RESTORATION METHOD STATEMENT FOR THE CONSERVATION AND MAINTENANCE WORKS TO ĦAZ-ZEBBUG PARISH CHURCH DEDICATED TO ST. PHILIP OF AGIRA

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MSc Conservation Technology for Masonry Buildings
May 2017

1. Description of the project, current and future use of the building

The aim of the project is to carryout conservation and maintenance works to the structure and masonry fabric of the parish church of Haz-Zebbug dedicated to St. Philip of Agira.

The parish church was built in 1621-1632 with a Latin cross plan. It was enlarged in the early 20th Century (1913-1918) with the construction of the two side aisles. An Oratory was also built adjacent to the church to house the statues of Good Friday procession.

The church is a Grade 1 Scheduled Building that is a building of outstanding architectural and historic interest that has to be preserved in its entirety.

The church is in a good state of repair. However but there are many areas that necessitate periodic maintenance and restoration works. The priority is to repair the waterproofing of the dome that is all cracked and water is infiltrating and dripping in front of the main altar during heavy rains. Several damages and cracks into the masonry structure of octagonal drum supporting the dome were identified during site inspections and deterioration mapping exercise.

The side and back facades of the church also require interventions to address various deterioration mechanisms. The lower side of the facades are suffering for extensive deterioration due to rising damp coupled incompatible previous plastering and repair works using Portland cement. Other issues are black crusts on the underside of fascias, loss of mortar joints and damaged sculptural elements. Similar deterioration mechanisms are also the cause of extensive damage to lower part of the facade of the Oratory.

The proposed interventions will address the infiltration of rain water from the dome, the repair of cracked lintels, the removal of cement and re-pointing joints using lime based mortars, the reinstatement of leaking surface water runoff from the roof of the church and the repair of the water proofing 'deffun' layer covering the barrel vaulted roof of the church. The works will also include the replacement of the obsolete lighting system of the dome.

The aim of the Restoration Method Statement is to define the works that are required and establish a standard methodology of intervention for the whole building. This would result in planned approach and unified intervention methodology. The aim is to carry out the restoration interventions in phases over a number of years, as funds for the works will be collected by the community.

2. Historical background

The parish church of Haz-Zebbug knows it origins in the 14th century when land was donated by an individual named Filippo from Catania for the construction of a church to serve as a new church for the villages of Hal-Muxi, Hal-Mula and Hal-Dwin. The land was donated on condition that the church is dedicated to a Sicilian Saint, Saint Philip of Aggira. In 1436 the church was recognised by Archbishop Salvatore De Mello as a new parish church. In 1575 during the pastoral visit by Mons. Dusina, the church had 12 altars.

Works on the construction on a new church (the present church) had commenced in 1621 and works were completed in 1632. On plan the church in built in the form of a latin cross. The facade has two belfries with a central doorway with Doric columns supporting a portico. It is not known who was the architect who was responsible for the construction of the church. The church is very similar to the church of Hat-Attard. Quentin Hughes suggests that the architect could be the son of Gilormu Cassar, Vittorio Cassar.

The dome of the church has an octagonal drum that supports a dome and a lantern. In 1660 a new choir was constructed and new altars were added. Later on in 1672 the construction of the new dome was still underway.

The facade of the church is said to be built on a plan of architect Tumas Dingli in 1637-1655. In 1689 Lorenzo Gafa was also requested to carry out some modifications. In 1729 Archbishop Alphern De Bussan has consecrated the church.

The parish church had been enhanced and furnished with paintings by important local artists such as Fra Luca Garnier, Francesco Zahra, Antoine Favray, designed by Rocco Buhagiar, sculptors

The drum supporting the dome has an external octagonal shape with 8 windows in the centre of each facade. Internally the drum has a circular shape. The drum and dome were decorated by sculptures and frescoes by the Zebbug painter Lazzaro Pisani.

In the early 1900 the church was enlarged by the construction of naves on both sides of the main aisle. The naves are divided into four as chapels dedicated to various Saints. The works were completed in 1918. The design and construction of the naves is attributed to architect Edwin Vassallo1. The cost for the construction of the naves amounted to three thousand sterling.

The Oratory adjacent the church was built in 1906 on a plan designed by architect Perit Godwin Galizia for the storage of the statues of the passion of the Christ that are used for Good Friday procession.

The church is a scheduled Grade 1 building for its architecture and artistic importance.

[1] Architect Edwin A. Vassallo son of architect Andrea Vassallo.

3. Current Condition

On completion of the Restoration works on the two bell towers of the church (PA3635/08) in 2009 and the re-paving of the parvis in 2011 (PA450/11), various restoration works are being planned to the dome, the side facades on Triq Sant Antnin and Triq il- Kinisja, as well as the facade of the Oratory.

The main aim the Restoration Method Statement is to identify the areas were restoration works are required and establish a methodology for the implementation of these works in a phased approach.

An extensive programme of site inspections, deterioration mapping and site trials to document the state of conservation of the dome, drum was carried out and it is being expanded further to carry out deterioration mapping of the side facades and the facade of the Oratory.

The parts of that church in that require restoration interventions are the following;

1. The drum, dome and lantern;
2. The perimeter walls of the church abutting, Triq Sant Antinin, Triq il-Knisja and Triq il-Parrocca;
3. The facade of the Oratory on Triq Il- Knisja.

3.1 The lantern, dome and drum

The octagonal drum, the dome and the lantern have been inspected a number of times and the following deterioration has been identified. The dome was built on an octagonal shaped drum with eight ribs.

The lantern was re-constructed during the 1980's and therefore it is a new construction. It does not have any deterioration damages except for dark stains of dirt and minor biological growth. The windows of the lantern are of galvanised steel and glass. They are still in good condition. However, it was noted during one of the inspections that there are no openings or louvers in the windows for the ventilation of air at the highest point and therefore a lot of water condensation is generated onto the internal walls and windows of the lantern.

The condensation is causing the peeling off paint layers of the lantern as well powdering of stone and detachment at the base of the lantern. Pieces of stone have also been found in-front of the main altar.

Photo 1: The existing lantern

The main concern on the dome is the infiltration of water that drips down in front of the main alter in considerable amounts every time it rains as shown in Figure 2. This water is damaging the paintings and decoration of the dome, drum and lunette.

Photo 2: A plastic tub used to collect dripping water from the dome.

The dome is waterproofed with a lime based hydraulic binder with terracotta chippings, 'deffun' that is in turn covered with multiple layers of bituminous and exterior paint. The paint layers are in many locations detached from the 'deffun' and in many locations flaking off with the result that rain water percolates underneath the paint.

In many locations the 'deffun' of the eight segments is severely cracked and detached from its sub-grade. In one of the segments, the 'deffun' layer has also been patched and partly replaced with concrete mortar. The location of this patch lies exactly above a vertical crack that is visible on the inner side of the dome.

Corroded steel pipes of an old lighting system are also fixed to the masonry fabric with some being buried in the 'deffun' layer. These corroded steel pipes, metal fittings and attachments are cracking masonry. Some of the pipes that are laid in a shallow trench in the 'deffun' are a cause of concern cracks have formed along the pipe allowing water to percolate into the compacted material found below the 'deffun'.

During the inspection, non-functional and obsolete metal halide artificial lighting fixtures (modified street lighting luminaries), redundant cables, many steel nails especially onto the ribs and other metal inserts for temporary festoon lighting and loose lightning conductor cables were also noted. The two cast iron surface water runoff pipes that direct water from the roof of the drum to the roof of the church have to be inspected and one of these pipes would has to be reconnected as it was blocked and replaced by a plastic pipe water spout.

The internal crack and the repair patch of the dome and flat roof of the drum and shear cracks on the drum have also been identified during the inspection. The cracks on the facades of the drum do not seem to be active. Further investigations and monitoring is however recommended by the installation of crack gauges during the works is necessary to determine whether there is any structural movement in the dome.

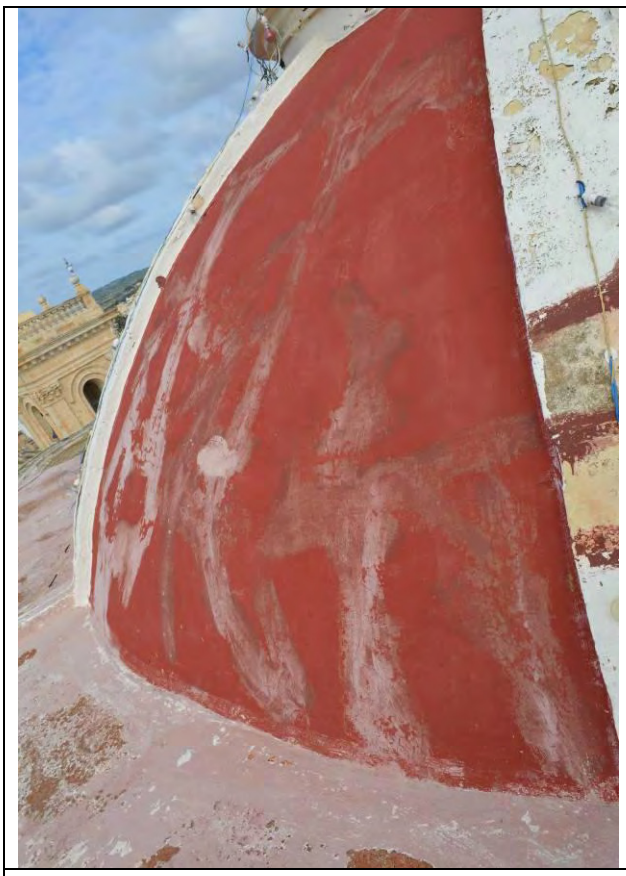
	
A – Paint layers covering '*deffun'* layer and cracks.	B - Flaking paint and detached paint and obsolete metal inserts.

Photo 3– Existing dome waterproofing and cracked deffun layer.

C - Heavily cracked '*deffun*' layer.

D – Obsolete light fittings and metal inserts.

E- Inspecting the condition of 'deffun' layer.

F- Modified surface water runoff pipes.

Photo 4 - The condition of the dome.

The drum that supports the dome has an octagonal shape with decorative pilasters at the edges. The drum is very think and on the southeastern facade, a spiral staircase leads to the flat room of the drum. The elevations terminate with a cornice.

In each of the face of the drum, there is a central window with a sculptured frame. Above the window lintel there is an arch to relief the loads from the lintel. The windows have an inclined ceiling that when checked from internal side it is the base of the dome. Therefore, half of the dome is buried into the octagonal drum. Furthermore, all the windows of the drum are connected together with a narrow passage.

To the drum are also installed mobile network antennae its cable ducting and associated equipment. Although the antennae are not visually intrusive the ductwork is.

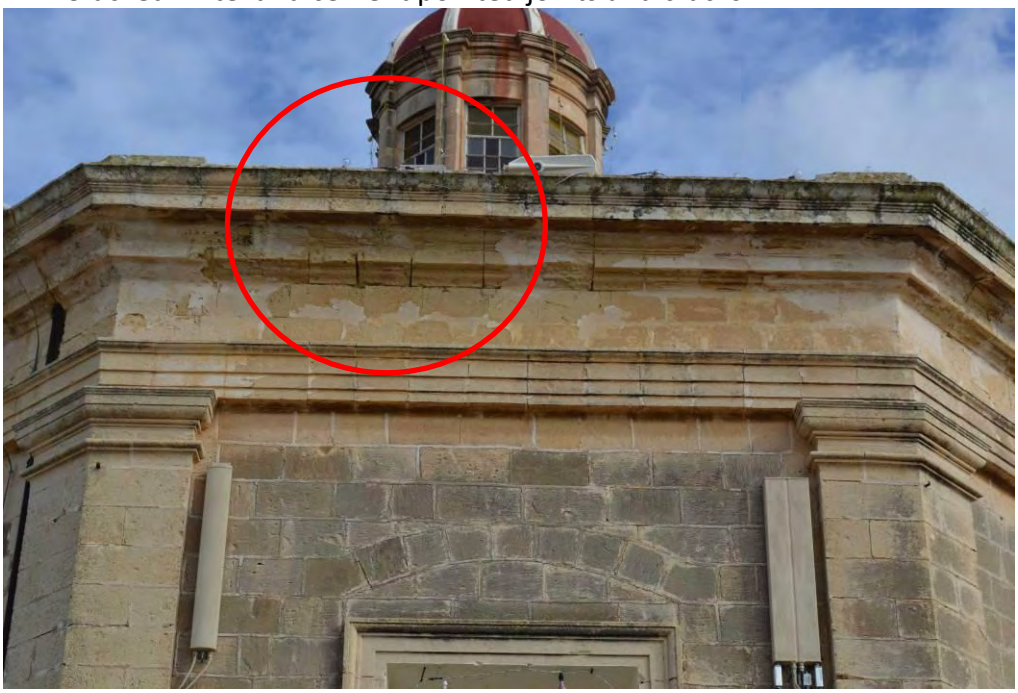
Various inspections were carried out to visually assess the damage of the octagonal drum and prepare deterioration drawings.

The deterioration and damages that were identified are;

1. Cracks in lintels of the bay windows especially on the north and south facades and corresponding vertical cracks and open mortar joints above the lintels. Shear cracks in the masonry blocks in the lower part of the below these elevation are also present.
2. The majority of the shear cracks and open joints are plastered and painted over with cement based plaster and paint.
3. The damage to the masonry fabric is mostly concentrated below the cornice where there is powdering, flaking and detachment of stone. There are also remains of a lime plaster, that is also a flaking off.
4. Cracks and detachment of the sculptural elements around the windows and cornice.
5. Dirt, infiltration of water and a thin black crust on and below the cornice.
6. Biological growth on all elevations with the north facing elevations, B,C and D having extensive biological growth.

The following are some photos showing the type and extent of deterioration mapping. The deterioration mapping of the eight elevations are shown on Deterioration Mapping drawing 03 and drawing 04.

A – Cracked Lintel and cement pointed joints and cracks.

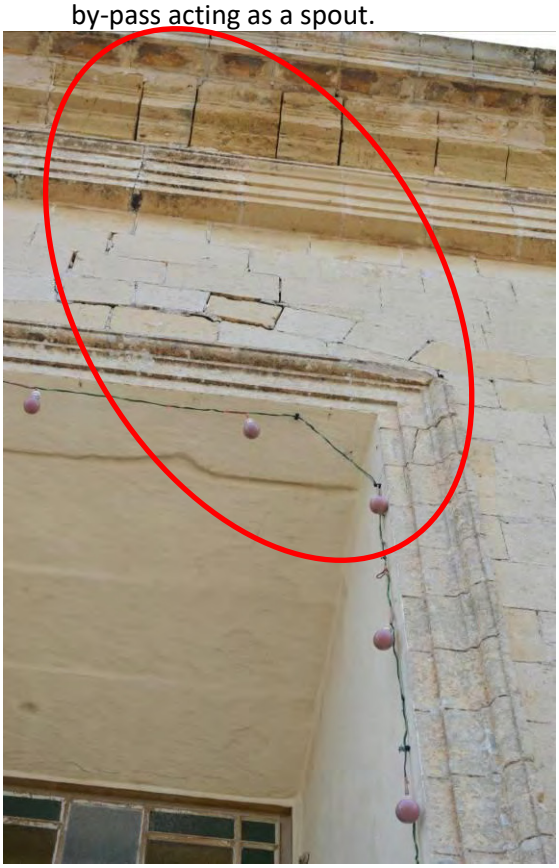


B – Flaking and loss lime plaster underneath the cornice.

Photo 5 - Deterioration of the drum.

A- Blocked cast iron pipe with a Upvc pipe as by-pass acting as a spout.

B- Cracked lintel and other cracks above the window up to the cornice.



C- Further cracks, open joints, flaking stone and black crust.

D- Cracked mouldings, cement repairs and obsolete steel pipes.

Photo 6 – Further damage to drum.

3.2 Side and back facades and new naves

The church is a block that is surrounded by Triq Sant Antinin, Triq il-Knisja and Triq il- Parroċċa. The facade along these streets are bulit of masonry and are have plain walls with pilasters, topped by a cornice at the top.

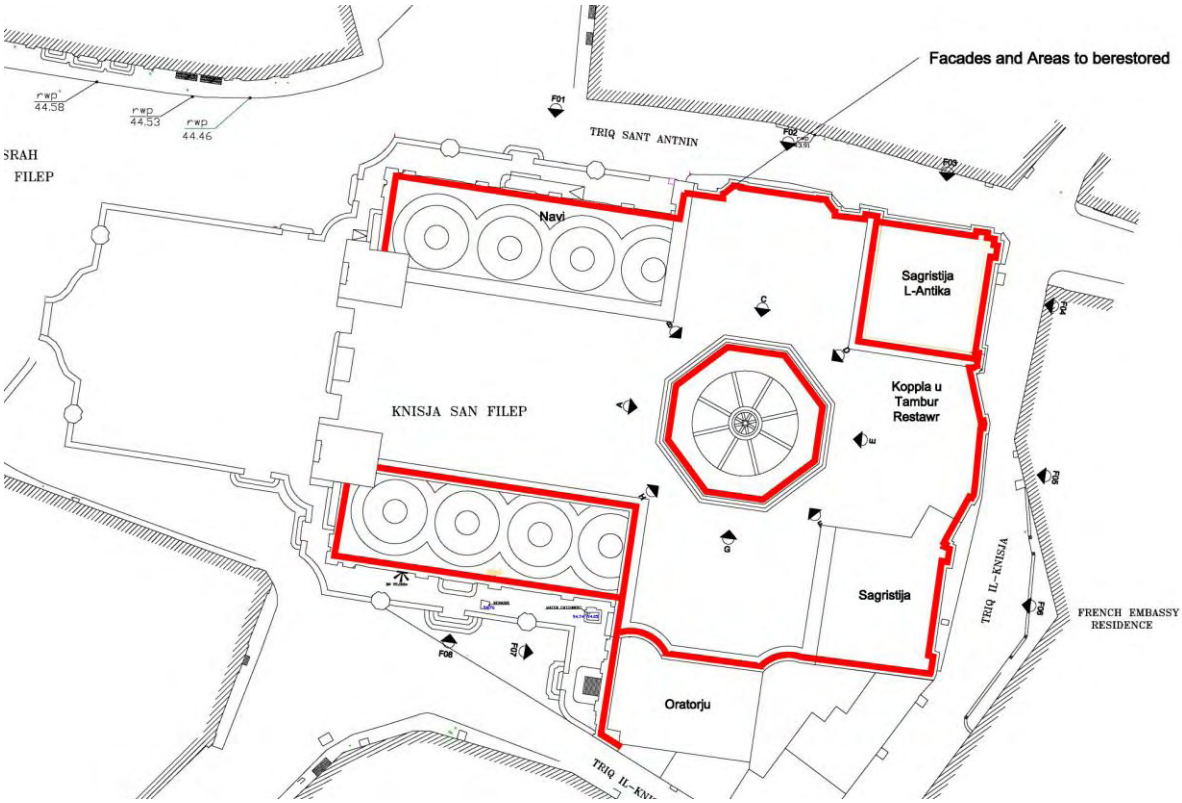


Figure 1 Plan showing St. Philip and its surrounding streets

The facades on the side are those of the old church and that 'new' facades of the two aisles constructed in the 1900's.

The facade of the old church are in a relaitve good condition expect for the lower 4 meters from road level that are deteriorated moslty due to rising damp and plastering/ remedial works in which cement base mortar was used in during the plastering and white washing works that were under taken as part of the rountine maintance of the external facades.

Along triq Sant Antnin and Triq il- Knisja the deterioration of the facade is mainly in the lower part of the facade up to a height of about 3m. The deterioration consists in open joints, falking

paint, powdering, flaking and stone detachment of some stone blocks and extensive areas of cement mortar repairs. In some areas the stone was hacked to key in the cement rendering.

The condition of the rest of the facade, (in the upper level) is in a very good condtion and stone has a good orange to red patina. The only form of superficial deterioration are dust particles and biological growth with the highest concentration being on the cornice. On the underside of the cornice there is also a thin layer of black crust. There are also a some open mortar joints and black curst on the underside of the cornice.

Photos showing the deterioration of the facade at the lower levels are found below.

Photo 7 - Condition of the side elevation with on Triq Sant Antinin having open mortar joints, extensive concete plastering and flaking and powdering of stone.

Photo 8 - Condition of the back elevation with on Triq Il-Knisja having open mortar joints, extensive concete plastering, flaking and powdering of stone.

Photo 9 - Condition of the back elevation with on Triq il-Knisja having open mortar joints, extensive concete plastering and flaking and powdering of stone.

Photo 10 - Condition of the side elevation with on Triq il-Knisja having open mortar joints, extensive concete plastering and flaking and powdering of stone.

Photo 11 - Detail of extensive cement plastering along the side and back facades.

Photo 12 - Detail of extensive rising damp, past repairs using cement, powdering and loss of mortar joints.

The extension of the church was carried out in the begining of the 20th century with the construction of two side aisles with four bays each. Each bay is covered by a dome. The works are taught to be the works of Architect Andrea Vassallo.

The aisles were built on both sides of the church onto Triq Sant Antnin on the left hand side and Triq il-Parroċċa on the right hand side.

The both side aisles are in a relatively good condition except for minor deterioration that is expected for a 100 years old building. The walls are in a very good condition and have good orange to red patina. The mortar joints are in good condition and except for some joints that are were repaired using a white mortar that makes these repairs very visible.

There are also many metal inserts and nails that are used for the fixing decorations and statues during for the village feasts decorations. The nails and metal inserts are cracking and damaging the stonework of these facades.

The main deterioration is located around the cornice and parapet wall. The deterioration consists of dust and biological growth on the upper part of the cornice and upper part of the parapet. Black crust is also found on the underside of the cornice and below the decorative column capitals and triangular pediment of above the door.

The other damages to masonry is flaking and powdering of the lower side of door jamb onto Triq il-Parroċċa as shown on Photo 14 A.

Photo 13 A - Left hand side facade of the side aisles onto Triq Sant Antnin.

Photo 13B - Right hand side facade of the side aisles onto Triq il-Parroċċa.

Photo 13- Photos of the side aisles

Photo 14A – Detail of deterioration of stone below the cornice, dust, biological growth and black crust.

Photo 14B – Detail of deterioration of stone below the cornice, dust, biological growth and black crust.

Photo 14 – Typical deterioration of the nave built in the early 1900.

3.3 The Oratory

The Oratory is found on the left hand side of the church in a small square at the intersection of Triq il-Knisja with Triq il- Parroċċa.

Oratory has an elaborated facade with four pillars and that extend up to the full height of the facade. The main door is located on the centre of the facade and above it on the second level there is a stained glass window with the symbols of St. Philip of Agira.

Photo 15 - Facade of the Oratory onto Triq il-Parroċċa.

Above the main door and window are capped by a triangular pediment and a large elaborated cross sculputed in local lower globigerina limestone. One either side of the cross there are two large finials of torches.

The Oratory was designed by Perit Godwin Galizia to house the statues of the Passion of the Christ that are used in the Good Friday procession. Perit Godwin Galizia, was responsible for various religious works in particular for the design and construction of St. Gregory Church in Sliema and Birzebbugia Parish Church.

Works for the construction of the Oratory started in 1906 on the initiative of Don Salvatore Zammit.

The interior of the Oratory is very has very elaborate sculptures with a central altar. One the walls there are also four paintings by Chevalier Antoine de Favray that were in the located in the main chruch prior to its extension.[2]

Photo 16 Detail of the upper part of the facade of the Oratory with extensive biological growth.

The most extensive deterioration of the masonry fabric of the facade is found at ground floor level.

The cause of the extensive deterioration damage due to rising damp and salt crystallisation. Furthermore the facade was plastered and painted and then white washed. As in other areas cement based mortar was extensively used in the repair works.

[2] Four pantings by Favary (1706-1798) were

Photo 17 Detail of the lower part of the facade of the Oratory with extensive deteriotation of masonry Fabric due to rising damp.

Due to the action of salt crystallization process, the stone work in particular mouldings have been severly damaged and in some cases lost, by powdering and flaking the porous limestone.

The height of the damage increases at the connection with the old part of the church with extensive powdering and flacking and cracking of stone. The use of cement mortars for rending is also present in this area.

A cast iron pipe is also installed at the in the corner of the pilaster. Biological growth and dirt is also found around the pipe. This is an indication that the cast iron pipe is cracked and is leaking rain water. Therfore the pipe would need to be repaired or replaced.

The deteriortion at the upper level is very minimal. This includes open joints below the ground floor level cornice, superficial deposits and light crust below the cornices, a dark biological colonisation and also alveolization on the underside of phinials and the cross on the roof.

The door of the Oratory also needs to be cleaned, restored and repainted.

The cause of rising damp along the facade has to be investigated further as the Oratory was built in 1906 a time when the laying of a damproof membrane was required by law.

Photo 18 – Details of the deterioration of the lower side of the Oratory.

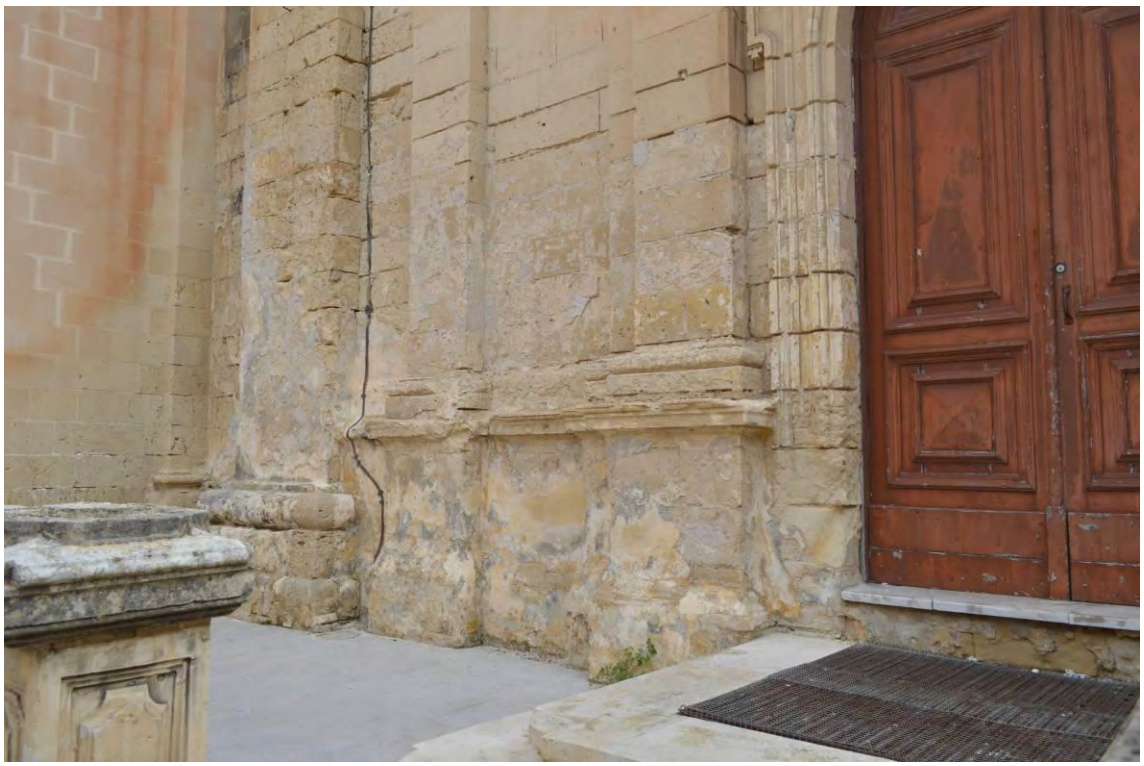


Photo 19 - The extensive deterioration and damage to the lower left hand side of the Oratory.

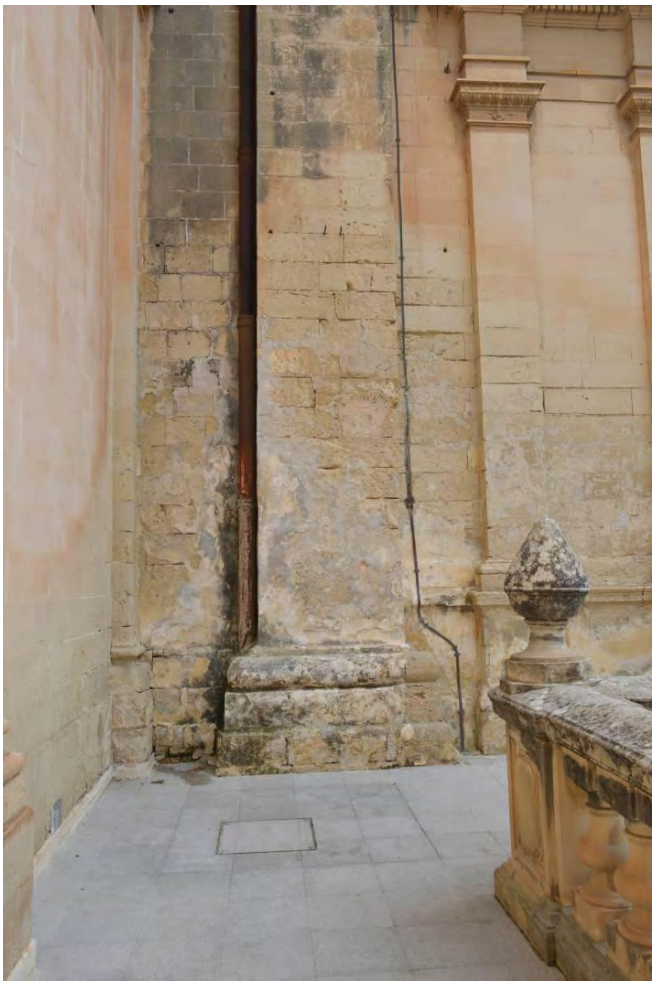


Photo 20 - Rising damp at the interface between the old church and Oratory and damaged cast iron pipe water pipe

4. Conservation interventions

The principles that will guide the conservation of the church are the following;

a) **Minimum intervention** An important objective of conservation is to preserve as much of the original material as possible.

b) **Maintenance** - In order to reduce the frequency and extent of necessary repairs, it is vital to minimise the rate of decay and deterioration. This can only be achieved by implementing a regular and informed maintenance and care regime.

c) **Preserve as found** - Heritage professionals no longer strive to restore the original appearance of buildings and artworks but instead aim to respect the current state of objects. This obviously excludes cases of serious damage and decay, when the conservator has to intervene in order to improve stability, and cases necessitating the removal of previous repairs which are damaging to the building or object, their use and interpretation.

d) **Like for like repairs** - Repairs should be carried out with materials and techniques that are compatible with the original materials.

e) **Reversibility** - Any new additions to a building or object should be carefully considered. Some materials used today could turn out to be damaging at a future date or could be superseded by a preferable material. We can't predict what technical advances will be made in the future and, therefore, there has to be an opportunity for the easy removal of additions.

f) **Recording** - Projects should be documented. This includes a description of the object's or building's condition before any interventions, the architect's or conservator's diagnosis and decisions, details of treatments, new findings and the state of the object after conservation. Such records will be of invaluable help to future generations responsible for these buildings and objects

The restoration interventions that are required for the rehabilitation of this building are listed below;

3.1 Drum, Dome and Lantern

a) The removal of metal inserts nails and redundant artificial lighting fixtures, cables and steel pipe ducts and organisation of existing mobile communication antennae;

b) Removal by hand of all paints from the existing 'deffun' layer and masonry followed by the consolidation of the existing detached 'deffun' layer were possible and replacement using traditional methods and workmanship;

c) The application of reversible water proofing system above 'deffun' layer;

d) The dry and wet brushing for the cleaning of all masonry fabric to remove dirt and excessive biological growth;

e) The careful removal of black cement pointed joints and cracks and the removal of friable renders below the cornice;

f) Raking off mortar joints and re-pointing using a Natural Hydraulic Lime based mortar;

g) The pinning using stainless steel or glass fibre pins and injection with epoxy resin of cracked lintels and detached mouldings especially sculptured moulding around windows;

h) The piecing in of a new sculptured stones slabs if required to reinstate damaged or missing elements around windows and cornice;

i) Plastic repair works were necessary and the laying of a new lime based waterproofing cover to the cornice and damaged stone;

j) The repair of damaged masonry by stone replacement and/or piecing in at the base of lantern/top of dome;

k) The reinstatement of the original flow of surface water runoff and replacement of cast iron pipes with similar lined cast iron pipes or with new-fired clay pipes;

l) The redecoration of internal side of the lantern due to the flaking paint and prior to ensuring proper natural ventilation;

m) Repair/or re-install and certification of the lightning conductor system;

n) The installation of new architectural lighting system for the dome using energy efficient lighting fittings. All fixtures and cables will be fixed using stainless steel screws;

o) The installation of crack gauges to monitor the movements and cracks especially in the drum;

p) Application of a transparent lime based 'velatura'.

3.2 Side Facades

a) The removal of metal inserts, nails and redundant cables and fixtures;
b) The removal of all vegetation on cornices and higher parts to the structure;
c) The careful removal of all modern renders and cement based mortar and plasters;
d) The dry and wet brushing of masonry fabric to remove dirt and excessive biological growth with damaging the patina of masonry fabric;
e) Stone replacement of heavily damaged masonry fabric by new stone were necessary and piecing in where necessary;
f) The chemical cleaning of black crust especially on the underside of cornices using poultices with paper pulp;
g) The raking out of joints and the re-pointing using slaked lime or hydraulic lime based mortar;
h) Plastic repair works to reinstate the form and shape of original stone when replacement is not deemed necessary;
i) The replacement of damaged or in appropriate asbestos pipes and cracked cast iron pipes with new cast iron internally lined pipes or clay pipes;
j) The filling of cracked masonry using lime injection technique;
k) The pinning of detached masonry using stainless/glass fibre pins set in epoxy resins and injection of cracks or detached masonry using fluid epoxy resin.
l) The restoration of timber doors, windows, and the replacement of existing aluminium apertures with timber apertures.
m) The restoration of wrought iron metal grilles in opening and re painting.
n) The plastering and painting using slaked lime in the lower parts.
o) The application of a propective cover using lime water and natural colours to as a protective leyer and homogenise the apperarance.

3.3 Oratory

a) The removal of metal inserts, nails and redundant cables and fixtures;
b) The careful removal of all modern renders and cement based mortar and plasters;
c) The dry and wet brushing of masonry fabric to remove dirt and excessive biological growth with damaging the patina of masonry fabric;
d) Stone replacement of heavily damaged masonry fabric by new stone were necessary and piecing in where necessary;
e) The chemical cleaning of black crust especially on the underside of cornices using poultices with paper pulp;

f) The raking out of damaged and open joints and the re-pointing using slaked lime or hydraulic lime based mortar;

g) Plastic repair works to reinstate the form and shape of original stone when replacement is not deemed necessary;

h) The inspection of cart iron pipe to ensure that there is not blockages, followed by the repair or replacement of damaged cast iron pipe with new cast iron internally lined pipes or clay pipes;

i) The filling of cracked masonry using lime injection technique;

j) The pinning of detached masonry using stainless/glass fibre pins set in epoxy resins and injection of cracks or detached masonry using fluid epoxy resin.

k) The restoration of timber doors and windows repainting using oil based paints.

l) The application of a propective cover using lime water and natural colours to as a protective leyer and homogenise the apperarance.

5. General Restoration Interventions

The methodology of the restoration interventions that are indentified above for the various areas of the church are described in detail below.

1. <u>Removal of all ferrous and non-ferrous inserts and cables to the facade</u>

   All ferrous and non-ferrous inserts that are inserted or fixed to the façade will be carefully removed as part of the cleaning process. Two existing floodlights, installed above the cornice will also be removed. Metal inserts and nails will be removed by the drilling of holes, using an electric driller, next to the metal insert, so that it can be dislodge sideways. The drilled holes will be filled with lime based mortar during the pointing works as outlined in work specifications.

2. <u>Removal of vegetation to the facade</u>

   Any vegetation will be sprayed with herbicide and left to dry for four to five weeks. As soon as it dries out it will be carefully removed with its roots. The location of the roots/joint/crevice will then be carefully cleaned to remove all roots, seeds and organic material from the crevice and then injected with fluid hydraulic lime or mortar depending the width and depth of the crack.

3. <u>Raking out of unsound lime renders and mortar joints.</u>

   The facades will be inspected in more detail once the scaffolding is place by the Architect and Civil engineer in conjunction with the conservators to identify the location of unsound plasters and friable mortar joints.

   All unsound lime renders and joints will be removed using small chisels and hand tools in order to break the mortar with minimal damage to the edges of the individual stone blocks. The use

of mechanical tools such as rotating-disc cleaners and dry or wet sand-blasters or tipped metallic tools will not be permitted.

Any cement based renders will be removed slowly layer after layer to expose the masonry fabric. Care will be taken to ensure that no damage is caused to the underlying masonry fabric and delaminated stonework.

4. Cleaning

Dirt from stonework including mouldings, cornices, etc. will be carefully dry brushed, one section at a time using a stiff bristle or a nylon brush. Care will be taken to ensure that no damage is caused to friable, delaminated stonework. If so deemed necessary, such areas will be pre-consolidated adopting procedures outlined hereunder.

Dirt on stonework that could not be removed by dry brushing will be wet brushed, one section at a time using a stiff bristle/ nylon brush and de-ionised water having a conductivity inferior to 60µS.

Area of thick cushions of moss and lichens will be cleaned using surgical blades, spatulas and stiff bristle brushes. Care would be taken during this intervention to lift only the moss so that no damage is procured to the masonry fabric. To ensure that no damage is procured, various trials will be carried out before commencement of the cleaning works to determine the most effective procedures and tools for the works.

Areas on façades that are affected by algae and lichens would be treated with a biocide. The biocide would be applied in concentrations suggested by manufacturer, to affected areas of the façades and horizontal surfaces of such as cornices and sculptural elements.

The biocide would be applied by a brush or by a pneumatic garden type sprayer to a dust free surface. The application will commence at the top of the vertical wall to be treated and the biocide applied in horizontal movements. The biocide would be left for the time as specified by the manufacturer. The surfaces are then brushed off to remove dead growth with a stiff bristle brushes and water. Following dry brushing the application may be repeated for a second time, depending on the intensity of the infected areas. The treatment will be followed by wet brushing with clean de-ionized water to further remove biological growth and thus achieve the desired level of cleaning.

Areas of black crust will be softened using poulticing technique with a chemical such as Ammonium Bicarbonate or MORA pack. Test areas will be carried prior to application to determine the type, duration of poultice and number of cycles that have the least minimal impact on the masonry fabric.

Once the black crust is softened with the poultice the surface will be wet brushed using de-ionised water and depending on the desired level of cleaning and effectiveness of the poulticing the procedure may be repeated to achieve the required level of cleaning. On completion of the chemical cleaning process the masonry fabric will be wet brushed or desalinated to remove all salts introduced in this cleaning process.

5. Pointing of mortar joints

All joints opened on the façades, will be carefully cleaned using stiff hand brushes, wetted with distilled water using a hand held sprayer and then pointed with mortar. The mortar will be made up of three parts fine crushed sand, one part natural hydraulic lime (NHL 2.5) and clean potable water. Fine brick dust will also be added to the mortar to improve its hydraulicity and strength.

The mortar is then placed and pressed into the joint using a trowel or spatula. The excess mortar is quickly removed and the edges of each masonry block are cleaned using a sponge and clean distilled water. The mortar is then cured with a wet sponge repeatedly to avoid shrinkage cracks.

Deep joints and cracks will be filled up in layers and frequently cured to avoid shrinkage cracks. All pointing will be left shy from the surface and made in such as a manner to allow efficient flow of water along the façades.

6. Repair of cracked masonry fabric and sculptural elements

The delaminated, shattered and cracked masonry elements would be repaired by the use of epoxy resins and stainless steel or glass fibre dowels were necessary.

Inclined holes will be drilled in the damaged masonry fabric to the desired depth. The drilled holes will be flushed with alcohol and left to dry. Epoxy mortar will be then injected into the hole using a hand held gun or a hypodermic syringe whichever is suitable for the intervention. Pre-cut glass fibre rods or stainless rods are then sunk into the epoxy mortar. The pins would be sunk into the hole so that they are at least 5mm to 10 mm below the surface. The number, diameter and direction of the glass fibre/stainless rods will depend on the size of the masonry fabric to be anchored. The holes will be then sealed with mortar.

Fine fissures will be then grouted with a fluid lime using a hypodermic syringe.

Very thin fissures would need to be injected with a low viscosity epoxy resin this would be carried out firstly by sealing the crack with latex paint or modelling clay in order to avoid spillage of epoxy resin onto the surface will be resorted to only for areas where injected fluid lime mortar would be inadequate.

7. Repair of masonry fabric using plastic repair

Horizontal surfaces of projecting elements such as cornices and other flat surfaces will be protected by mortar mixed with brick dust to direct rain water away from the structure and minimize water penetration into the masonry fabric.

Large alveoli formed on the masonry fabric, will be reinstated using plastic repair techniques. The material used for the plastic repair, will be a purposely pre-mixed mortar for plastic repair works. During the intervention care will be taken to ensure that each alveolus is filled in individually with the mortar pressed into the alveoli. The mortar will be left shy off the surface with the surface cleaned and left free of any mortar. The extent of filling of the alveoli will be determined on site by the architect in charge and will vary to reflect the physiognomy of the deteriorated masonry fabric.

Deteriorated/damaged masonry work on any part of the structure, including mouldings, cornices, etc, will be repaired through plastic repair techniques. The material used for the plastic repair will be a pre-mixed mortar that matches in colour to that the masonry fabric.

8. Stone Replacement

Limestone used for the works will be of the Lower Globigerina limestone (frank) type supplied from an approved source. The new stone work will be worked carefully, true to shape (ikkartabunat) and free from defects such as cracks, splits, blade marks, chipped edges or any other blemishes.

The stone will be fine-grained, free from defects, including spots, stains, clayey material (soll), or hard shell fragments. Any stone showing clay markings (swaba), patches of 'soll', nodules, or chipped edges or corners shall be discarded.

The blocks will be free from vents, cracks, fissures, discolouration, or other defects, which may adversely affect strength, durability or appearance; the blocks need to be thoroughly seasoned, dressed and worked in accordance with shop drawings prepared by the Contractor to the approval of the Architect in charge.

The limestone blocks will be faced and trimmed in a way that no chipped edges are visible, unless recycled masonry originating from the original construction itself is used.

The blocks will be transported to site on pallets and handled in such a way as to minimise damage and waste.

Replacement units will be cut and dressed to;

- Specified minimum bed depths and agreed face lines with the Architect in charge and suitable allowances are made for any final finishing works that are required in-situ.
- Sizes and profiles matching existing masonry, and with existing joint widths maintained.
- With sinking for fixings and joggles accurately aligned and positioned in relation to existing masonry.
- With each block/dressing clearly marked on a concealed face to indicate the natural bed and position in the finished work.

The stone will be cut and dressed so that the natural bed is horizontal in plain walling, vertical at right angles to wall face in projecting stones and copings, and at right angles to line of thrust in arches.

Deteriorated masonry including mouldings, cornices, coat-of-arms, sculptural elements that are severely deteriorated will be marked on site and then replaced following an instruction by the Architect and Civil Engineer in charge element.

Any deteriorated stonework will be carefully chiselled away to a depth as specified in this document or as directed by architect in charge, taking care, in the process, not to damage surrounding sound old stonework. All re-instated stone will be of varying thickness and in no case less than 230mm in thickness or as directed by architect in charge, such as to ensure a

good interlocking effect with the adjacent area of wall. All newly re-instated masonry will be grouted to the original wall with an appropriate lime based grout.
Where applicable, all new stonework will be worked to templates to match the original prepared as specified in this document, and all exposed surfaces will be finished by traditional mason's hand tools. No machine finish will be allowed.

Any interstices resulting between newly re-instated leaf and original fabric of bastion face will be grouted with a hydraulic lime-based grout. Grouting will be carried out at course height intervals to ensure that the all voids are grouted.

9. Consolidation of deteriorating masonry fabric

Areas of stone that are delaminated or powdering will be inspected in detail and an assessment will be carried out case by case to determine whether the consolidation using ethyl silicate or ammonium oxalate. Trial patches will be carried out on stone before application of a particular product.

Delaminated and powdering of stone block will be consolidated where necessary using consolidants.

Prior to the application of consolidants a number of salt tests and detailed analysis would be carried out prior and during the progress of work, areas to be consolidated will be identified. Where levels of salt are considered to exceed acceptable levels, policing of the stone will be carried out to reduce the salt content of the fabric to acceptable levels ready to receive consolidate as directed by architect in charge. The poulticing procedure will be repeated for as many times as deemed necessary until level of salts within the structure is considered acceptable.

Consolidants used will be as specified the specifications for workmanship and materials and will be applied in such a way as to guarantee an acceptable penetration, exceeding 30mm. In cases where the extent of delamination is such that the layers of stone have become detached, the space resulting between the layers will be suitably cleaned prior to the application of the consolidant.

The consolidation of cracked masonry fabric will be carried by fluid lime injection. Prior to the injecting with fluid lime, cleaning will be carried out by low pressure air, conveyed through pipes adequately sized to reach within the interstices, followed by the liberal application of an approved volatile solvent, such as acetone. The intensities **will** be injected with a fluid lime-based mortar. When injecting, care will be taken to ensure pressure exerted on delaminated stone sections does not cause the shearing of the same material. In cases where the detached material is of considerate dimension, carbon fibre rods, bridging the weaker layers with the stronger fabric, and grouted with the same fluid lime-based mortar will be introduced. Glass reinforced polyester resin and/or carbon fibre rods will be inserted such as to be least obtrusive.

10. Repair timber apertures

All timber doors and other timber apertures will be repainted. The timber apertures will be restored by the removal of all paint layers using approved liquid paint strippers, the wood surface cleaned, and wood slightly sanded. Following the completion of this intervention the door is painted with two coats of undercoat followed by two coats of oil based paint.

11. Finishing

Anti-roosting bird spikes will be fixed/ installed to all projecting cornices and ledges and a transparent finishing coat (velatura) will be applied to restored masonry. The main aim of the velatura will primarily be that of giving a unified appearance to the restored fabric. The mix of the velatura will be prepared to the approval of the architect in charge.

12. Design and installation of Architectural Lighting

Architectural lighting of the dome and drum would be carefully designed to meet the international requirements for the Architectural Lighting of Historic Buildings.

The design will utilise small energy efficient luminaries with tight beam optics so that light is directed where it is required so that there is no light dispersion. Other measures such as shutters, flaps and baffles, etc will also be used to control the light beam in order to control light pollution.

The concept design that is being proposed is the installation of linear LED luminaries inside the windows of the octagonal drum.

The dome will be illuminated by small discrete 12W LED luminaries so that the spherical surface of the dome is lit up. The luminaries will be fitted with a visor or flaps so the light beam is controlled to avoid night time light pollution.

The lantern at the top of the dome will be lit internally in order to minimise light pollution and also highlight the interesting the coloured glass of the bay windows.

All fixings will be carried out using a stainless steel screws. The cables will be installed in the connecting passages around the drum and the existing spiral staircase in the drum will be used pass cables to the dome. An example of the type of luminaries that will be used is shown in Figure 2 and 3 below.

Figure 2 Linear Led tubes to be installed in windows of the drum.

Figure 3 - Typical luminaires that will be used for the lighting of the dome and lantern. Such luminaires can be fitted with flaps and visors to direct the light beam.

Specification of workmanship and materials

1. Stone

Limestone used for the works will be of the lower globigerina (*franka*) type supplied from an approved source. The new stone work will be worked carefully, true to shape (*ikkartabunat*) and free from defects such as cracks, splits, blade marks, chipped edges or any other blemishes.

1.1. Lower Globigerina Limestone Blocks

The stone will be fine-grained, free from defects, including spots, stains, clayey material (soll), or hard shell fragments. Any stone showing clay markings (swaba), patches of 'soll', nodules, or chipped edges or corners shall be discarded.

The blocks will be free from vents, cracks, fissures, discolouration, or other defects, which may adversely affect strength, durability or appearance; the blocks need to be thoroughly seasoned, dressed and worked in accordance with shop drawings prepared by the Contractor to the approval of the Architect in charge.

The limestone blocks will be faced and trimmed in a way that no chipped edges are visible, unless recycled masonry originating from the original construction itself is used.

The blocks will be transported to site on pallets and handled in such a way as to minimise damage and waste.

1.2. Production of Stone

Replacement units will be cut and dressed.

To specified minimum bed depths and agreed face lines with the Architect in charge. The Contractor shall ensure that suitable allowances are made for any final finishing carried out in-situ.

To sizes and profiles matching existing masonry, and with existing joint widths maintained.

With sinkings for fixings and joggles accurately aligned and positioned in relation to existing masonry.

With each block/dressing clearly marked on a concealed face to indicate the natural bed and position in the finished work.

1.3. Natural Stone Bedding

The stone will be cut and dressed so that the natural bed is horizontal in plain walling, vertical at right angles to wall face in projecting stones and copings, and at right angles to line of thrust in arches.

2. Removals of Additions/Accretions

The Contractor will ensure the careful removal of redundant cables and wires, light fixtures, and other accretions from the facades of the building. The methodology employed for this removal shall be approved by the Architect in charge prior to commencement of works.

Care will be taken to remove all metallic inserts, (especially iron and steel fixings) from the stonework.

Corroding metal fixings will be carefully cut so as to cause the least possible disturbance to the surrounding masonry; the associated rust debris will also be carefully removed.

Resulting holes will be filled-in using a suitable lime-based mortar when the break is small or by piecing-in stone, if the gap is large, as per specification.

3. Cleaning of Paint

Oil-base paints may be removed by a neutral paint-remover certified to contain no salts or any other deleterious agent. Repeated applications in paste form may be necessary to remove persistent stains

Old plasters and similar coatings will be removed by hand tools using manual methods and constant supervision so as not to damage the stone surface.

Cement pointing and facing will be removed manually taking care not damage the surrounding weakened stone.

Mechanical means, especially those involving the use of power tools (such as rotating-disc cleaners and dry or wet sand-blasters) or tipped metallic tools will not be permitted.

4. Removal of Cement Renders

Where identified by the Architect in charge, concrete / cement renders will be carefully removed by hand tools using manual methods so as to contain damages to the underlying masonry work

Electrical tools as well as tipped metallic instruments with sharp edges or corners, power tools (such as rotating disk cleaners) and sand blasting (dry or wet) will not be permitted.

5. Removal of Vegetation

Every effort will be made to remove all parts of plant including roots and stubs.

Plants/weeds will be removed by carefully cutting the plant at the base of the stem and then by the introduction of a suitable biocide to kill off the remaining part of the plant.

The product to be used should result in the desiccation of the plant after it has been absorbed; the dead parts will then be easily removed by hand, without risking re-growth.

The following factors shall determine which chemicals will be used:

- Chemicals which do not cause damage to the stone,
- Chemicals which do not create any risk to man or other life forms, apart from the ones treated, taking into account their toxicity with respect to humans, earth fauna and sea fauna,
- Their activity period and residual effects,

Do not contain harmful salts or other substance which can instigate or accelerate the deterioration of the stone.

5.1. Removal of Higher Forms of Vegetation

The Contractor shall cut out a metre section of the main stem, around 300mm to 1m above ground level; care must be taken not to damage the adjacent masonry.

After the removal of almost all aerial parts of bushes and trees, chemical spot spraying will be carried out on cut ends of stems and branches for perennial woody plants and on new buds and leaves in deciduous trees.

Systemic herbicides will be used with absorption through leaves or barks.

A procedure combining mechanical and cleaning means will follow to remove the plants completely.

6. Dismantling of Masonry Structures

All dismantling of masonry sections for subsequent reconstruction will be carried out carefully by experienced personnel, care will be taken to ensure that during the dismantling procedure each stone block is numbered and referenced to a drawing, specified image, photograph etc as directed by the Architect in charge.

The masonry blocks/sections will be removed in their entirety. Each unit will be identified clearly and indelibly on concealed faces. The methodology to be employed will be discussed with and approved by the Architect in charge prior to the commencement of works.

All masonry units will be cleaned from old mortar, soil etc and stored in a manner such as not to cause any damage.

7. Reconstruction of previously Dismantled Structures

Reconstruction will be carried out by experienced personnel who will ensure that the original face and joint lines, joint widths etc are respected to ensure that the final work matches the original in all respects. Care will be taken to ensure adequate bonding at junctions with the retained original structure.

The bedding surfaces of the masonry blocks will be dampened with de-ionised water having conductivity inferior to 50 µS to control suction. The masonry blocks will be laid on an evenly buttered bed of mortar prepared from a mixture of suitably slaked air line, and stone dust. Care will be taken to ensure that the exposed surfaces of the masonry blocks are kept clean.

The Architect in charge will indicate and approve which of the original masonry units will be replaced. Areas on the two uppermost courses of the parapet wall of the Casemates may require dismantling and reconstruction. Their structural stability will be assessed by the architect and civil engineer in charge.

8. Replacement of Deteriorated Masonry

Every effort will be made to retain as much as possible of the original masonry structure. To this effect no stone will be replaced without the prior approval of the Architect in charge.

Store replacement will be limited to individual badly deteriorated stone blocks and the total number of stone replaced will be kept to the minimum possible.

All new stone work used will be similar in material colour size and configuration to the original and will match with the existing course height.

Methodology employed for the cutting away of the deteriorated masonry sections may vary depending on the particularities of every individual case. Nonetheless, care will be taken to ensure that only hand held tools and small power tools (jiggers) which do not cause damage to the structure and/or immediate stone blocks will be used.

The cutting of perimeter joints may be carried out with a masonry saw. If stone is to be retained, the cut will be made by a purpose-made fine saw blade or with a plugging chisel in the case of a wide joint. Where stone is to be replaced, the stone will be chiselled away starting from the centre and moving towards the edges.

8.1.1. Replaced Stonework

Only new stonework, machine cut to a true shape (ikkartabunat) and hand finished will be used unless otherwise directed by the Architect in charge.

Care will be taken to ensure that new stonework is not chipped or otherwise damaged.

The Contractor will ensure to provide, erect and maintain for as long as necessary all struts, timber planks etc, required for the support of all new and old masonry.

The Contractor will be responsible to prepare all necessary form work required for the replacement (in section or in whole), or reconstruction of arched element such as arched windows, vaults, arches etc. The formwork will be faithful to the original profile.

All newly replaced stonework will have a minimum bedding of 150mm.

Non-hydraulic mortar will be used unless otherwise specified by the Architect in charge. The mortar bed will not be less than 12mm thick.

8.1.2. Laying of Replacement Masonry

Joint surfaces will be dampened to control suction as necessary. The units will be laid on a full bed of mortar and all joints filled. Care will be taken to ensure that no mortar/grout encroaches upon exposed the faces.

The new stone will be dampened to avoid risk of dewatering mortar.

All faces, angles and features will be carefully aligned and set out to ensure satisfactory joint widths and relative positioning with existing masonry. The exposed faces of new material will be kept to the face lines as agreed with the Architect in charge.

8.1.3. Grouting Joints

Grout mix will be based on lime, fine coralline and globigerina limestone sand (xahx).

Joints around replacement masonry units will be thoroughly grouted wherever joints cannot be fully filled with bedding mortar.

The grout will be kept back from the exposed face to allow for the depth of pointing specified; this will be achieved by using an approved temporary sealing material. The Contractor will ensure that the grout does not stain the exposed face.

The Contractor shall not point replacement masonry until all the work has settled-in. The pointing of the outer 25mm (as a minimum) shall be left until all bedding work has settled.

8.1.4. Jointing of Masonry Works

Replacement stone will be cut and shaped with such a manner as to ensure the minimum loss of the original material, yet provide a firm seating for the replacement.

The new stone work will be left proud of the original to ensure adequate finishing on site.

All existing joint widths shall be respected and bridging of joints will not be permitted.

The pockets to receive inserts will be accurately cut with small, sharp chisels and small saw blades to a neat, square profile. The sides of pockets will be undercut, where necessary, to provide space for specified bonding material.

Where so directed by the Architect in charge, the contractors will dove-tail the new insert with the original to ensure adequate bonding.

New shoulders will be formed to receive any replacement cramps.

The pocket will be cleaned out thoroughly and the inserts installed accurately and securely. The Contractor shall ensure that no bonding material encroaches upon the exposed faces.

Piecing-in may also be carried out in larger areas, in which a piece of stone is added to fill in a missing area or replace a part of a deteriorated stone by the insertion of an appropriately cut stone piece, attached using structural adhesives (e.g. epoxy or polyester adhesives), as approved by the Architect in charge.

8.1.5. Bonded Dowels

The Contractor shall submit samples/ method statements for the use of stainless steel, glass reinforced or epoxy resin dowels used in conjunction with polyester or epoxy resin adhesives shall be used, and as approved by the Engineer.

Suitably sized holes will be drilled in the background and rear of the replacement/insert to receive dowels and adhesive. The Contractor will ensure that the holes are aligned to allow accurate positioning of the replacement/insert and that enough depth is allowed for sound anchorage.

The holes will be cleaned, all dust removed and adequately flushed with water; adequate drying time shall be allowed. Smaller holes may also be cleaned by blowing out with a small tube.

The dowels will be secured into clean, dry holes with adhesive. No adhesive shall be used to bond stones at joints unless agreed otherwise with Engineer.

The pins will be cut to size prior to the injection of the resin and will not be closer than 6mm to the surface for small diameters and 12mm for large diameters.

The resulting holes will then be filled with matching mortar.

9. Plastic Repair

Plastic repair as specified in this document will be used in areas indicated by the Architect in charge.

Any deteriorated, flaking, powdering etc masonry will be carefully removed to expose a sound background. In the process care will be taken not to weaken the structure or damage the adjacent masonry.

The top and vertical edges of the repair area will be undercut to provide sufficient bonding and reduce the formation of visible shrinkage joints.

Suitable non-ferrous reinforcement approved by the Architect in charge will be used for all plastic repair interventions which have a projection of more than 40mm from the stone surface or an area which exceeds 50mm by 50mm.

Pre-fabricated glass reinforced polyester, or epoxy rods having a diameter of not less than 6mm will be used. Holes will be drilled with the background to form a grid of dowels fixed not more than 40mm apart. Dowels shall have a minimum anchorage in stone of 60mm, and the Architect in charge may request that this bedding depth be increased. All dowels will be adequately bonded to the masonry fabric with an approved epoxy resin.

Adequately gauged stainless steel wire will be used to form a mesh between the dowels. This mesh will be secured to the resin dowels. This mesh will be secured to the resin dowels by an approved epoxy resin.

When preparing the reinforcement, allowances will be made to ensure a minimum cover of 20mm.

The plastic repair mortar will be based on a lime binder.

Aggregates used will vary from coralline sand, to marble and globigerina limestone sand (xahx) to pozzolanic additives, as agreed with the Architect in charge.

The mixes shall approximate a 1:3 binder to aggregate ratio, unless otherwise agreed with the Architect in charge.

In the mortar preparation, the Contractor shall ensure that the grains of sand and stone dust are adequately coated with the binder paste.

Slaked lime will be used as a binder, with the putty mixed wet with the aggregate and stored in an airtight container as far in advance as possible.

In demanding exposure conditions, hydraulic additives (such as hydraulic lime, terracotta dust) may be added to the coarse stuff immediately before use.

Hydraulic lime may be used to substitute completely the slaked lime, as per Architect's instructions.

Cement gauged mixes will only be used if directed by the Architect in charge.

The mortar will be built up in layers where necessary, each layer not exceeding 12mm.

The finishing coat will match the existing surfaces and approved sample/s.

The Contractor will ensure that repair mortar is not stronger than the adjacent fabric.

10. Mortars

Ready-mixed lime mortar will only be used if approved by the Architect in charge.

The Contractor shall ensure that all pointing is built up in layers not exceeding 10mm in thickness or as recommended by the manufacturer in cases where the use of ready-mixed lime mortars are permitted.

The background will be thoroughly cleaned to remove all dust and debris; the areas of application shall be dampened to control suction.

The mortar will be built up and firmly applied in layers until the specified thickness is reached; the Contractor shall ensure good adhesion with no voids. A mechanical key will be formed to the undercoat/s by combing or scratching so as to produce evenly spaced lines.

Each layer will be allowed to achieve an initial set prior to the application of subsequent coats, and prevented from drying out too rapidly by covering immediately with plastic sheeting and/or dampening intermittently with clean water.

The finishing mortar joint will be formed accurately to the required planes/profiles and flush with adjacent masonry, as per Architect in charge instructions.

The Contractor will provide adequate protection from adverse weather until the mortar repairs have fully set.

11. Grouting

The Architect in charge may request grouting of voids resulting between new and old masonry, displaced masonry, etc with an organic material such as hydrated or hydraulic lime. The lime grout will be prepared with or without filler depending on the size of the gap.

Glass reinforced polyester, epoxy or stainless steel ties will be used as and where directed by the Architect in charge.

Grouting holes will be formed in joints at suitable horizontal and vertical centres to suit coursing and achieve an effective distribution of grout and fill all voids, as per Architect in charge's approval.

The maximum length of each lift between pours will be established to prevent any disturbance of the masonry.

Unless re-pointing precedes grouting, the joint shall be sealed as necessary on either side of the grouting holes with an approved temporary material to prevent leaking of grout. The temporary seal shall be kept back from the face work to allow for specified re-pointing.

Before grouting, the delivery holes will be thoroughly flushed with clean water.

Site trials, in all areas indicated by the Architect in charge, will be carried out for the different methods of grouting so as to establish the parameters required to achieve uniform grouting.

11.1. Grouting by Hand

The grout material will be poured under gravity into the interstices formed by the masonry structure.

11.2. Grouting by Gravity Injection

The approved equipment will include a control of grout flow at the head of the hose (plug) and at the delivery nozzle (stop valve).

The height of the pan above delivery nozzle (subject to site trials) shall be sufficient to ensure an adequate flow, usually around 4.50m.

11.3. Pumped Injection Grouting

The delivery pressure shall be established after site trials.

11.4. Mortar Repairs of cracks

Mortar injection of cracks will be carried out with proprietary fluid lime based mortar as specified in this document.

When injecting, care will be taken to ensure pressure exerted on delaminated stone sections does not cause the shearing of the same material.

In cases where the detached material is of considerate dimension, carbon fibre rods, bridging the weaker layers with the stronger fabric, and grouted with the same fluid lime-based mortar will be introduced. Carbon fibre rods will be inserted such as to be least obtrusive

12. Epoxy Resin Injection

Epoxy resins as specified in this document, having suitable characteristics and viscosity, will be used for the injection, under pressure, of cracked masonry sections previously consolidated.

Epoxy injection will be resorted to only for areas where injected fluid lime mortar would be inadequate

13. Pointing

The use of Portland cement in mortar mixes will not be permitted.

All mixes will be lime-based, and be compatible with the stonework in colour, strength and permeability; they will also be as close as possible in colour, composition and properties to the original mortars.

Pozzolanic or similar additives will be preferred alternatives to give strength and durability to a lime-based mix, unless instructed otherwise.

The properties of the mix will be improved if hydraulic lime is used instead of both hydrated lime and pozzolana; in such cases, only aggregate will be added; no cement or other pozzolanic additives shall be necessary.

Prior to pointing/re-pointing, all open joints will be cleaned from dust and loose materials, and the surrounding stones adequately wetted by de-ionised water. All pointing shall be carried out in moist, warm conditions and in layers not exceeding 10mm thickness.

Fresh pointing will be allowed to dry slowly and be adequately protected from excessive heat and direct sunshine by a tarpaulin and will occasionally be wetted to avoid cracking.

A minimum of 24 hours will be permitted between the applications of each layer of pointing.

When laying new stonework, all vertical and horizontal joints will be adequately buttered with mortar.

14. Preparation of Masonry Structure for Pointing

The existing mortar will be carefully removed without damaging the adjacent masonry or widening the joints using a bent spike or small hand-held chisels to a minimum depth of 25mm and never to a depth less

than their width. Impact tools will not be used. Power tools such as rotary discs (chasers) will not be allowed.

If mortar has failed to such an extent that the joints are largely empty, then the joints will be deep tamped and, if necessary, hand grouted to fill the voids up to the distance required for pointing.

The Contractor will clean and dampen the joints.

The work will commence at the top of the wall moving downwards.

If joints exhibit biological soiling, a biocide will be applied prior to flushing out.

Dust and loose debris will be removed, the joints will then be dampened with clean de-ionised water to control suction as necessary.

14.1. Pointing Methodology

The Contractor will clean and dampen the joints with clean de-ionised water.

The mortar face will be kept as far back as required to achieve the original joint width.

If the stones have retained sharp edges, joints will be filled flush unless the original joint face was profiled in some other way. In the case of weathered edges, or where the stone has spalled off, the face of the new mortar will be kept back such that the apparent joint width does not increase.

The required finish will be as per original surviving masonry and as approved by the Engineer.

When using lime mortars, the fresh mortar will be kept as humid as long as possible to slow down setting rate and hence avoid cracking.

After the initial set has taken place, the Contractor will stipple the joints with a stiff brush to remove laitance/excess fines and achieve a coarse texture.

15. Determination of Salt Levels

Salt levels, as well as the types of salts will be determined before, during and after treatment,

Samples will be taken at depths of 0-25mm, 50-75mm and 75-100mm within the deteriorated zone as established by the architect in charge.

16. Desalination by Poultice Treatment

Where salt desalinisation may be considered necessary, paper pulp and/ or clay packs will need to be adopted. The clay poultice shall have a sepiolte clay base.

Both clay and paper pulps will be free from soluble salts, and any staining additive.

The poultice will be worked with de-ionised/ distilled water into a thick, sticky cream, and carefully ironed onto the surface with suitable spatulas, and permitted to dry slowly, attracting salts away from the stone fabric.

The dried material will be disposed of away from the structure being restored and will not be reused.

This process may have to be repeated for as many times as so deemed necessary, until the level of salts within the stone fabric has been brought down to an acceptable level. For payment reasons, this exercise will be considered as an intrinsic part of the poulticing exercise, and in no case will the contractor be allowed to make claims for extra costs in relation to workmanship, and/ or material.

16.1. Sepiolite Clay

The sepiolite clay used will be natural having a water absorption superior to 148% and an apparent density of around 555g/l. The sepiolite clay used will be asbestos free with a specific surface area of 218 to 222 sq.m./g. pH value shall be 8.0 +/- 0.5.

16.2. Paper Pulp

The paper pulp used in the work shall be chemically stable, having a cellulose content of 99 +/- 1% and a calcium content of 0.025 +/- .005%. Average fibre diameter should be 20 microns, while the average fibre length shall be of 300 microns.

17. Cleaning: General Considerations

The cleaning method adopted will, as far as possible;

Be effective in removing the deleterious substances from the stone surface.
Not produce any substances which will encourage any future deterioration of the stone.
Be slow enough such as to allow good control by the operator.
Must not cause any micro-fractures or any other discontinuities of the stone surface, as these may initiate or encourage new deterioration processes.

Abrasives, chemicals, or high pressure water jetting will not be permitted. A controlled nebulous pulsating water spray system will preferably be used. The process will ensure that no over saturation and softening of the stone occurs. In those areas where this system is not sufficient to reach the required level of cleanliness, controlled micro-blasting on plain, non-decorative areas will be considered. Systems adopting sand, gravel, or water blasting techniques will not be considered.

Micro blasting systems used will be such as to function effectively at low pressure, and use low quantities of water. The abrasive material used will be calcium carbonate having size and configuration which will not damage the surface texture of the stone fabric.

It is important that any water used throughout the cleaning operation be free from salts. No chemical agents will be permitted.

The aim of the cleaning exercise will primarily be that of cleaning the face of the stone and removing all accumulation of carbon, sulphurous compounds, and other contaminants, but will retain the patina of time. On completion of works, the stone is to be brought to its natural patina, texture and profile. All discoloration will be removed from the face of the stone. No original carved relief arises or surface textures will be damaged or altered.

Contractor will ensure that all electrical supplies serving external equipment have been disconnected and that, unless specified otherwise, fittings and associated cable have been removed.

The Contractor will take all measures to prevent:

Ingress of water, cleaning agents, debris and dust into the building via windows, doors, vents and other openings.

Protection of ventilation grilles, airbricks, or other ventilation openings without sealing them.

Damage to all components and finishes that can reasonably be protected during cleaning procedures, including lightning conductors, roof coverings, flashings, rainwater goods, glass, metal works, services equipment, signage and paving.

Staining of surfaces from ferrous or other reactive metals.

The Contractor will use approved protective boards, sheeting, films, sealants and sealing tapes that do not stain protected materials and that can be readily removed after cleaning without damaging or staining the protected material.

17.1. Tests to be conducted during the Cleaning Procedure

The Contractor will be responsible to carry out tests as outlined in this document to determine the extent of salts within the masonry fabric. These tests will be carried out prior and repeated during and after the cleaning process has been completed. The contractor shall furnish the Architect in charge with the results of the tests.

Putty moulds of stone surfaces indicated by the Architect in charge will be prepared prior to the commencement of the cleaning works and repeated after final cleaning.

17.2. Trial Cleaning

The Contractor is to prepare trial samples for all cleaning methods in locations agreed with the Architect in charge.

The Contractor will inform the Architect in charge before carrying out each trial cleaning method to enable the Architect in charge to approve of selected testing area and be present during the preparation and execution of trial samples; the period of notice shall be agreed with the Architect in charge.

17.3. Monitoring

The Contractor will regularly monitor effects of each cleaning procedure against the degree of cleaning established by approved trail sample/s.

18. Lower Pressure Cleaning

Low pressure micro blasting cleaning with pressures not exceeding 3 Bar. The water used will be free of salts and having a conductivity not exceeding 60 µS.

High pressure blasting or washing using pressures in excess of 3 Bar will not be allowed.

The contractor will ensure that any water resulting from this cleaning process is not allowed to flow in the streets.

The Contractor will take all the necessary measures to ensure that cleaning agent or residues are not allowed to stray onto adjacent or protected surfaces.

The Contractor will ensure that the grit used in the cleaning process is weaker than the stone being cleaning. No cleaning shall commence prior to the approval of the Architect in charge.

The Contractor will clean, collect and safely dispose of all debris from scaffolding, ledges, etc at the end of each day.

The Contractor will prevent marking of cleaned areas from dirt and debris splashing up from scaffold boards.

All cleaning will commence at the uppermost section of the structure to avoid washing dirt onto previously cleaned surfaces.

Approved cleaning procedures or materials will not be modified without approval of the Architect in charge.

The Contractor will seek approval from the Architect in charge should it be necessary to take additional measures for cleaning.

19. Brushing by Hand

Prior to commencing any cleaning method, the Contractor will remove loosely adhered deposits and growths using suitable corrosion resistant brushes and micro scalpels that do not damage the stone surface.

The use of brushes with steel bristles will not be permitted. Nylon brushes will be preferred.

20. Water cleaning by Hand held Systems

General cleaning will be carried out by means of low pressure washing (less than 2 bar) using water with a conductivity inferior to 60 µS and hand held mineral/nylon fibre brushes as directed and approved by the Architect in charge.

Chlorinated mains water will not be used.

In the process, care shall be taken to ensure no damage is caused to mortar joints and original plasters.

Stubborn deposits will be removed first. Softened deposits will be removed with suitable brushes that do not damage the surface. Any debris will be thoroughly rinsed.

The Contractor will seek the prior approval of the Architect in charge prior to making any changes to the agreed cleaning process.

21. Water Spray Cleaning with Mounted Nozzles

Water spray cleaning with mounted nozzles will be used in areas which require a prolonged period of wetting, as approved by the Architect in charge. The wetting will last for a period sufficient to produce swelling of the layer of dirt and in combination with small brushes to cut down the saturation period, and shall be attached to a length of pipe connected to the approved water supply. Chlorinated mains water, and water having a conductivity of more than 60 µS will not be allowed.

The spray will be atomised from fine nozzles situated at least 300mm away from the masonry. Enough water pressure and small enough orifices shall be required to atomise the water.

The equipment will be of a type which allows the position and direction of nozzles to be readily adjusted relative to existent surfaces and profiles.

For each surface, the nozzle positions and spraying cycles that enable deposits to be removed/ softened whilst keeping the water running off the surface to a minimum shall be established.

The nozzle positions and spraying cycles that enable deposits to be removed/ softened whilst keeping the water running off the surface to a minimum shall be established. The flows will be directed from the top downwards so that the tickling of water softens the lower areas of the dirt build up.

Regular monitoring and adjustment of the washing cycle and nozzle positions will be ensured by the Contractor as work proceeds; in addition, water spray/ mist will be controlled by adequate sheeting which shall reduce the effect of draughts of air blowing away the water from the building, since the effectiveness depends on how successfully the mist can be contained.

The heaviest deposits will be removed first; softened deposits will be removed with suitable brushes that do not abrade the surfaces. Any debris shall be thoroughly rinsed.

The water spray technique will not be allowed in severely damaged areas

22. Chemical Analysis

The Contractor will test the pH value of clean water used for rinsing, the wetted surface and all chemical agents to be used in the cleaning processes before application.

All solutions will be thoroughly mixed before taking a sample for pH measurement.

All readings will be carried out at the same temperature, or compensated for if taken at different temperatures. All data shall be submitted in writing to the Architect in charge.

23. Cleaning of Organic Growth

Surface soiling, by organic growth, will be initially removed by simple dry bristle knife blades and spatulas, provided that the substrate is sound enough, without damaging or abrading the surface and as approved by the Architect in charge. If the surface below the growth is delicate or liable to be marked or scoured in any way, this preparation must be limited to removal of higher plants only, and approved by the Architect in charge.

The application of mild biocides that have a long-term inhibiting effect on re-colonisation will follow the initial removal of organic growth.

Products to be used will be neutral products belonging to the chemical class of compounds methoxytriazine, acting by being absorbed both through the roots and the leaves and have a wide spectrum of action; other products include quaternary-ammonium compounds, or as per Architect's in charge approval.

The biocides will be applied in strict accordance with the manufacturer's recommendations for safety and protection of the workers and the environment.

The general removal of organic growth such as fungus lichens and the like will be limited to places where these are possibly causing harm and as approved by the Architect in charge.

In an exceptionally dry period, and in areas where it is recommended to remove the organic growth, dormant dry lichens will be revived with light water spraying prior to the application of the biocide. Application of biocidal treatments will not be undertaken during wet weather or when windy conditions lead to excessive drift of spray.

The Contractor will protect all surfaces that are excluded from chemical cleaning. All chemical agents shall be contained within each treatment area.

24. Chemical Cleaning by Liquid Gels

For each area/surface, the lowest possible concentration of agent/s and the shortest dwell times are established. The Contractor is to keep written records of concentrations, dwell times, number of applications, ambient temperatures and rinsing water temperatures.

The Contractor will ensure that the chemical agents and rinsing water/sprays are contained within each treatment area and, agents or rinsing water/sprays, do not come in contact with surfaces that are either excluded from the cleaning or that have already been cleaned. It is important to prevent wind drift.

Before each application of agent, the surface and adjacent areas are wetted using clean water applied by a low-pressure spray. The wet surface is also tested for pH. The cleaning agent is then applied evenly over the surface and is not allowed to dry out.

The treated surfaces are then rinsed thoroughly and evenly with clean water working from the top of each area downwards. Water spray pressures that will drive cleaning agent into, or cause disruption of, the surface material and joints, will not be used.

PH testing and neutralisation procedures will then follow.

25. Poultices: General Considerations

The principle behind poultice treatment is that once soiling is dissolved, dirt is held in contact with the pack, rather than dissolved and permitted to fill the pores. The intimate and extended contact of the cleaning materials means that smaller quantities and lower concentrations of chemicals need be used.

The use of the AB57 (Mora Pack) with paper pulp/ cellulose and/ or sepiolite clay is being requested. The Mora Pack is a mild chemical pack containing agents which facilitate the dissolution of calcium salts. The poultice will be prepared by mixing the chemicals into a consistent sticky paste.

60g sodium bicarbonate
60g ammonium bicarbonate
25g ethylene diamine tetra acetic acid (EDTA)
10g surfactant disinfectant (neutral)
60g sepiolite clay/ paper pulp/ carboxymethylcellulose (CMC)
De-ionised/ distilled water as required. Tap water or water containing salts will not be permitted.

The mix is then suitably ironed to a thickness of 4 to 5mm on the pre-wetted soiled surface, and covered with a polyethylene film to prevent the poultice from drying up. The poultice is left in place for a contact period as considered necessary by the architect in charge, after which it is gently removed and the treated area rinsed with de-ionised water and brushed with a suitable nylon brush.

Given the nature of the crust, this process shall be repeated for as many times as so deemed necessary, until the black crust formation has been removed, and a satisfactory level of cleaning is obtained.

25.1. Chemical Cleaning – Poultices Removers for Iron Stains

The clay pack for iron stains will consist of Sepiolite clay and / or paper pulp added to a solution of glycerine, generally sodium citrate. The paste will then be applied to the stain surface and left to dry.

The paste will then be removed with wooden or other non-metallic spatula.

Several coatings might be necessary to lighten the stain; for stubborn stains, the surfaces shall be wetted. When lifted off, the surface is washed with copious amounts of water.

Given the nature of the crust, this process shall be repeated for as many times as so deemed necessary, until the black crust formation has been removed, and a satisfactory level of cleaning is obtained.

25.2. Chemical Cleaning – Poultices Removers for Cuprous Stains

The removal of cuprous stains will be carried out by mixing one part of ammonium chloride with four parts powdered talc or sepolite clay or paper pulp. A 10% solution of ammonia water will be added to the mix.

The surfaces will be wetted with clean water prior to the application of the paste and then be left to dry.

The paste will then be removed with a wooden or other non-metallic spatula and shall then be rinsed thoroughly with clean water.

It may be necessary to reapply, remove and rinse off the paste, to lift or satisfactorily lighten the stain, as instructed by the Engineer.

Given the nature of the crust, this process shall be repeated for as many times as so deemed necessary, until the black crust formation has been removed, and a satisfactory level of cleaning is obtained.

25.3. Chemical Cleaning – Removers for Graffiti / Aerosol Paint

a) The pasteous, solvent-free remover for mineral surfaces will be applied in a thick layer left in contact with the paint for long enough to cause softening and to enable scraping and brushing to take place successfully; the layer will be covered by a thin layer of plastic (as per manufacturer's recommended procedure).

b) Following this application, the surface will then be washed thoroughly with warm water and neutral pH soap.

c) Given the nature of the crust, this process will be repeated for as many times as so deemed necessary, until the black crust formation has been removed, and a satisfactory level of cleaning is obtained.

25.4. Chemical Cleaning – Soap / Detergents

The Contractor will apply a non-foaming soap blend for water rinsing and completion of the cleaning.

The lowest possible concentration of agent and the shortest dwell times will be established for all areas and surfaces.

The Contractor will keep written records of concentrations, dwell times, thickness and number of applications.

Powdered detergents will not be used.

26. Consolidation

Stone consolidants are applied to the stone fabric as liquids, depositing a solid material within the pore structure of the material.

The main function of a stone consolidant should undoubtedly be that of restoring the cohesion, physical properties and appearance of the deteriorated stone. It is thus important that the choice of a suitable consolidant will be based on the following parameters:

a. Consolidating value, whereby the treated deteriorated stone recovers its original properties, mainly strength, surface hardness and abrasion resistance.
b. Durability
c. Depth of penetration, affected mainly by the viscosity and surface tension, rate of gel or precipitation formation, method and conditions of application, and rate of evaporation.
d. Stone porosity. As the proportion of fine pores increases, the stone becomes more susceptible to salt attack. The consolidant should, ideally not alter the pore size distribution of the original material.
e. Moisture transfer
f. Compatibility. Cured stone should have three-dimensional properties similar to that of the original stone. Consolidants should not form by-products containing harmful salts that can cause further damage to the stone.
g. Appearance of the consolidated stone.

The consolidants to be used shall be non toxic and of a one component system, having a silicium organic compound base (70 to 80%). They shall be thin, and have a low viscosity of 3.3c ST at 25°C or better, certified to penetrate deep into fine capillaries. They shall not impair the breathability of the stone structure, be durable and resistant to local weather. The consolidant used shall be colourless, have a density in the region of 0.96 to 0.98 g/ cm^3, or better, and cure without any salt formation. The consolidant shall be catalysed by atmospheric humidity. The consolidant shall be applied to specifications detailed by the manufacturer. It shall not be applied to stone subjected to high moisture content, or characterised by an elevated salt content. Ideally, the stone is to be consolidated by flooding either by a coarse-droplet, or preferably by a long-bristled brush.

The consolidant shall be applied generously and uniformly to the stone surface, until the stone surface is saturated. If so considered necessary, the architect in charge may request that this exercise be repeated for as many times as so deemed necessary.

The consolidant shall not be applied in windy or elevated climatic temperature conditions which would impair the penetration of the same material. Consolidated areas should be protected from water, wind, and other natural/ man-invoked adverse conditions for a minimum of 30 days, or more if so specified by manufacturer.

26.1. Lime injection mortars

The injection mortars used will be suitably prepared from good quality and chemically stable hydraulic lime, free from salts, pozzolans and other inert additives, mixed into consistent thixotropic, injectable putty.

Prior to injection, all stone surfaces will be desalinated, adequately consolidated, cleaned from any accumulated dirt/ dust and suitably wetted with de-ionised water. Mortar shall be injected into the crevices using suitably sized syringes. Application should not be permitted in ambient temperatures exceeding 30°C.

The injection mortar used will have a specific weight of 1200kg/m^3, an initial set of an average of six (6) hours, and a final set of approximately ten (10) hours, attaining a mean compressive strength of 26 N/mm^2, and an average flexural resistance of 7N/mm^2 after 28 days. The set mortar shall attain an elastic modulus of 15 (+/- 1.5) N/mm^2, and a change in dimension not exceeding 1.60µm.

26.2. Lime (Hydraulic and Air Limes)

Unslaked Lime (quicklime) (*gir mhux imtaffi*), shall be prepared from suitable, good quality upper coralline limestone. The quicklime should preferably be prepared in a wood-fired kiln in a temperature not exceeding 900°C. The stone matter should be suitably cooked to prevent under burning, over burning, or sintering of the stone, keeping the contents of any inert residue to the minimum as permitted by established International standards. The quicklime shall be crushed to a fine powder, sieved, packed, and delivered to site in dry conditions, and soon after baking. When testing sample of lime using Hydrochloric acid as detailed in BS 6463, the CO_2 content of lime supplied shall be in the region of 3%.

The hydraulic lime should be natural, free from any additions such as Portland cement, etc., or any other material, which contains any quantity of deleterious salts such as sulphates, chlorides, nitrates, etc. The hydraulic lime offered should be that defined by standard norms as eminently hydraulic lime C3/ XHN 60, though natural cements, class D/ XHN 100 (roman cements), may be used subject to the approval of the architect in charge. The hydraulic lime offered shall have an initial putty setting time in water of 2-4 days, acquiring a stone-like consistency following 12months curing in water. Composition of CaO and MgO shall be over 50%, while SiO_2, Al_2O_3, and Fe_2O_3 shall amount to approximately 12%-25% of active clays. Crushing strength at 28 days of a mixture of 1:3 lime: sand, shall be in the region of 6.00N/mm^2. For natural cements, class D, crushing strength at 28 days of a mixture of 1:1 lime: sand, shall be in the region of 10N/mm^2. Hydraulic lime used shall have a stone colour, and shall be certified to have been produced at a temperature inferior to 1100°C. It shall be ground to a fine powder having a specific area of 8000cm^2/g.

26.3. Epoxy resins

The epoxy resin used shall be a solvent-free resin-based product supplied in two packs (resin + hardener), having a low viscosity, and certified by manufacturer to suitably fill cracks in the region of 1mm or more as so required. The resin shall be certified by manufacturer to have a suitable bonding to masonry, be colourless (or have a stone colour), be resistant to chemicals, and have an effective adhesion even on moist masonry surfaces. The material shall be easily injected into the crack structure using proprietary methods and tools, including suitably sized non-return injection valves. It shall have a compressive strength greater than 60N/mm^2, and a flexural tensile strength of more than 30N/mm^2.

All masonry surfaces to be treated with epoxy resins shall be clean, free from any loose material, greasy substances, etc. Cracks should be superficially sealed with an epoxy resin having suitable viscosity, and proprietary injection nozzles fixed. Following the injection of the epoxy resin, and after allowing sufficient time to ensure that the structural stability of the delaminated or otherwise masonry structure is restored, the masonry is carefully cleaned from the superficial epoxy resin applied previously to seal cracks.

27. Sand for lime mortars

Sharp, well graded and conforming to the methods of sampling and testing and quality requirements of BS882 or BS1200, unless specified otherwise.

28. Lime (Preparation of Air Limes)

Quicklime (unslaked lime) will be slaked soon after it has been produced.

The slaking will be carried out in a container of suitable shape and material which will not permit the material to overheat during the slaking process.

Soon after slaking the lime will be sieved through a 5mm gauge sieve to remove any uncreative material.

The slaked lime putty will be allowed to mature under water for a minimum period of 4 weeks before being used.

The slaked putty will then be mixed with the aggregate specified above in ratio of 1 part lime to 3 parts sand is as specified and approved by the Architect in charge.

28.1. Ready prepared lime mortar

Ready prepared lime putty will be produced in conformly to standards set out in BS890.

The density of the lime putty shall range between 1.3 and 1.4kg/l and shall not contain any salts (nitrates, chlorides, sulphates, etc) which contribute towards the deterioration if the stone.

28.2. Pozzolanic Mortars

The use of pozzolanic additives such as brick dust, pozzolanic etc to enable air limes to set hydraulically will be permitted. However care shall be taken to ensure that pozzolanic (natural or artificial) added are not toxic and do not contribute towards the deteriorations of stone. Pozzolanic such as pulverised fuel ash or others which contain salts detrimental to the stone will not be allowed.

Any pozzolans will be added to the mortar just before use.

28.3. Lime wash

Prior to the application of the lime wash, the background will be washed to remove dust and grime, and then allowed to dry to a damp state. Any organic growth will be treated with a suitable biocide as directed by architect in charge, and dead material brushed off before applying lime wash.

Apply the lime wash to the substrate with a long-haired bristle brush, using horizontal, vertical, and diagonal strokes, ensuring the lime wash is applied as thinly and evenly as possible, and is burnished into the surface. Overly heavy coats will craze and crack when they harden and dry. If this occurs, wash off with hot water and a stiff bristle brush and ensure that the new covering is properly applied.

Containers of lime wash will be constantly stirred during application to ensure even distribution of lime and pigment. Allow the first to dry fully before applying the second coat, and so on, lightly dampening the background before applying the next coat. Damping shall ideally be carried out by spraying water to an area of approximately 2 sq. m. at a time. Protect from strong winds and direct sunlight during the drying out period. Lime wash shall be produced from mature lime putty mixed with water to a suitable consistency. The mix shall be sieved into a bucket, working through any lumps, but leaving any grit in the sieve. Add colour as directed by architect in charge, mix well and sieve again prior to use. It is difficult to match lime colour batches. It is thus ideal that all lime wash provision required be prepared in one batch.

29. Apertures

All apertures are to be painted in a suitable colour compatible with the area such as dark green. Timber doors at ground floor will be sanded down and repainted with oil based paint.

Timber apertures are to be stripped from flaking paint and restored by a qualified carpenter. Care shall be taken in their removal and transportation. The apertures will be finished in a paint colour compatible with the area.

30. Terracotta rain water pipes

Terracotta pipes and fittings used must be off the traditional handmade type.

Pipes and fittings must be free from any defects, cracks as well as free from manufacturing defects.

Pipes used have to be baked to a suitable high temperature and glazed on the internal face. Glazing shall be free from any cracking, or other defects, which will affect the impermeability properties of the pipes. Junctions and connections between different pipes shall be adequately sealed with an appropriate silicone based sealer as approved by architect in charge.