Scientific Bases of Treatment of Stones and Monumental Buildings

Restoration, Conservation and maintenance

Treatment of Stones and Monumental Buildings

Cleaning and Removal of Salts

Consolidation (Pre and Pro)

Supporting and Completion

Final Maintenance and Exhibition

Cleaning and Removal of Salts

Types of dirt (before cleaning)

Firstly we should define the different types of dirties and surfaces accumulations affecting our cultural heritage. This dirt on the stone material appears as a persistent layer and of more or less regular thickness where the products of distinct types are mixed without distinction. These materials divided into several categories:

Crusts and remains of previous treatments.

Spots

florescence, areas of colour loss, spots due to dissolution of metallic structure elements, to sprays and paints, etc. Substances of biological origin: vegetation and micro fauna.

Smoke and dust

particles formed by ash, solid oils that are not burnt and proceeding from the erosion of solid materials.

Monumental Stone Cleaning

Introduction cleaning of Stone, mean eliminate the surface dirt and the harmful products. This is a stage of vital importance since sometimes it is the only intervention that is done, and the main problem of cleaning is its irreversibility. The cleaning conditions and must be compatible with the later stages of intervention. Before the intervention, one has to consider the aspects that will determine the choice of method, and these are:

The historical-artistic value or interest of the monument and the state of conservation.

Factors relative to the rocks: its physical-chemical nature, texture, technical and petro-physical properties and environmental behaviour in the area where it is located.

Factors relative to the substance to be eliminated: nature, type, extension, and thickness. Speed of cleaning action so that the worker can control its effects.

The method used must not generate products damaging to the stone and the worker, neither there should be surface modifications that facilitate its deterioration.

There is no universal cleaning product which exists, for each type of material specific products should be used, causing the minimum desegregation of petreo-material and dissolution of cementing agent (Parrot). Before proceeding with the cleaning, two operations should be realized to see if the state of the rock makes it advisable. We will now go to the main methods of cleaning, we will focus on those mechanisms that are the most well known and frequently used.

One is the *pre-consolidation* of the rock if it is very decohesioned, but lightly so as not to consolidate also the dirt or pathology.

The other is *desalinating*, because not eliminating the salts completely would be in detriment to the behavior of the stone in later treatments

Methods of Stone cleaning, is the 1st step used in the field of conservation and restoration of stone, here, we can define the suitable scientific materials and methods to use it for removing all accumulated particles, soils and salts from the surface of stone buildings by using next scientific steps:

Mechanical Cleaning Methods

Chemical Cleaning Methods

Recent Cleaning Methods

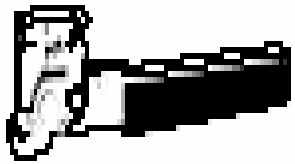
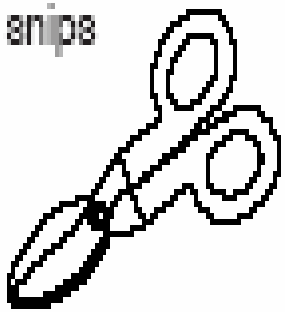
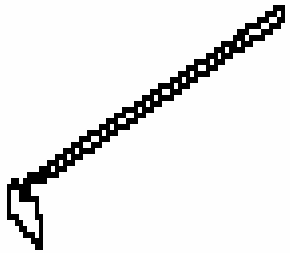
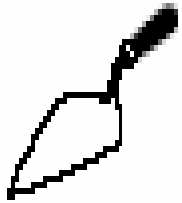
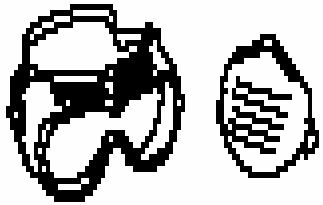
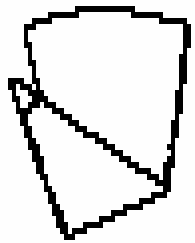
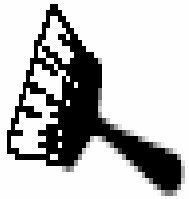
Mechanical Cleaning Methods

Mechanical Cleaning, These techniques separate the dirt of the petreo-material to be cleaned employing the mechanical energy that is generated when projecting abrasives. It is very important that the separation takes place right on the interface dirt - surface of the stone. It is the first step used in the field of stone cleaning, where we can apply many scientific methods for this purpose without using any kind of solutions (*water or chemical materials*). In this part of study we can use the next methods:

Dry Brushing (1st step)

Electric Whetstone (2nd step)

Sand Plasting (3rd step)

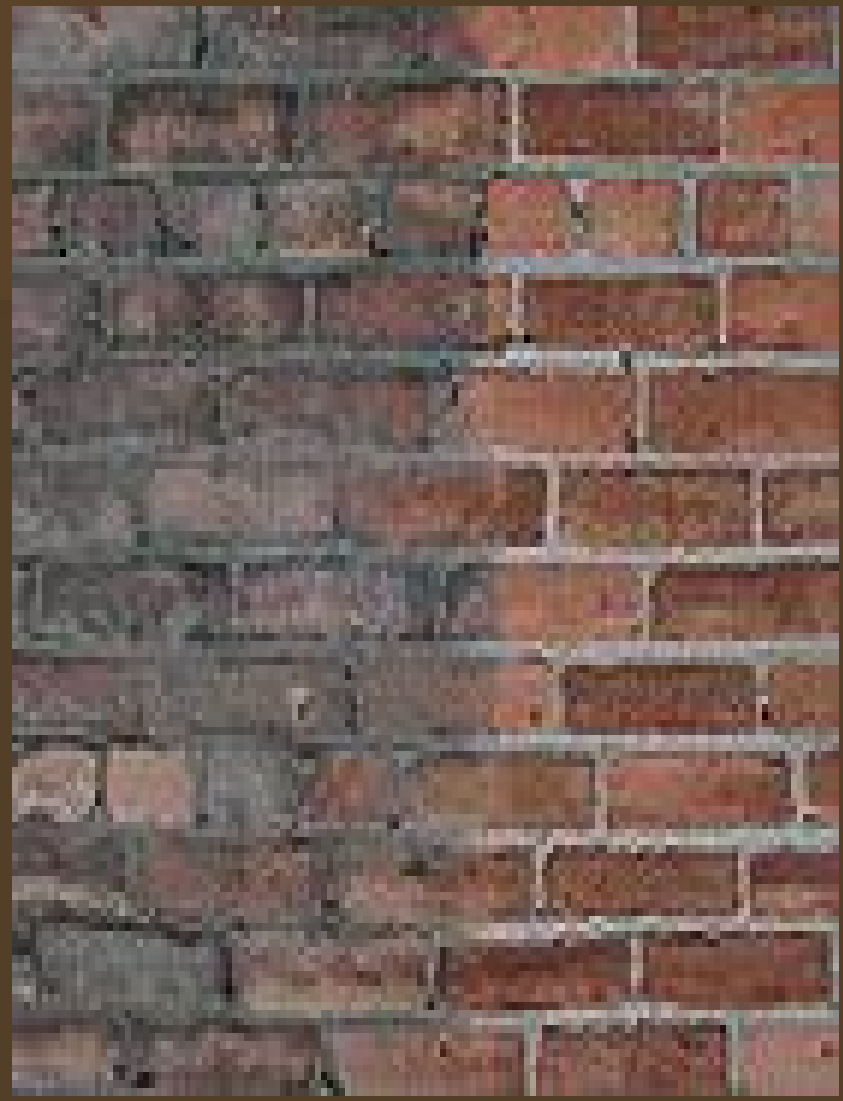
hammer 	hammer tacker 	tin snips 	wheel barrow 
hoe 	masonry trowel 	level / chalk line 	grinder 
circular saw 	safety glasses / dust mask 	grout bag 	soft-bristled brush 

Tools of mechanical cleaning

Dry brushing 1st step

Dry Brushing **is the simplest operation used for cleaning stone surfaces by using some of brushes (*Plastic* and *Bronze*) and many small instruments (*Spatulas* and *Lancets*) because of its big ability on removing all soiling, small particles and organic colonization. Also, there are other simple methods are may be used such as: sandpaper, pumice stone, knife, bronze and phosphorous brushes, glass paper, etc…**

Different kinds of cleaning brushes



Electric whetstone 2nd step

Electric Whetstone **is an electrical machine which must be used under highly attention because of its high ability for scratching and disaggregating the stone surfaces, if it used before scientific studies. In this method we can clean the stone surfaces by using different shapes and sizes of Whetstone (*Spherical, rounded, pointed* and *angular*) which compose mainly of Carborandum.**

Sand plasting 3rd step

Sand Plasting **one of the most important methods used for cleaning the solid stone surfaces by using crushing materials as *Carborandum, sand, walnut shells and dolomite* or any other materials though pressed air current, this is a "*Dry Air Abrasive*". Also, we can add *Water* or other media with abrasive grains for cleaning stone surface, this is a "*Wet Air Abrasive*". The mechanical action of the method is a function of:**

A- The abrasive particle

Type: pumice stone, aluminium oxide, glass and sand**.**

Strength: minimum 5 in the Mohs scale**.**

Form: spheres, hollow or solid

Size: the thinner it is, better penetration and precision.

B- The abrasive jet.

Pressure and density: ?????????

Application time : ?????????

Distance: between mouth of the jet and the surface to be cleaned.

This method has, over time, lost prestige because it was used before in an uncontrolled manner and the abrasive particles had angled edges. On the other hand we can see that there are another developed technique of **Micro-jet of sand.** It is very similar to the previous one but the particles are of less strength and their size is less than 60 micras, they are normally of glass and aluminium oxides. They are very effective for removing thick and strong incrustations, thin crusts and black crusts which cover stones with polychromes. The main advantage is that the jet pressure and the quantity of abrasive projected can be regulated, thus the cleaning can be regulated and can be used on all types of rocks. An inconvenience is that it is slow, a lot of dust is taken out which has to be collected and the apparatus destined for this end is expensive, and the cost of sand is also high.

Sand Plasting instruments

"Sand plaster"

Chemical Cleaning Methods

Chemical Cleaning, **is the second step used in the field of stone cleaning after finishing the mechanical cleaning, where we can apply many scientific methods for this purpose through using some kinds of solutions (*water or any chemical materials*), in this part of study we can use the next methods:**

Spry with Ionized Water

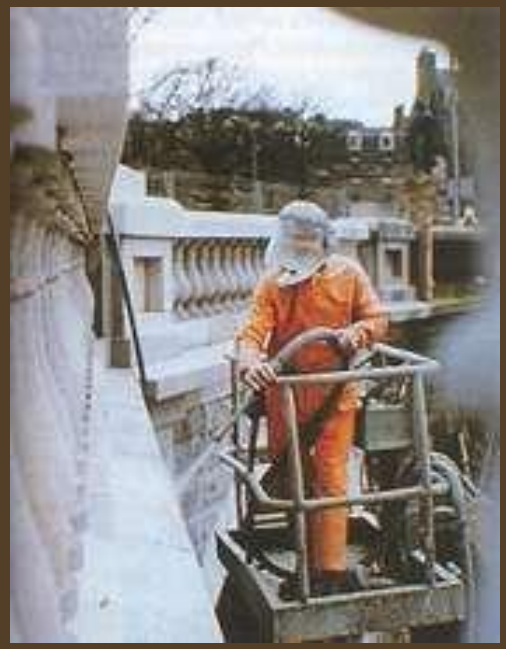
Solvents and detergents

Acidic and Alkaline cleaners

Poultices Removal Method

Spry with ionized water

Ionized Water **define as a desalinize water which will be used for removing all thin steadfast stains from stone surfaces, particularly the solid stone surfaces (*Granite*, *Diorite*. ect…) because of there high durability for bearable of water pressure without any harm. this operation is called (*Washing*), in this operation we must use a special kind of tools as (*anti crust tools*, *coarse brushes* , *phosphoric bronze brushes*).**



Solvents and detergents

Solvents and detergents, these are some chemical materials used for stone cleaning and removing several kinds of dirties especially organic accumulations through applicating some scientific techniques according to the durability state of stone surfaces. These materials as

* **Eiana**, "*CMC+Synthenol, Syclohexanone Isoprobyl Alcohol*"
* **E.D.T.A.**,"*Ethylene Diamino Tetra Acetic Acid*".

Acidic and Alkaline Cleaning

Acidic and alkaline cleaning **include the use of water. Both cleaners are also likely to contain surfactants (wetting agents), that facilitate the chemical reaction that removes the dirt. Generally, the masonry is wet first for both types of cleaners, then the chemical cleaner is sprayed on at very low pressure or brushed onto the surface. The cleaner is left to dwell on the masonry for an amount of time recommended by the product manufacturer or, preferably, determined by testing, and rinsed off with a low-or moderate-pressure cold, or sometimes hot, water wash.**

More than one application of the cleaner may be necessary, and it is always a good practice to test the product manufacturer's recommendations concerning dilution rates and dwell times. Because each cleaning situation is unique, dilution rates and dwell times can vary considerably. The masonry surface may be scrubbed lightly with natural or synthetic bristle brushes prior to rinsing. After rinsing, pH strips should be applied to the surface to ensure that the masonry has been neutralized completely.

Acidic Cleaners. acid-based cleaning products may be used on non-acid sensitive masonry, which generally includes: ***Granite***, ***Most Sand-stones***, ***Slate***, ***Unglazed Brick***, ***Unglazed Architectural Terra cotta***, ***Cast stone*** and ***Concrete***. Most commercial acidic cleaners are composed primarily of ***Hydrofluoric acid***, and often include some ***Phosphoric acid*** to prevent rust-like stains from developing on the masonry after the cleaning. Acid cleaners are applied to the pre-wet masonry which should be kept wet while the acid is allowed to "work", and then removed with a water wash.

Alkaline Cleaners should be used on acid-sensitive masonry, including: ***Limestone***, ***Polished***, ***Unpolished Marble***, ***Calcareous Sandstone***, ***Glazed Brick***, ***Glazed Architectural Terra cotta*** and ***Polished Granite***. Also, Alkaline cleaners may be used sometimes on masonry materials that are not acid sensitive after testing, but they may not be as effective as they are on acid sensitive masonry. Alkaline cleaning products consist primarily of two ingredients: a non-ionic detergent or surfactant; and an alkali, such as potassium hydroxide or ammonium hydroxide. Like acidic cleaners, alkaline products are usually applied to pre-wet masonry, allowed to dwell, and then rinsed off with water, longer dwelling times

maybe necessary with alkaline cleaners than with acidic cleaners. Two additional steps are required to remove alkaline cleaners after the initial rinse, firstly the masonry is given a diluted slightly acidic wash often with acetic acid to neutralize it, and then it is rinsed again with water.

Poultices removal method

Poultices Removal, this a famous technique used for removing the different dirts and soluble salts from surface and sub-surface of stone buildings by using some kind of clay pasts and viscous materials (***Attapulgite*** and ***Sepiolite***), also we can use some kinds of especial paper (***Japanese paper***), Then, we can use the next Method:

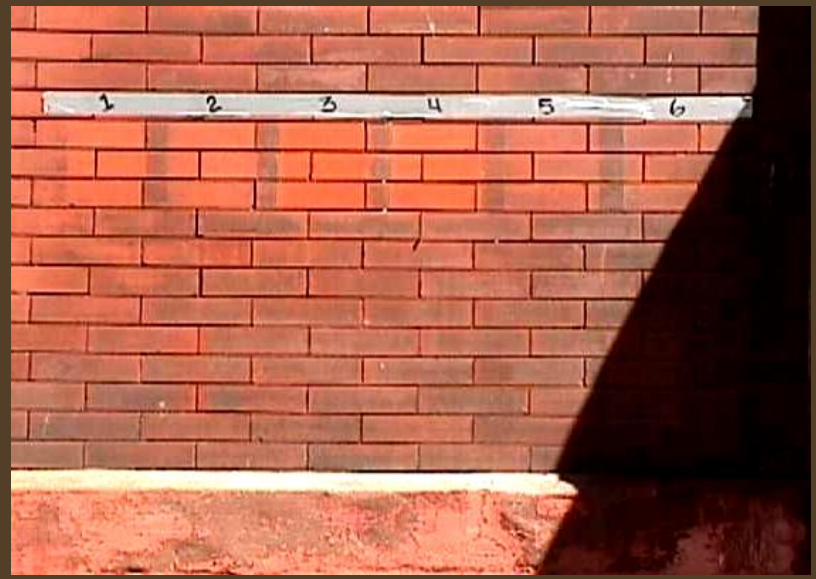
1- Adding the soft clay powder according to "***state of stone surface and quantity of salts and dirties***" to water with good mixing

2- Covering the stone surface with resulted pasts and leaving it for enough time (fully drying and cracking) with noticing the next variations:

* ***Temperature degree***
* ***Moisture content***
* ***Air current***

3- Covering with a thin layer of Poly Ethylene on the surface for avoiding the rapidly drying.

4- Finally, cleaning the stone surface by other mechanical and chemical methods according to its state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Recent Cleaning Methods

These methods of cleaning, were resulted from recent laboratory experiments and divided to:

- **Steam cleaning methods**
- **Ultrasonic cleaning**
- **Laser cleaning**
- **Plasma cleaning**

Steam cleaning methods

Steam cleaning **is used for removal chewing gum - paint layers - grease and oil stains from monument surfaces and floors. etc... Although it has been accepted method for external cleaning of historical and monumental building surfaces, it is only recently that small-scale steam machines have become available for sculpture cleaning. Also, we can say that this methods is an ideal cleaning methods because it is controllable, causes minimal wetting and it pressure forces dirt out of undercutting and details that would otherwise be laborious to clean.**

Ultrasonic cleaning methods

Sonic vibration **uses for removing different surface dirties is a new techniques in the archaeological field, where *ultrasound* is used widely throughout industry for removing problem contamination from all forms of hard surfaces, such as metals, plastics and ceramics. Its unique properties can be harnessed to clean items of all shapes, sizes and technical complexity, penetrating holes and cavities that are impossible to reach using ordinary cleaning methods. Ultrasonic easily removes grease and other hard to clean substances from complex parts, both inside and outside with no smearing and no missed spots. Also, we can see that the ultrasonic cleaning applications may be used in another field as powder coating; Jewellery; metal finishing; optical parts and much more. In the field of archaeological conservation we can note that the materials may be cleaned by this technique are:**

- **Stones**
- **Brick**
- **Mortars**
- **Plasters**

Benefits of Ultrasonic cleaning

- Better for cleaning of complex parts (does not rely on having “line of sight” as jets of liquid, for example, would do).
- Improves results of water-based cleaning solutions to match or surpass solvents (restrictions on use of solvents are increasing, as are numbers of solvents banned).
- Contaminants are dispersed away from the surface of the part, preventing the formation of a saturated layer of solvent, which can slow the cleaning process by preventing fresh solvent/cleaner approaching the surface (particularly beneficial for bores etc and for uneven surfaces).

Laser cleaning methods

Laser cleaning **of natural stone surfaces is possible on the basis of some physical properties of laser radiation (extremely monochromatic, highly coherent light of high brightness and low divergence; selective absorption in materials). They allow one to focus on relatively high energies over very short time periods (pulses of some nanoseconds) on the soiled or encrusted stone surface. The absorption of laser radiation in soil layers and black crusts generates very high temperatures over a very short time and leads to vaporization and ejection of the soil material away from the impact site without any remarkable heat flow into the stone surface.**

Within the last few years some laser systems have been specially designed for and used in the field of conservation of artworks. Most of them are Nd:YAG lasers with a wavelength of 1064 nm (nano meter). They are successful especially in the case of black encrusted limestone and marble surfaces, as shown by case studies in France (Notre-Dame in Paris and others), and in Italy and Germany as well (e.g. sculptures from the Cologne Cathedral). Compared with the "classical" mechanical and chemical cleaning techniques in stone conservation and restoration, the laser shows the following advantages:

* **Cleaning without any mechanical touch to the surface (suitable for cleaning loose scales, removing crusts from deteriorated stone surfaces) etc.**

* **Selective removing of very thin (microns) layers without affecting, the underlying original surface.**

* **"Self limiting effect" in the case of dark layers or crusts on light stone surfaces (e.g. white marble). Better absorption in the dark layers leads to their ablation while the light stone surface reflects most of the laser light at a certain level of energy density.**

The efficiency of laser cleaning in comparison with the classical mechanical cleaning techniques is still too low on a lot of substrates to clean a whole facade. For that reason, the laser technique nowadays is mainly used in the case of restoring sculptures and building elements of higher artistic rank and quality, where good cleaning results (without damaging original surfaces) compensate for the longer working time. Finally we can define the Laser cleaning as:

"a valuable addition to the conservator's toolbox as it offers a highly selective, reliable and precise method of removing layers of corrosion, pollution, unwanted paint and other surface coatings".

How does laser cleaning work? **A laser is a unique source of energy, providing an intense, highly directional, pure form of light that is able to deliver energy to a surface in a highly controllable manner. Lasers can be found in everyday, almost mundane uses (including barcode readers and CD players), as well as the highly specialized (surgical tools used in eye operations). In fact, the laser cleaning systems used in conservation have been modified from medical systems developed for cosmetic surgery. The most commonly used laser cleaning systems in conservation emit short pulses of infrared light, typically at a wavelength of 1064 nm. Light at this wavelength quickly heats the dirt on the artwork, which expands and comes away from the surface. In many cases, the light interacts only weakly with the surface of the artwork and the removal process stops as soon as the clean surface is exposed. It is, therefore, possible for an experienced conservator to completely remove unwanted layers without over cleaning the valuable surface of the artwork. Patina, fine surface detail and important surface coatings can be preserved. Laser cleaning systems offer an extremely high level of control and precision.**

laser cleaning.wmv

Finally we can see that this video clip demonstrates the effectiveness and versatility of laser cleaning. It shows conservators working on materials including a detailed and fragile stonework frieze and the outside of an old building. The flexibility of the technique is really shown when a live rose is successfully cleaned. The conservators are shown holding a pen-like structure which is used to accurately direct the short pulses of infrared light on to the area being cleaned. You can see the light flashing on the surface of the object. Once the pulse has faded you can see the underlying material is much cleaner, while the surrounding area is left unaffected.

Methods of Laser cleaning

There are 2 essential methods which we can dived it as fallow:

Dry laser cleaning

The surface to be cleaned is irradiated by a short laser pulse and it is assumed that thermal expansion of the substrate surface or the particle due to the absorption of the laser energy plays the major role in the cleaning mechanism, this thermal expansion is thought to accelerate the particles and to lead to inertia forces strong strong enough to overcome the adhesion forces acting on the particles.

Steam laser cleaning (SLC)

A transparent liquid is condensed onto the surface just before the laser pulse, as in DLC the energy absorption in the substrate leads to a rapid temperature increase, also the liquid is heated via heat diffusion. Particle removal is governed by bubble nucleation and growth at the solid-liquid interface and the subsequent explosive evaporation of the liquid film.

watch a video of laser cleaning

http://www.hirst-conservation.com/2018/09/13/laser-cleaning-external-alabaster-high-speed-timelapse/

Plasma cleaning methods

Plasma cleaning **can be produced by active gas oxygen, hydrogen or argon usually refers to the removal of some contamination layers from the stone surface due to the reaction between the discharged components (i.e., ion, electrons excited atoms) with the impurities at the stone surface. This technique involves the removal of impurities and contaminants from surfaces through using different types of energetic plasma such as RF plasma, DC glow discharge and Dielectric Barrier Discharge (DBD). The main principle of the plasma cleaning is that the ionized excited molecules and radicals, created by the electrical field, bombards and reacts with the surface of the sample. These activated molecules may etch, sputter, some layer from the substrate surface. These mechanisms lead to changes to the surface properties of substrates. When introducing molecular gases into plasma, chemically, active species are formed, such as molecules in excited states, radicals and ions. Layer corrosion is removed from the substrate through seven steps, these steps are:**

a) Formation of the reactive particle

b) Arrival of the reactive particle at the surface to be etched

c) Adsorption of this particle at the surface

d) Forming chemical reaction "the reactive particle" at the surface, i.e. a chemical bond is formed

e) Formation of the product molecule

f) Adsorption of the product molecule

g) Removal of the product molecule from the reactor. Conservation and restoration

The stone surface may be cleaned by plasma etching if a volatile chemical compound is formed by the bombardment. These species can react with each other, neutral molecules or with the surface of the sample. Within the same context, it could be claimed that the reaction of the plasma has two forms: reduction and oxidation reactions based on the nature of the molecules and the process conditions. On one hand

plasma reduction or hydrogen plasma allows the reaction of chlorinated products, oxides as well as corrosion products from the historical bricks through a reduction process based on the presence of atomic hydrogen.

B A

Iron stains

B A

Copper stains

watch a video of laser cleaning

http://m.youtube.com/watch?v=Bjzgltlyh_I

Removal of salt (de-salination)

Soluble salts and Insoluble salts.

The salts affected the archaeological buildings are divide into two groups:

Soluble salts will dissolve in moisture in the air. This property is known as deliquescence. The salts can move through the porous structure of an artifact as moisture is drawn out through evaporation. As the salts reach the surface of the artifact they may crystallize as white, often furry growths on the surface. If the surface is less porous than the underlying structure they can crystallize just below the surface. These crystals exert immense pressure and may cause the surface layer to spall off, they contain Chlorides, Nitrates and Sulfates.

Insoluble salts are not truly insoluble but will take days or weeks to dissolve in water. They are not deliquescent and so will not cause further damage after excavation. Insoluble salts can, however, be quite disfiguring, and may require removal for identification or reconstruction of an artifact, they contain Carbonates, Sulphides and Phosphates.

Removal of soluble salts from artifacts the traditional technique has been to soak the artifact in water. This technique is not appropriate for artifacts with fragile surfaces. A typical treatment is carried out as follows: 1) The artifact is immersed in a known volume of deionized or distilled water and left to soak. 2) After a set amount of time, typically 24 hours, the salt level is measured using the silver nitrate test (see Conserve O Gram 6 / 3) or a conductivity meter to identify the levels of salt that have been removed from the ceramic. 3) The old water is discarded and clean water is replaced to the same level as before. 4) These steps are continued until the amount of measured salt has leveled off or reached a low level.

In addition, poultices could be used as mentioned before

Removal of insoluble salts, can be mechanically removed using surgical scalpels, ultrasonic chisels and pins, pneumatic chisels, pressurized water jets. If calcareous deposits cannot be removed mechanically, chemicals are used. Cleaning with chemical compounds must be controlled, and mild substances must be used that cannot damage the physical and chemical structure of the object. According to different literatures and experiments, a weak acid (acetic acid), a strong acid (nitric acid) and a chelating agent (EDTA tetrasodium salt) could be used according to the monuments states. For the application, some techniques could be used such as 1) immersion as a direct method. 2) cellulose pulp poultice 3) rigid gel as the indirect ones. In the case of the immersion method, before placing the pieces into the solutions, they were immersed in a deionized water bath. Therefore, the pores were filled in so the solution cannot flow that deep and damage the clay core. In order to remove the remains of the deposits after cleaning mechanical cleaning with wood swabs should be done. The following techniques were used for removing of:

calcium carbonate stains: structurally sound bone can be immersed in 5-10 % solutions of hydrochloric acid or formic acid. Monitor process closely.

Iron stains: 5-10 % oxalic acid has been used to remove iron stain stains from bone.

stubborn stains, 5 % ammonium citrate used alone or 5 percent ammonium citrate followed by 5 percent oxalic acid are effective treatments.

sulfide stains: 5-10 % hydrogen peroxide is used to remove sulfide stains. Stained bone may be placed in a hydrosulfite solution followed by dilute hydrogen peroxide to remove any remaining stain.

Finally, the neutralization process to remove any products' remains, consisted in static baths of deionized water changed every 24 hours until conductivity measurements reached balance, after finishing the stones dried in a drying chamber.

Heating methods must be used under highly attentions in small areas

Consolidation
(Pre and Pro)

After the previous steps, the action of the agents of alteration continues to modify the porous system of the rocks and its capacity of water absorption. The product employed must avoid the degrading action of water on the rock, creating an impermeable barrier to water but permeable to water vapor. Here we can say that the treatments have to be applied when the rock is dry, they should penetrate right up to the rock that is sane, covering walls of pores and fissures, should be reversible and adhere to the substrate, they should not generate harmful sub-products such as salts, modify substantially the porous system of the original material and neither its permeability to water vapor, so as to permit the respiration of the rock.

One should also take into account the chromatic incidence (they are usually transparent so as not to modify the color and natural shine of the stone), the expiry date, toxicity, resistance to acids and alkaline and ultraviolet radiation, ease of handling or the economic cost. Since the ideal product does not exist, a majority of the times it is necessary to adopt a compromise solution that does least damage to the rock. The behavior and efficiency of treatment depends on the porosity of the rock, of the tests to be done and the product itself.

Consolidation of Stone monuments

Consolidation the essential aim of this action is to improve the mechanical resistance of the rock, increasing the cohesion of the grains of the surface area and avoiding its coming apart. The consolidants should be applied in layers, taking care not to form a much stronger and resistant layer than the petreo substrate and which comes apart. To achieve a good penetration and adherence between the deteriorated part and the sane one, the consolidator should be liquid, not viscous, have low surface tension and solidify in the interior of the rock. Viscous, have low surface tension and solidify in the interior of the rock. Two groups of products exist.

Consolidation of Stone Surfaces, is an important term identify in general as surface treatments, it is the 2nd in special circumstances, may be 3rd step used in the field of conservation and restoration of stone. Ideally, we can note that all surface treatment or consolidants applied to stonework of artistic or historical materials should be characterized by the next 3 topics:

*Reversibility * Non toxic * Non flammable

In our field, there are many attempts for realizing this purpose along time beginning with using waxes, Lime water Shellac, tell using some synthetic materials through using many techniques for realizing purpose as:

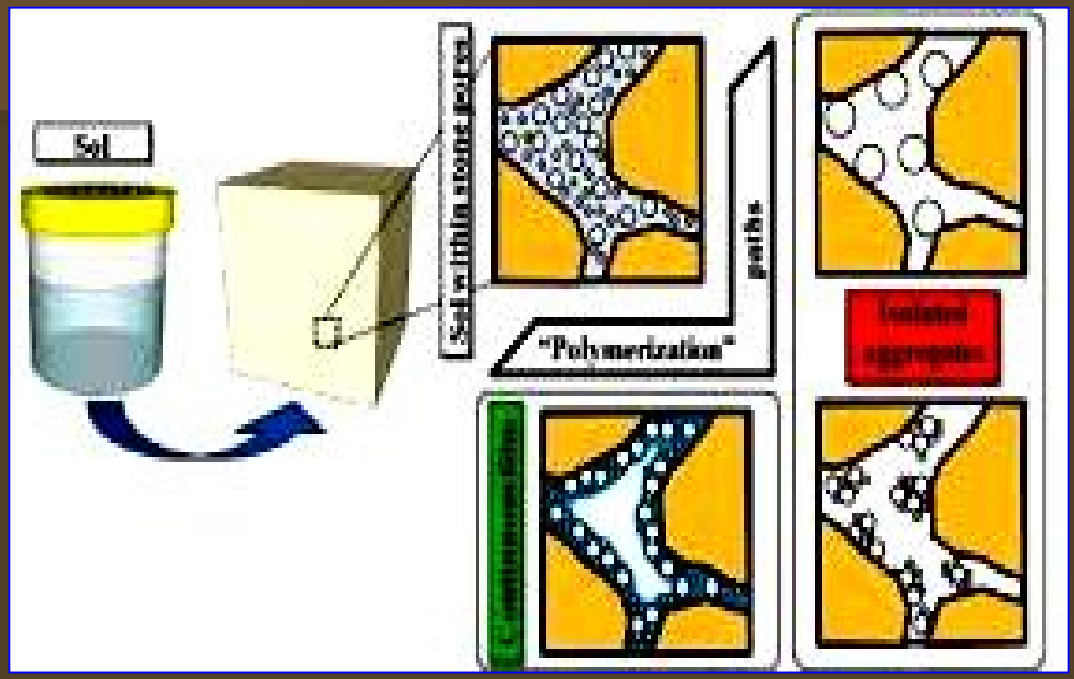
Spray technique

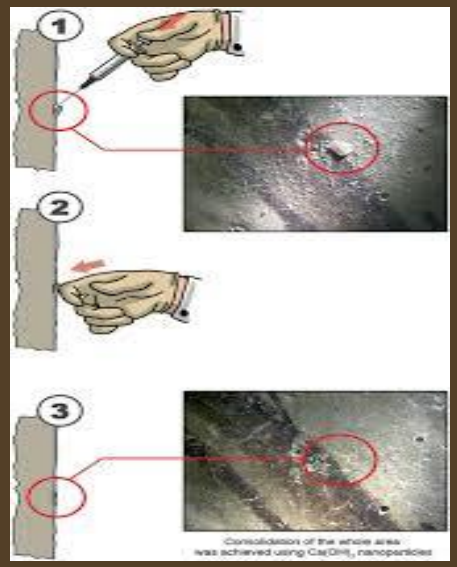
Injection technique

Impregnation technique

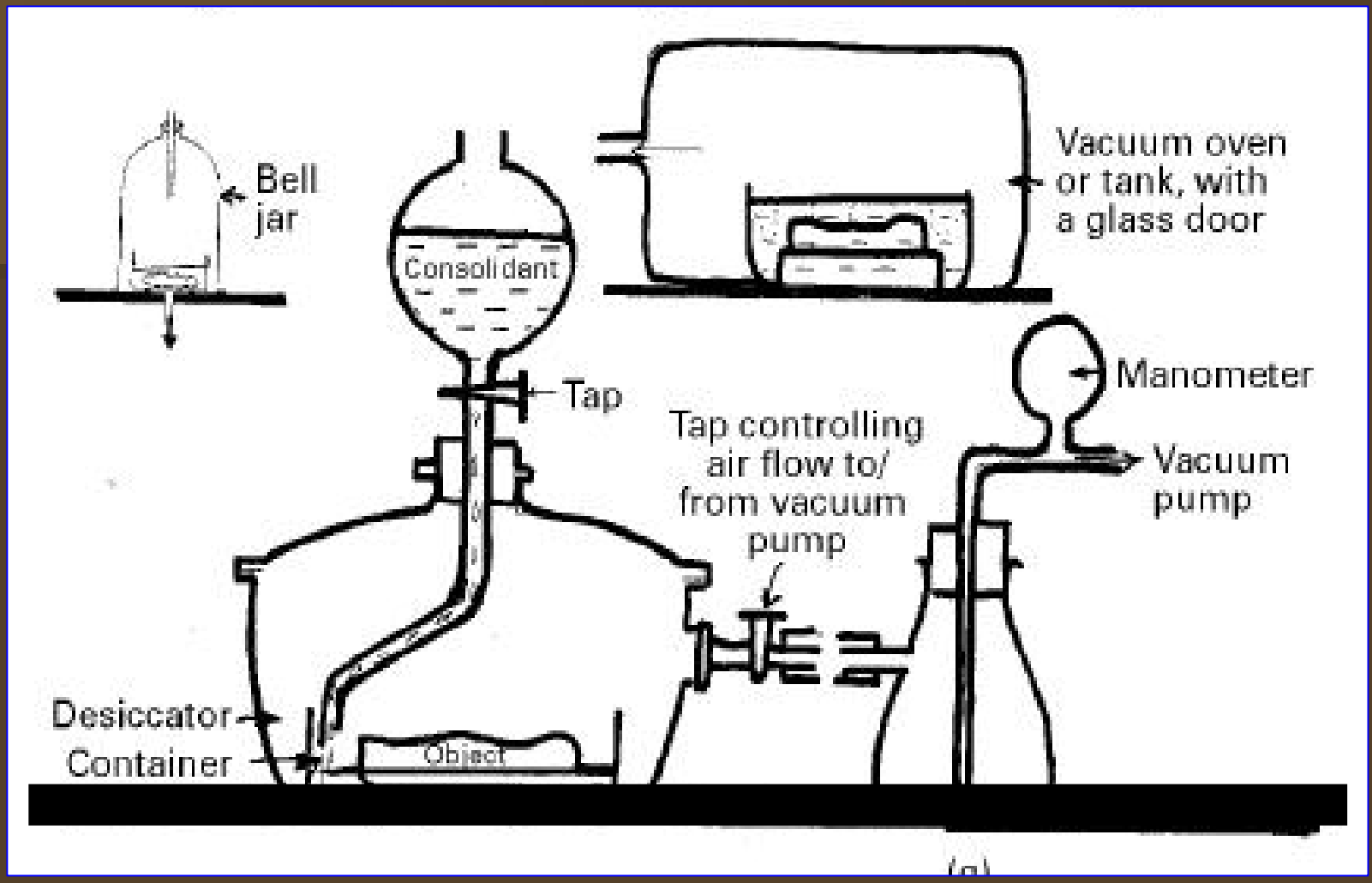
Under vacuum techniques

Spray technique

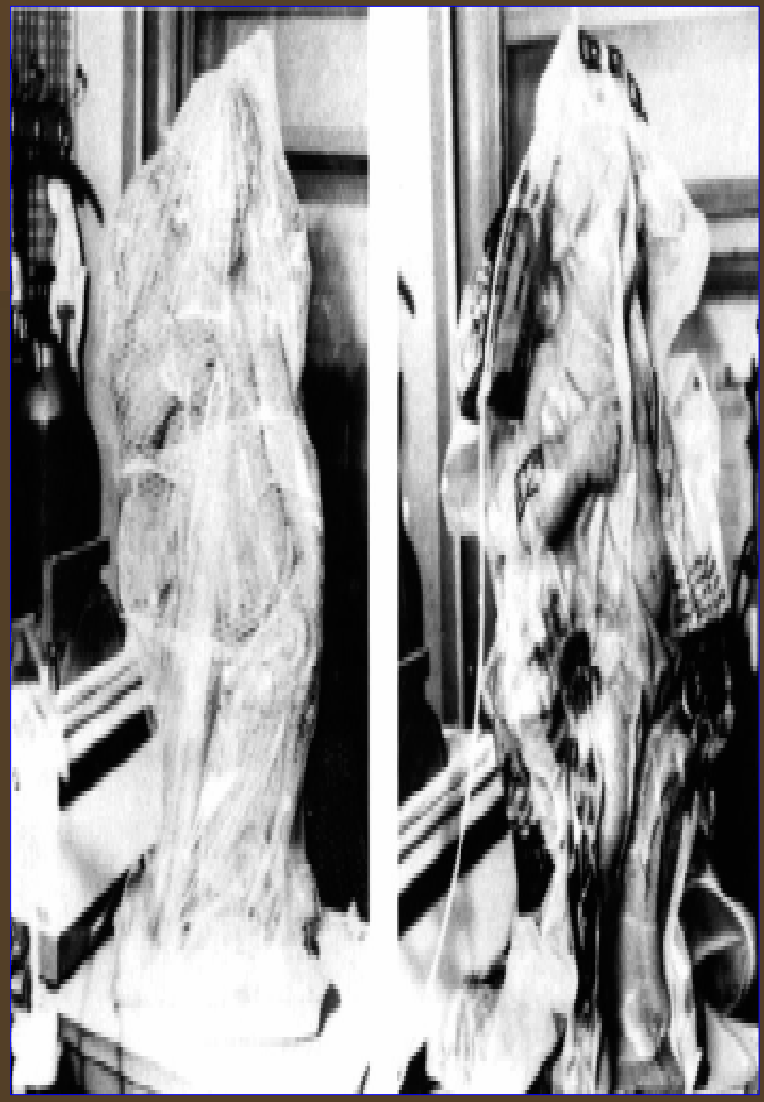




Injection technique



Impregnation technique



Under vacuum techniques

Consolidant materials

In addition we can see that there are several of recent materials used in the field of consolidation as

Water repellant materials

Colorless treatment materials mostly applied directly after cleaning

Adhesives

Classified as natural and synthetic consolidant materials according to their origin

Water repellant materials

Water repellent is actually a collective term used for fabrics that don't get wet easily (duh). That includes both water resistant and water-proof. So, a water repellent jacket can be either water resistant or waterproof, depending on the level of repellency. Durable water repellent or "DWR" is a coating added to fabrics at the factory to make them water-resistant hydrophobic. Most factory-applied treatments are fluoro-polymer based; these applications are quite thin and not always effective. Durable water repellents are commonly used in conjunction with water proof breathable fabric such as Gore-Tex to prevent the outer layer of fabric from becoming saturated with water. This saturation, called 'wetting out,' can reduce the garment's breath ability (moisture transport through the breathable membrane) and let water through.

Adhesives

There are many kinds of *Adhesives* used in the field of conservation which classified into major 2 group as fallow:

1) Natural adhesives (*principally made up of natural materials*) as:

* ***Blood albumin, Fish glue, Casein and Beeswax as an Animal adhesives***
* ***Arabic gum, Canada balsam, Rosin and Starch as a Vegetable adhesives***
* ***Mineral waxes, Resins, Silicates and Paraffin as a Mineral adhesives***

2) Synthetic adhesives are principally made up of *polymers* as:

* ***Polyurethanes, Silicones, Latex, Polysulphades, Neoprene as a Elstomers***
* ***Cellulose derivatives, Vinyl polymers, Acrylics, Polystyrene, Polyamides as a Thermoplastics***
* ***Epoxides, Polyesters, Aminoplast, and Phenoxy resins as a Thermosetting***

3) Organic consolidants such as

* ***Alkali silicate***
* ***Fluorosilicon compounds***
* ***Barium and strontium salts***

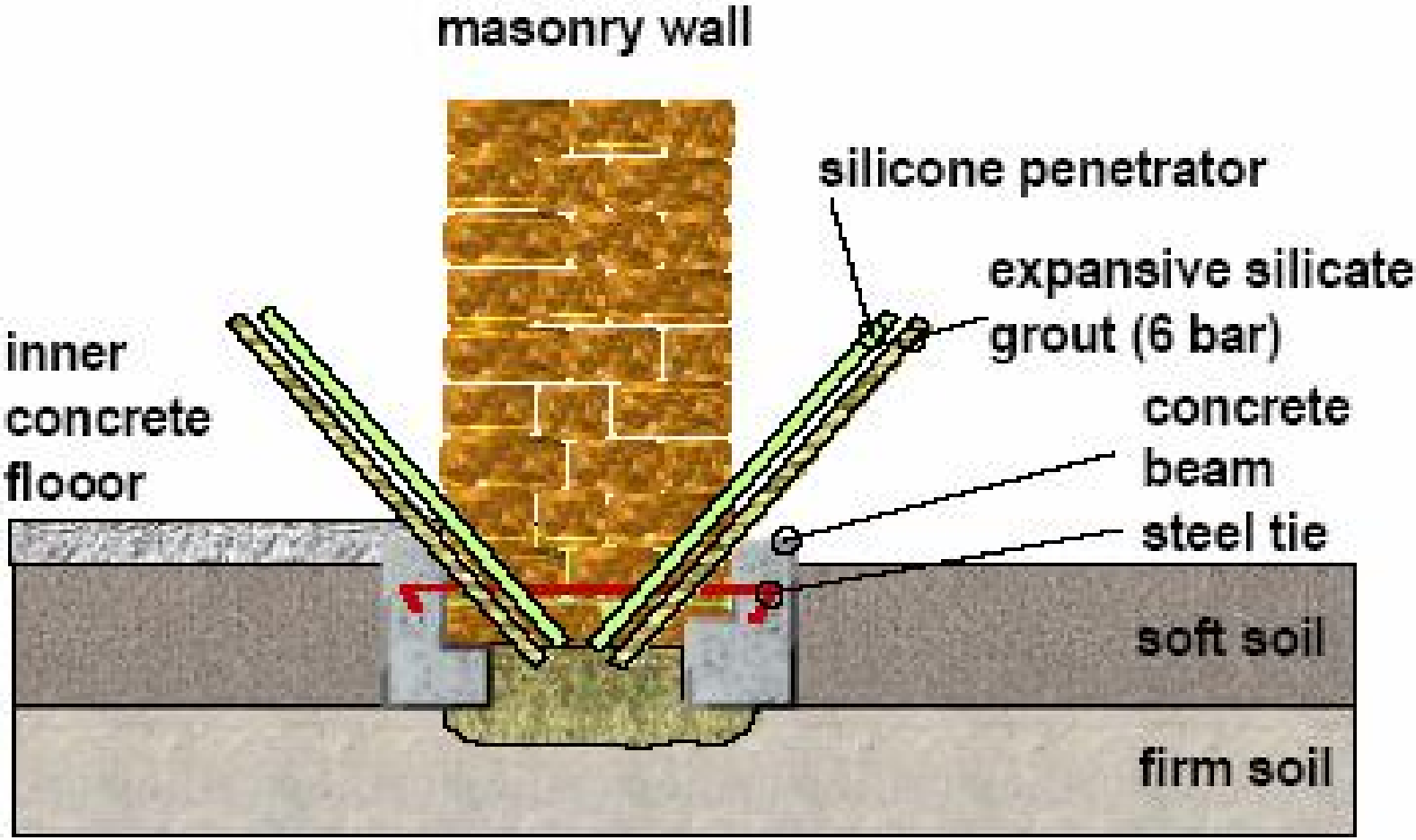
Supporting and Completion

Stabilization of shallow foundations

Recently, the new combined technique for the consolidation of shallow foundations of heritage. Buildings and the prevention of masonry walls from raising damp has been developed using new methods and new Product. There are many known solutions for the placement of moisture barriers in the level of wall some of them are based on the construction of horizontal diaphragm, which prevents capillary moistening of the walls from the ground.

There exist some varieties, particularly in various technological solutions, for constructing a hydro-impermeable layer. Most common stabilization of walls without foundations has been the construction of the missing foundation in the ground. In case of poor, over moistened foundations, acting as conduit for moisture from the ground into the walls, the known technological procedures have been carried out by sawing and knocking out the walls.

Then inserting hydro insulating tampons as the horizontal hydro insulation, these kinds of interventions are un-favorable in earthquake prone areas, because they may influence the lowering of earthquake resistance of the entire masonry building. Therefore, other non-destructive methods of are more suitable.


masonry wall
silicone penetrator
expansive silicate
grout (6 bar)
inner
concrete
flooor
concrete
beam
steel tie
soft soil
firm soil

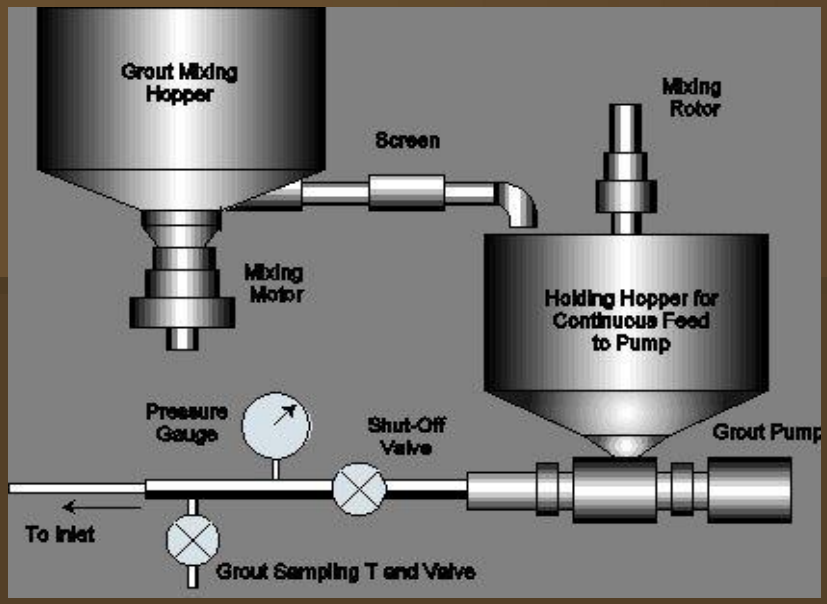
Grouting of stone masonry

The most effective and economic strengthening of voided stone and mixed stone-clay brick masonry can be achieved by pressurised grouting. The grout material composition is often an issue of discussion between constructors and conservators. The main dilemma is related to the influence of chemical substances that are present in cement by its nature or because of the modification of cement grout modification.

It is well-known that the concern of conservators is related to sulphurous and alkali compounds and their influences on painted surfaces of heritage walls. Therefore, the grout producers are together with researchers trying to develop grouts that would meet the requirements of conservators. An example of the development of what are called "*Masonry friendly grouts*" is described according to the specific problems to be solved by grouting.

The stone masonry needs not to be injected by pure cement grout where regarding strength demands, 60% of cement can be substituted by next techniques. The next steps show the example of this process.

- Fine sand aggregates of different origins. Reducing the quantity of cement, less stone masonry.
- Foreign material is introduced in walls. Hydrophobic additives that are added to the grout hinder .
- Transport of water and water dissolved salts through porous structure of the grouted wall and help in drying out of walls.
- The main purpose of grouting is to fill as much voids as possible. This makes stone masonry more homogenous and prevents movement of stone blocks and rubble during earthquake action.
- The needed strength of hardened grout is not too high because internal stresses induced in stone to-grout interfacial surfaces are not high.



Grout mixing and pumping equipment

Grouting procedures

Patching

It is a process that means completing and patching the lost places according to bot code of ethics code of practices and with the use of tools and materials appropriate to each situation, this technique contains (8 steps)

Existing damage.

Preparation of the repairs.

Stainless steel mesh used to hold form of void.

Patching beginning.

Patching mortar built beyond existing stone

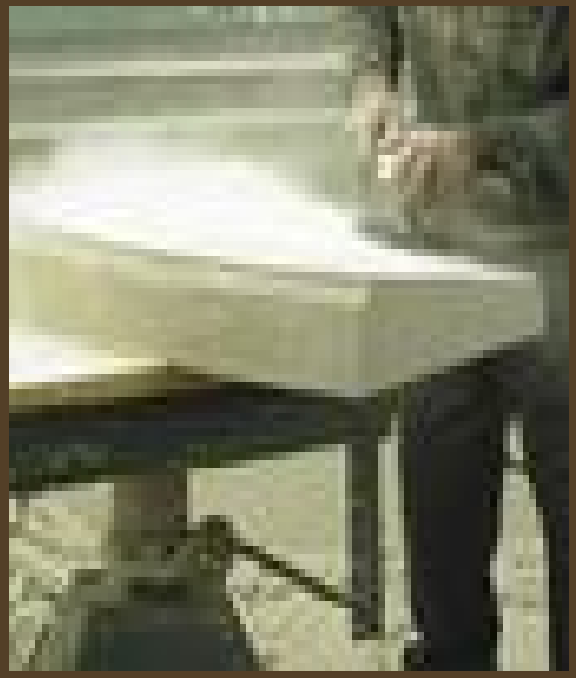
Patching mortar is screeded to original profile.

Screeding continues.

Finished repair prior to terra cotta glaze repair

Stone replacement

It is a process of completion of the large and lost areas that affect in loads and foundations according to the stone types after sufficient experimental studies that should be done on the soil characteristics and the nature of place, this technique contains (-- steps)



Stone replacement by curving and cutting

Cutting the edges
and drilling the holes

Putting the mortar
built within the holes

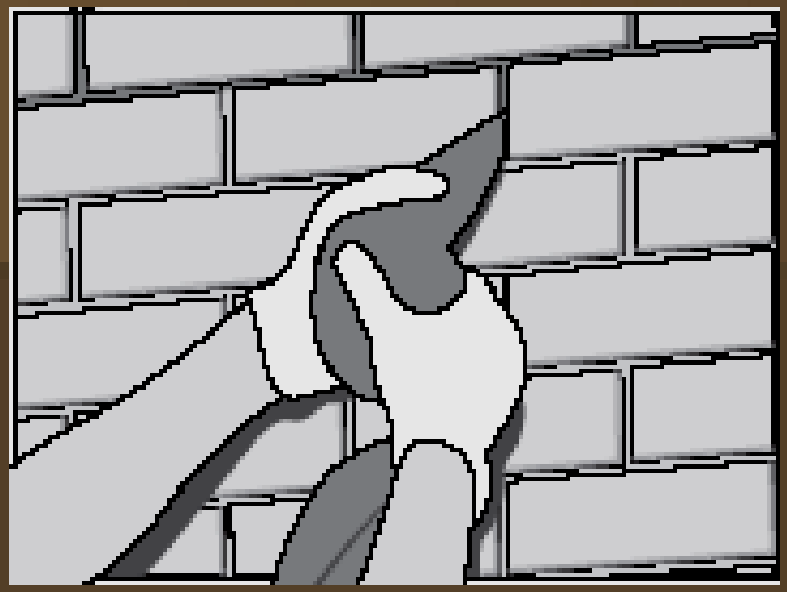
Replacing the blocks
on the mortar beds

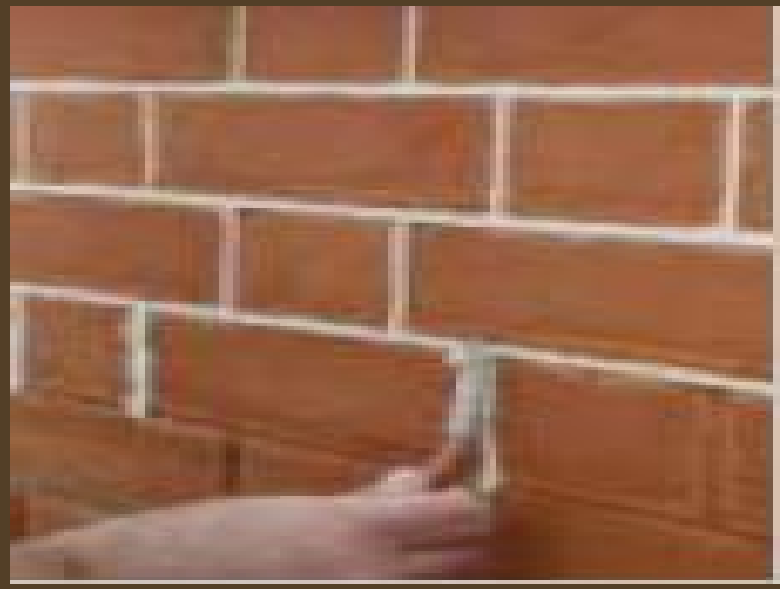
Final Maintenance

Final maintenance

By maintaining heritage sites; repairing, cleaning, or correcting defects we are not only preventing deterioration of precious original materials, we are also ensuring that possible hazards are avoided. Purpose of final maintenance protection is to do regular and routine works to prevent extensive and expensive repairs. In addition, ensure longevity, reduce costs and improve value. Also, it must be consistent with our needs and respectful of our financial means, while ensuring that your building is evaluated annually. It could be achieved through 3 categories:

* **Corrective maintenance:** work necessary to bring a building to an acceptable level (often recommended by a conservation plan), such as treatment for moisture.
* **Emergency maintenance:** work that must be done immediately for health, safety or security reasons or that may result in the rapid deterioration of the st- structure or structure fabric if not done, such as components repairs.
* **Planned maintenance:** work to prevent problems which can happen predicta- within the life of a building, such as cleaning or painting





Case studies