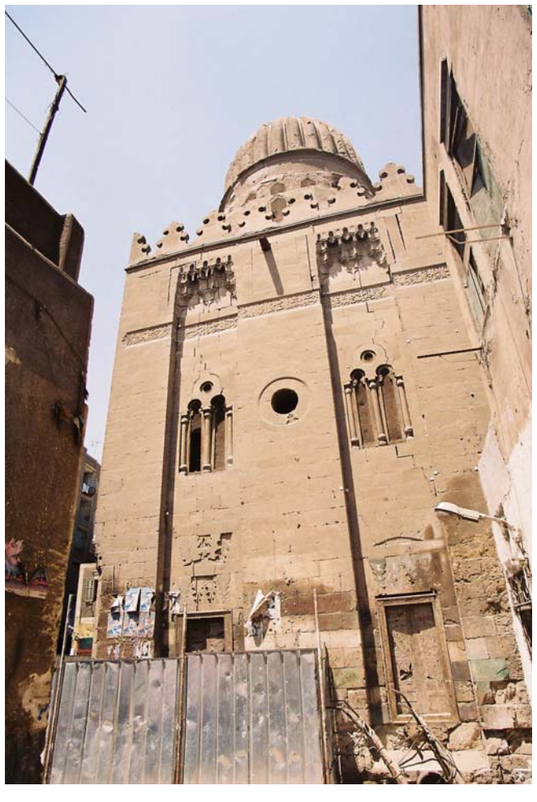
Picture 14

Picture 15

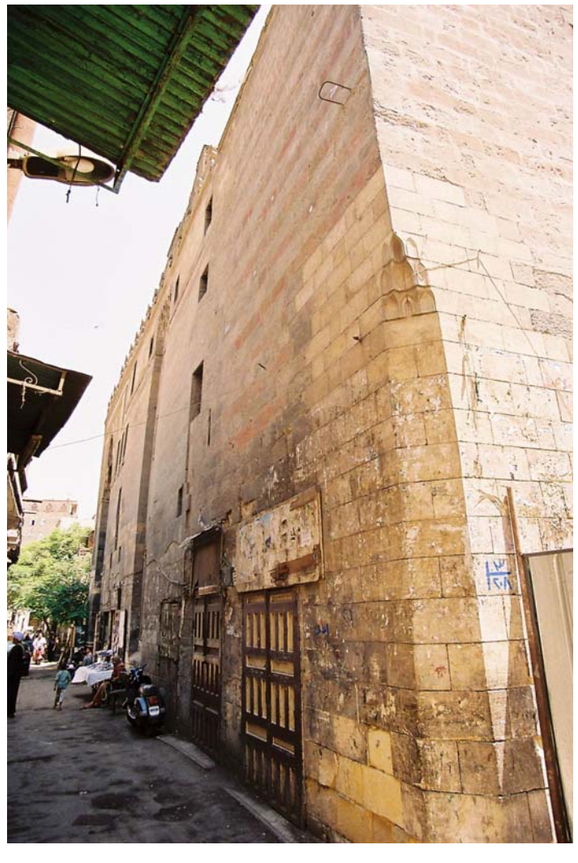
Picture 29

Picture 31

Picture 32



Picture 42



Picture 41

Picture 40

Picture 20

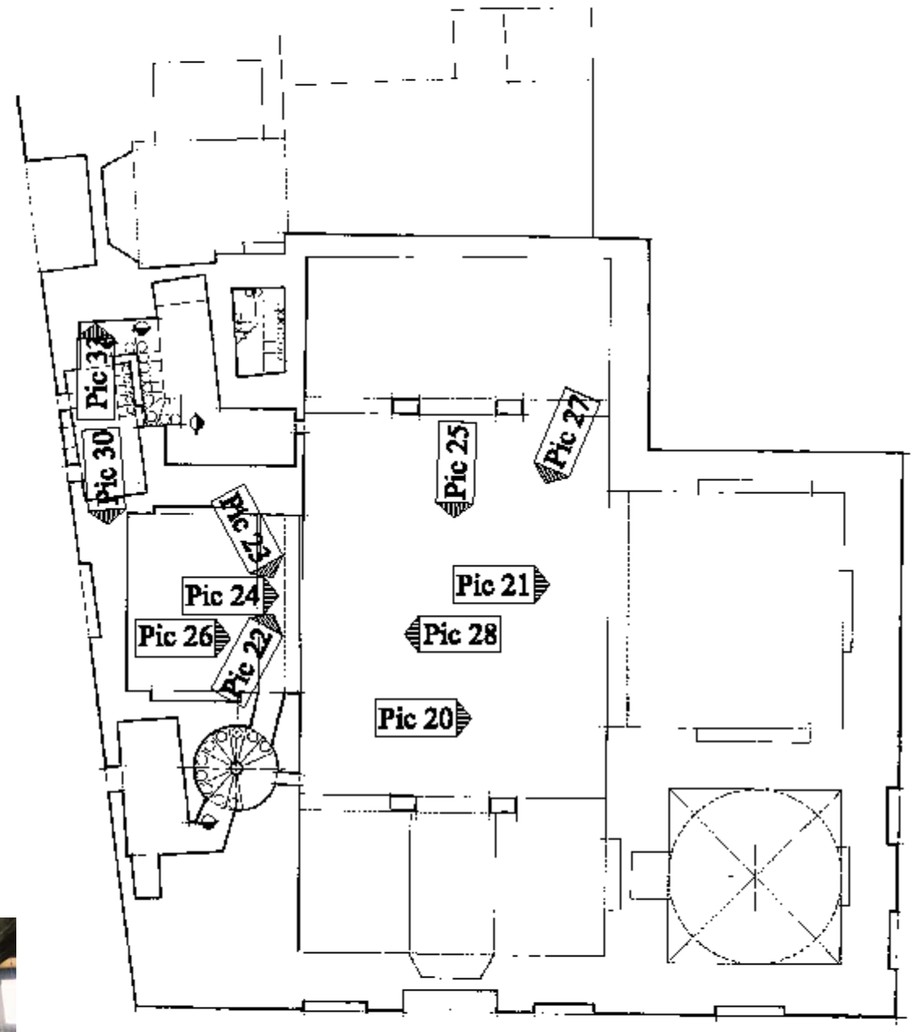
Picture 23

Picture 21

Picture 24

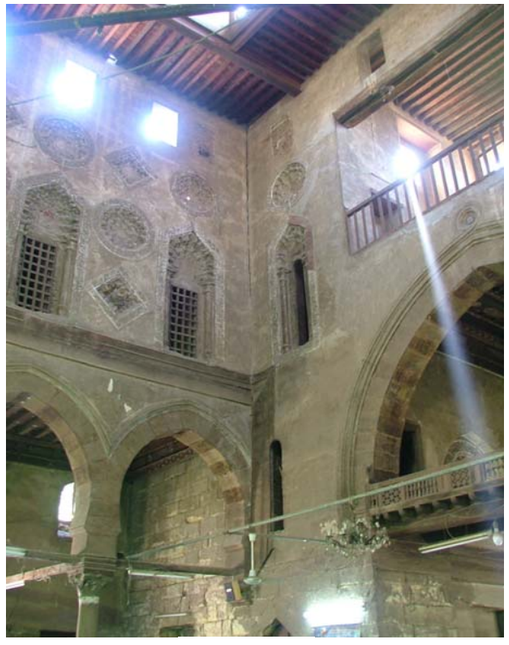
Picture 22

Picture 25



Plan of first level

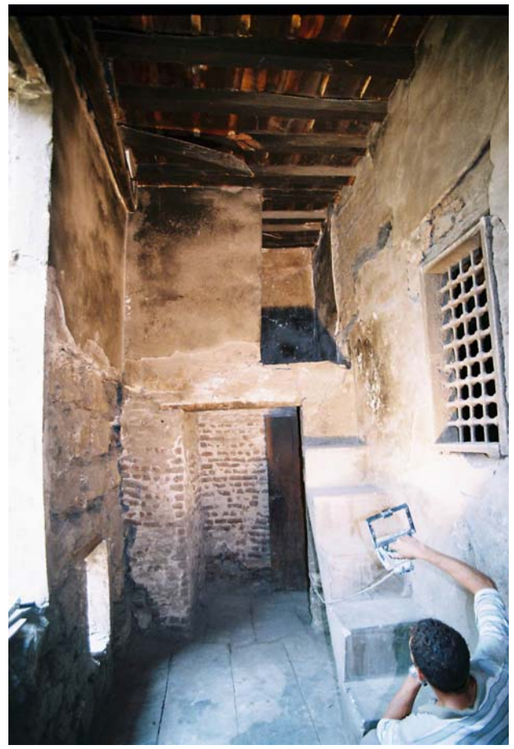
Picture 26



Picture 27

Picture 28

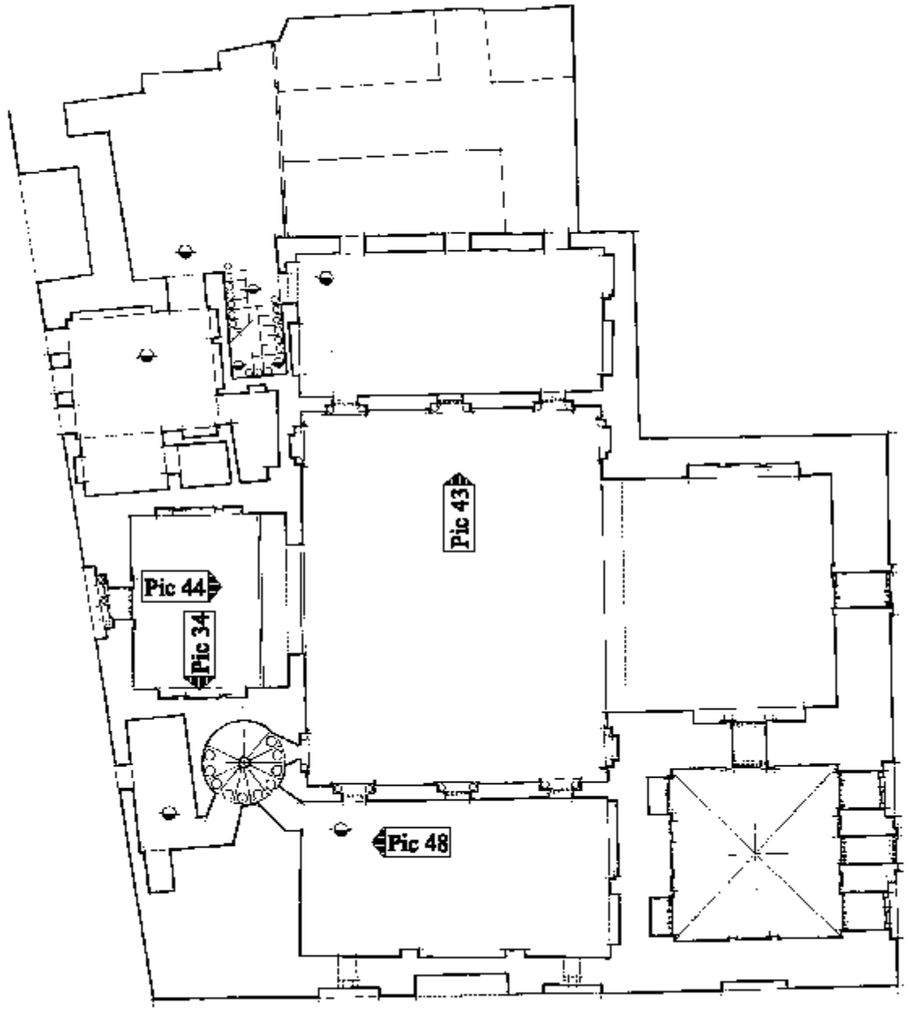
Picture 30



Picture 33

Picture 34

Picture 44

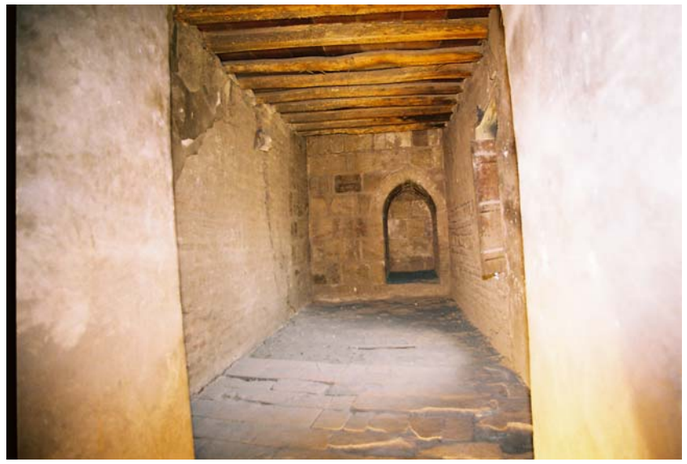


Plan of second level

Picture 43

Picture 48

Picture 38

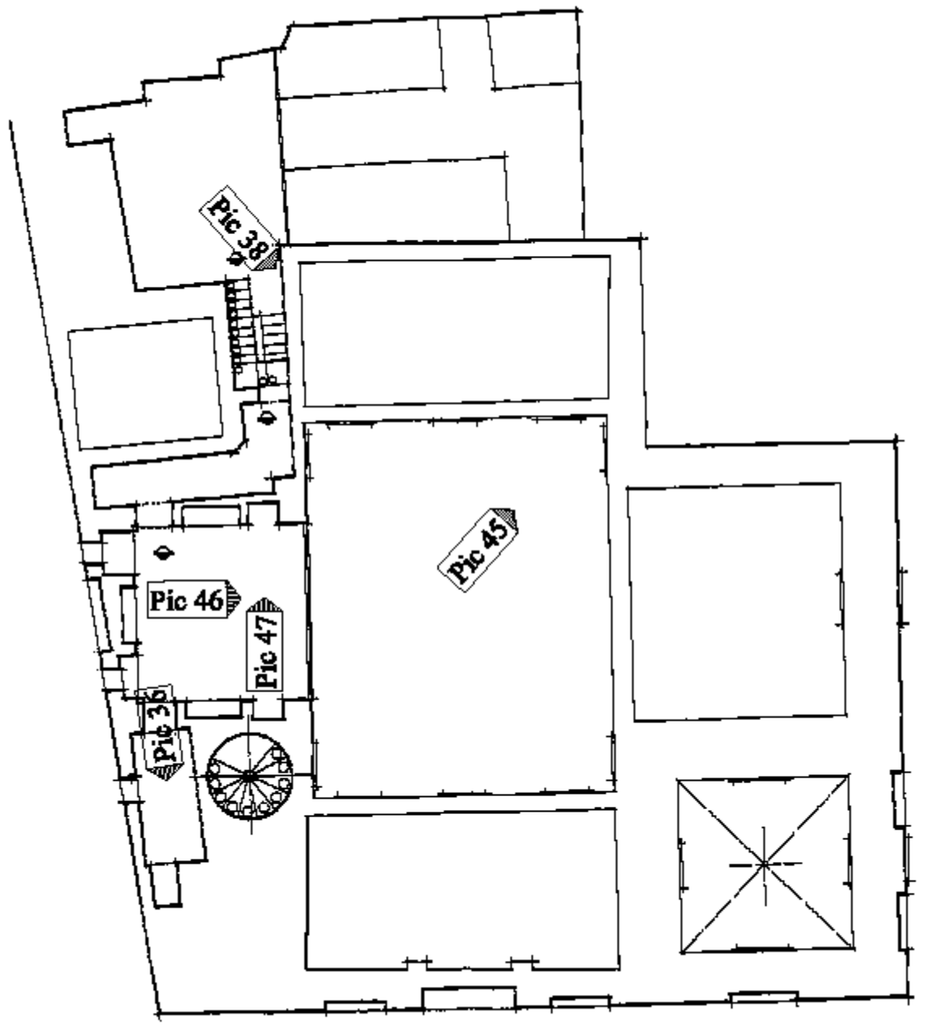


Picture 36

Picture 46

Picture 47

Picture 45



Plan of third level