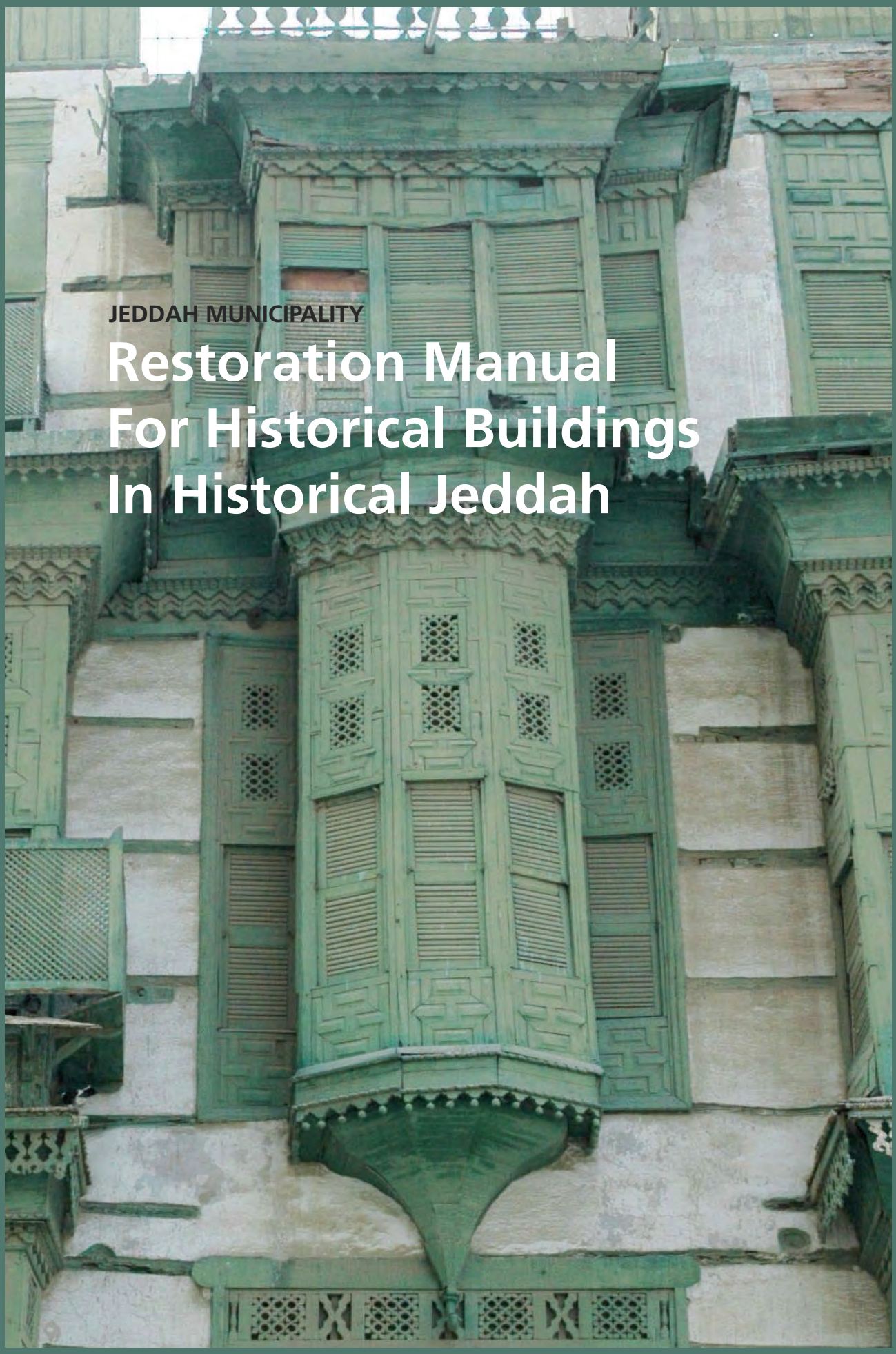


JEDDAH MUNICIPALITY

Restoration Manual For Historical Buildings In Historical Jeddah

INDEX

Preface

Conservation and restoration: a concept of sustainability

It is important in regard of the conservation and restoration theme to start from considerations and instructions stated (implicitly or explicitly) in the **1987'th Chart of Conservation and Restoration** of art works and culture that had been renewed, integrated and essentially replaced by the **'Restoration Charter' of 1972**.
These considerations applies **to all objects of any age and geographic area which are considered significant in a artistic, historical and generally cultural perspective**. Are thereby part of this universe of objects topics as architectural constructions of urban aggregations, natural environments of particular interest, anthropogenic fauna, geological environments 'built' as parks, gardens, agricultural landscapes, it is also part of this whole any human artifact production of technical or scientific type, books, documents, which testifies customs and traditions of anthropological interest, three-dimensional representation moldings, figurative images on any support material (walls, paper, textile, wood, stone, metal, ceramic, vitreous, and so on).
Most of these 'objects' can be present even in fragments as archaeological findings and/or paleontological, isolated or incorporated into more extensive contexts.
From the moment of its construction or of its discovery the **Heritage** described above has been subject in every single part to a degrading process, a dispersive and/or destructive sequence of events, physical-chemical, geological, biological and anthropogenic aggressions.
A fundamental cognitive intent has imposed and imposes to counter and slow down the destruction, dispersion and deterioration actions with any conservative procedure, preserving the intrinsic and extrinsic conditions of each object treated, with the scope to preserve it in a status as closest possible to the original. The next step is to provide for the artifact an optimal conservation and proceed to its restoration.

Conservation is defined as the set of acts of prevention and protection aimed at ensure an optimal status that tends to an unlimited configuration of the material object of the treatment.
The conservation measures refers not only to the preservation of the single object or the array of objects considered significant, but also to the environment's condition, as long as verified as historically relevant and positive both from the physical point of view and for the maintenance routine.
The procedures of restoration that directly consists of the operations necessary to arrest as much as possible the progress of damage and deterioration must respect the characteristics of the object which are transmitted through its natural and original material vehicles, preserving it easily detectable. Conservation and restoration can't be united and

simultaneous, but they are complementary and in any case a restoration program is not possible without an adequate program of preservation, maintenance and damage prevention.
A further definition of Conservation of Cultural Heritage is to consider it as 'the competence to keep objects in the state that we received them to ensure a transition to the future in an unchanged status with their cultural values' (aware of the mutability of geographical and chronological terms of culture) with the capacity to minimize the intervention maximizing its intrinsic knowledge, which can be summed in 'the search for the best solution that coincides with **minimal intervention feasible**'. 'Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generation to meet Their Own needs' (see Brundtland Report 1987).
This also means having full knowledge and control of the quantity and quality of information that is necessary to manage to acquire the ability for the planning and implementation of the interventions.
Full knowledge of the value of our **cultural heritage, not only monumental**, and its role for the culture and economy of the country are the conditions to make a **sustainable** conservation work, and make it 'exportable' to other cultures, respecting the specific identities .
A conservative intervention must be ensured by a coherent, coordinated and planned activity of studying, of prevention, maintenance and restoration, actually this is in-core of the concept of sustainability.

For the building declared of historic and artistic interest specific procedures has been developed and therefore **can and should be applied in the case of intervention on a traditional building type** (as in the case of **Al Balat in Jeddah**) as well as for the type of rural architecture.

01.

It consists of:
- The historical, constructive, material, structural knowledge of the asset;
- Analysis for the reuse;
- Diagnosis as a summary evaluation of the conservation status of the property;
- Intervention to stop the deterioration, alteration and disruption actions, which includes improving the seismic reinforcements and engineering systems;
- Interventions for the reuse;

These last two interventions must be integrated without any bilateral conflict.

Sustainability is the ability to 'rule over' the procedures and operations and have a perspicuity view of the intervention's objectives.
- **Sustainability in respect of knowledge and analysis** lies in the ability to assume the real purposes for which the conservation project is accomplished, and how to recognize which and how much information is available (historical records, materials, construction techniques, deterioration and instability status etc.), the identification of optimal techniques as also the detection of the procedure to apply. To involve specialized designers fit to the examined cases.
- **Sustainability of the diagnostic phase synthesis**, is to involve experienced professionals able to properly diagnose the condition of the building, and to evaluate the efficiency of structural and seismic characteristics.
- **Sustainability during the intervention to stop a deteriorating process**, lies in choosing materials compatible with the existing, reversible, with solutions that tends to cancel the demolition and replacement where possible, that shall be recognizable, maintainable and accessible for inspections, choosing recyclable and disposable materials as well to rationalize the use of the working site.
- **Sustainability in the choice of the reuse means choosing** the intended use in such a manner to be compatible with the structures of the building, with the needs of the geographical and social context, with the expected return of the financial investment; means also to choose flexible design solutions that limits to the minimum demolition and structural modification of the construction , in addition to providing engineering system solutions not physically excessive and impactful and finally to rationalize the working site yard.

A **sustainable approach** that is common for a new building intervention as for a construction addition to the built, **should be extended to the conservation plan on an urban scale**: which means that sustainability shouldn't be understood only as a performance improvement, or for energy savings, but above all to establish a correct relationship between man and environment in terms of accessibility, improving energy efficiency, rainwater and gray water, a greater use of the green areas also implementing specific facilities, interconnection between different functional areas and so on.

01_ *The dense array of the old city.*

02_*Wooden door and stuccos carachterize merchants' residences.*

02.

2.

Guide lines


01.


02.


03.

Traditional techniques and innovative materials

The historic constructions chronologically up to the **'Technological Revolution'** occurred with the introduction of materials such as cast iron, steel and reinforced concrete has always used **natural materials** such as stone and clay, with lime mortars, pozzolanic grouts, Roman cementum, soft iron, wood, straw, earth and in the Far East bamboo.
In the **twentieth century** (as we shall see more in detail later) were used **reinforced concrete and steel** not only in new buildings but also in the static strengthening of building structures and even in monumental constructions.
More recently **new industrial production materials** has been used such as steels with high carbon content, polymeric materials, ceramics, composites once again also for the restoration and static consolidation treatments, **notwithstanding these procedures being non-compatible with the original materials used in ancient buildings**, proving very often to be invasive and non-reversible, especially when used in the consolidation of facilities, ends up to be **not 'sustainable'** especially in the **'test of time' perspective**.
For the science of restoration, especially static and structural consolidation is important to understand the relationship materials-form-structure with reference to the use of natural materials and traditional static systems.

The **'sustainable' materials** that should be adopted in the static consolidation should be:

- lime mortar, mortar natural hydraulic limes instead of cement mortars or gauged stuff
- stone or brick or ceramics reuse or otherwise porous materials of the same nature and with similar mechanical properties, production and possibly local anyway compatible with existing (non-perforated bricks)
- soft iron, malleable much more adaptable to the deformations to which they may be subjected to the masonry structures
- natural wood

The **techniques and technologies** used for operations of static consolidation must be coherent **with the structure of the building**: this involves a careful study of the 'historic' construction techniques and technologies, the mechanical behavior of materials used becomes crucial.
As it will be described in depth in the chapter 'Additional Information for the Conservation of an Historic Heritage Building', how there are **still in use in the current practice techniques of static consolidation which are invasive, non-reversible, of doubtful effectiveness**, reported from "casual" manuals and promotes, for example, an excessive and indiscriminate use of reinforced sewing with steel rods threaded and resin

injections of reinforcement, concrete edge beams reinforced with steel nailing connections on the perimeter wall for the reinforcement of wooden floors or reinforcement of wooden floors with slabs of reinforced concrete micropiles and armed seams for the support of the foundations.
It has to be stated that the user's consolidation manual reports solutions for the building elements (the wooden floors, walls, foundations, etc.) which can't be justified, or in some cases could result harmful for the building's preservation.

Restoration had experienced different intents similar to **'fashions'** and also in some cases has been driven by manufacturers interests with the consequence of the denial of the concept of consolidation sustainability as structural rehabilitation for a more convenient use of products.
This is true also for the **new materials** such as FRP polymer matrix, consisting of thermosetting resins, epoxy or polyester, or carbon (CRPF), glass (GFRP), aramid (AFRP) the concrete reinforced with FRP (associated with epoxy to adhere to existing structures) used to increase the masonry's resistance capacity and the bearing capacity of damaged structures.
There are **strong doubts about the use of these materials**, due mainly to the fact that they are subject to the phenomena of rupture for delamination (due to the loss of adhesion between the composite material and the surface of adhesion) consequentially in the operations of restoration they have strong contraindications because more than all a brittle fracture is sudden, and for this reason **dangerous**. These interventions are also not reversible, especially if associated with steel bars, they are to be considered **invasive** and can become even **harmful** because they can change the static behavior of existing structures.


04.

In the field of historical buildings restoration and static consolidation 'sustainability' it is **necessary to establish a set of criteria for any intervention, to ensure preliminary activities since from the planning, implementing a so defined 'path of knowledge' of the intervention.**
Knowledge means understanding the complexity of the building walls, singularities and constructive types, changes over time, the state of preservation and use, a careful structural analysis (global and local) and of course historical, architectural, construction, technological and material, surveys of the geometries and of the preservation status of the structural elements, investigations on the materials: everything works in order to avoid unnecessary interventions and 'calibrated' in every action that must be considered singly.
In a city's historical center, for the constructions subject to **seismic risks**, rather than operating in a contrary manner to the criteria of conservation of cultural heritage, it may be advisable to **accept a higher level of seismic risk than in modern buildings**.

01_02_03_04_05_
Jeddah's traditional building.
06_ *Roof of Bayt Noorwali.*

For a correct and conservative path proceed as follows:

- identification of the building and its location in relation to the risk areas
- knowledge of the relationship with the surrounding urban context
- geometric survey of the building including the fissuring and deformations
- history of the most significant building transformations
- survey on construction techniques and material characteristics, state deterioration and mechanical properties but also for the knowledge of the nature of any consolidation work performed in the past and their effectiveness
- knowledge of the foundation structures and subsoil

The purpose of this is to reduce the seismic vulnerability of the buildings, and ensure the conservation of the building, through local interventions that do not alter the local and global behavior.
Particular attention shall be assured during the planning, installation and maintenance of the systems, as to avoid any demolition or invasive replacement that is considered non-reversible instead it should be chosen interventions that are integrated with the structures with safety features and durability.
These directions can be synthesized (for an artifact that has an historical value and must be recovered and preserved) in the **guideline of the use of materials of same type and species of those used in ancient building**, which can be obtained through a careful study of their mechanical behavior, the used techniques, of its own technologies for their production **avoiding 'new' materials that have not had sufficient testing of durability not only in themselves but in the relationship with the ancient structures.**

05.

Evaluation and reduction of seismic risk of the buiding as cultural heritage

In the recent years in the international field it has manifested a greater attention to the building's conservation problems, in particular to the seismic risk, as a result of earthquakes that have seriously damaged the heritage showing how the interventions used since now were not therefore able to preserve the historical artifacts. In this regard directives has been issued on the subject of the **'Evaluation and reduction of seismic risk of the building as cultural heritage with reference to the Technical standards for construction'** that go in the direction of a greater respect for traditional structures.
The value of these guidelines is due to the fact that they are addressed to the distinctive characteristics of the cultural heritage, thus reconciling **the need to achieve high levels of safety with a proper protection of buildings, obtained through research of the minimum intervention possible.**

Another important fact is that the information provided by documents can be **applied to all types of buildings walls, those most valuable to the smaller buildings so as to the entire housing of the city's historical fabric.**

In this introduction the theme shall be outlined, for a proper and more extensive development refer to the restoration manual specific chapters, a possible intervention technique applicable to the **masonry structured buildings**, **evaluating the additions and their effectiveness, including**


06.

the impact on their reversibility, and therefore the optimization to choose in the first place less invasive procedure and consequentially that has the maximum reversibility and durability, conferring attention in the intervention costs.
Similarly it will be treated those techniques to avoid, for reasons of preservation of the building or for their ineffective results for the improvement of the static and seismic resistances.
It is important to understand that no action could be priory considered without an effect on the structural reaction of building.
However, these general guidelines are particularly interesting for the present series of buildings of **AL BALAD**.

1. Actions needed to reduce any missing connection of the building.

The purpose of these measures is to restore the building in a correct reactivity in reference to:
- a good clamping between the walls
- effective connections of the floors to the walls

It has been witnessed for the Historical Center in exam that there is no problems related to the vault's loads distribution, or of roofs that confers horizontal loads on the wall systems.
These observations are of course essential for an overall evaluation of the building from the standpoint of anti-seismic and are:
- **Insertion of steel rods** arranged in the two main directions of the building at the level of the floors and in correspondence with the load-bearing walls, anchored by steel ties can effectively confer a good reactivity of the building favoring the connection between the orthogonal walls and avoiding the tipping of wall portions when the horizontal structures can't ensure a joint. It can be made a local consolidation of masonry. It is not recommended to connect the steel tie in the thickness of the wall if the wall consists of several disconnected bricks courses, the use of anchorages by resin injections or cement mortar directly in the masonry can be problematic if not properly anchored
- **Clamping adjacent walls, or between the intersections of the walls** can be made with the "unstitch and sew" technique in case of damage or in the case of incoherent materials presence (with both stone elements that with bricks) to restore a proper masonry continuity. The **'armored' perforations are inadvisable** when there are less invasive solutions available; actually these interventions are not effective particularly in the case of wide sections of disconnected masonry facings. In the case when there was no other solution the elements inserted must be durable, of stainless steel and/or of

composite materials and the mortars injected shall be compatible with the technology of the original wall system. However it is preferable for masonry of not great quality the insertion of rods that provides connections at a general level.

- **Edge beams on the top wall** of the building can be a viable solution for connecting the walls and the roof, but the solutions do not all have the same effectiveness.
- **Edge beams in reinforced masonry** are the most recommended because collaborates well with the preservation phase of the existing masonry features: the best solution is that of a full-thickness brick masonry filled with appeals at regular intervals between a metal spiral (or composite) connected vertically with thin bars and drowned in the conglomerate: usually it shall consolidate the top of the original masonry by injecting injection mortar with lime.
- **Edge beams of steel** rather valid and minimally invasive and easily connectable to the wood elements making up the roof, which can be:
- **with a lattice structure** in the angular and steel plates connected by pierce armed that connect the two sides of the top wall **through dishes or profile steel elements** below the top of the brickwork possibly previously consolidated if of poor quality and connected to the metal structure by armored perforations.
- **reinforced concrete** solution for edge beams are less advisable and to be chosen only if of limited size to avoid an excessive weight and a stiffening of the structure, it has been proven that this option is harmful in case of earthquakes because their presence creates a tangential stress between the edge beam and the masonry causing the disintegration of the wall system. It is definitely suggested a consolidation of the masonry on the summit to counter the different rigidity of the two systems and in any case the connection must be vertically jointed to the masonry by steel reinforcements in pre holed perforations.

The efficiency of the connections of floors and the roof is of major importance to prevent any unthreading of the beams from the walls.
In the case of intermediate floors the head of the wooden beam can be anchored to the masonry by metal elements anchored on the opposite side of the wall.
It is not recommended the insertion of concrete edge beams collected on the masonry because it modifies the structural resistance of the wall, in addition of being very invasive.
Also in this case, as already mentioned for the top structure, it can possibly be made of the edge beams of steel made with plates or profiles on the two sides of the wall, connected with the outside by bars piersing the wall section, to build an edge beam only inside connected to the exterior wall through passive and widespread anchors.

2. Floor consolidation procedures and reduction of excessive deformability.

Floors must have a good connection to the walls with joint elements to avoid beams unthreading.
It is very important the function of the floor system in a masonry construction in case of an earthquake.
It is useful to a limited stiffening of the floors, to evaluate the effect, which is associated with an increase in resistance of the elements.
It's important that the floors with wood structure remains preserved as much as possible, because of the low weight. **A limited stiffening of the wooden floors** can be obtained by acting on the wood boards placing a second layer on the existing one, the disposal shall be perpendicular or inclined to the pre existing one, besides a particular care should be taken to the connection perimeter that shall be reinforced by the installation of steel strips or of composite materials, fixed on the wood boards with a diagonal direction.
It can be used also a bracing technique with steel rods. In case of floors of simple warping it shall be required to ensure a parallel connection between the wall and the beam with steel plates directly fixed to the boards and anchored to the masonry.
It is very effective to reinforce the slab from the flexural deformations, increase the resistance with a second board arranged perpendicularly to the existing one, nailed to cooperate with the beams through specific steel nails or wooden pins.
In special cases, you may consider reinforcing the floor through a **composite lightweight concrete slab**, in relation to the specific requirements of conservation. It may be necessary to connect the base to the walls with punctual elements as mentioned above.

3. Roof preservation operations

Wooden roof maintenance has to be proceed ensuring a similar elasticity of the underlying structures taking care of the mutual connections between the parts as described in the previous section, avoiding edge beams of concrete of exceed thickness for the consequential different rigidity in the building's structure system, this reason and also the fact that this procedure isn't compatible with conservation principles.

4. Interventions of masonry consolidation

This type of interventions are necessary to improve the mechanical properties of the walls as well as in the restoration of damaged or deteriorated portions of wall.

Depending on the type of masonry and the quality of the same it shall be chosen the solution that has to be adopted: however it is important to use materials with physical-chemical as mechanical properties similar with the existing ones. The purpose is to **confer the elements and their resistances an uniform continuity realizing reinforcements if necessary by clamp joints and specific connections.**
It has to be avoided as much as possible the inclusion of concrete elements using this material only when other interventions are more invasive.

The interventions aims to:

- Repair locally damaged or degraded parts.
- To improve the structural characteristics of the masonry of poor quality as the quality of the mortar.
- To reconstitute the continuity of walls in case of discontinuity or cavities or in the case of initiation of compartments, recesses, drains, chimneys especially if opened at different times during the buildings life, especially when these deficiencies are present in the corners or in the connections of the masonry.

The most suitable intervention is the "unstitch and sew" especially in case of damages or long fissures during the reconstitution of walls in poor preservation condition and this should be done using materials similar to the original, and as a form such as size, mechanical characteristics and _ resistance by rigidity _ taking care to connect in a proper manner the new elements to the existing masonry both in the plane and transversely in a manner to obtain the maximum grade of uniformity and continuity of the walls.

It can be used an **injection of mixture binders** operations to improve the mechanical behavior of the masonry, however after verification of the characteristic of the walls themselves and that of their inject ability (presence of empty hollows), paying particular attention to the injection pressure to avoid detachments or surface bulging.
Equally important is the **material to be injected which must be compatible** in all the perspectives _ chemical, physical, mechanical _ with the masonry.

As we shall see in the following chapter, it is necessary to **avoid cement based mortars that can cause damage to the walls and in particular to the surfaces to produce salts**; as we have seen personally during visits to Al BALAD are a common phenomena with efflorescence on the surface at the base of the buildings due to the outcrop of soluble salts.
Other operations can be performed, as in the case of facings consisting

in **mortar joint reallocation**, which is effective if, in the case of not very thick masonry either in depth on both sides of the masonry or the inclusion of **diatones also artificial** in the case of masonry not connected to each other accompanying and integrating the intervention also with mortar injections, the mortar joints etc; the diatones may be replaced by **anti-expulsive tie-rods** in the case a surface is not too extensive subject to intervention and in the presence of squared stone or brick as in the case of Al BALAD.

Also to be avoided or carefully weighed before it shall be used, the following measures for improving the resistance of the walls:

- We have already mentioned the unsuitability of the application of **reinforced plaster** overly invasive and not in line with the principles of conservation; also from the point of view of seismic given the high stiffness of the walls in such a manner reinforced, alters the structural behavior of masonry: in many cases it is preferable, if the walls are inconsistent and damaged and not very extensive, proceed with the demolition and reconstruction of those parts.
- The same type of strong doubts meets the usage of **fiber-reinforced sheets**, material which in the opinion of many is invasive, and of questionable effectiveness, both locally and general behavior for the non-compatibility of these materials including resins necessary for 'bonding, to the walls 'historical' (perhaps are conceivable only for localized interventions reinforced flexural, however necessary in the case of strings and sometimes we have not analyzed because quite rare in the center of Jeddah).
- The same applies to the **armored perforations, the traction rods in three directions as well as horizontal and vertical** of which however will be good to check the possibility of changing and distorting the original function of the masonry structure.

5. Interventions on Foundations

Investigations and analyzes are absolutely necessary to establish the need for operations on the foundation of the building if the observation has revealed you may tip the building structure due to seismic actions.
However, the intervention must be aimed at maximum uniformity of conditions of base in order to obtain a distribution as uniform as possible of the contact pressures. So it shall be preferable to choose interventions that provide for the **extension of the base backdrop underpinning** with respect to solutions that provide micro piles, jet grouting or deep-mixing.

Additional specifications for the conservation of the Historical Heritage Building

From ancient ages, for over **2000 years**, all buildings in Europe and in the Middle East, large or small, from poor homes to monumental buildings were constructed in the same way: by building bearing walls of brick or stone, attics and roofs supported by **wooden beams** or sometimes solid and above, using **lime, air or hydraulic, to wall and plaster**.
Subsequently, after the parenthesis of the exceptional experimental constructions of the end of '800 in steel and glass or the first reinforced concrete buildings, **from the late' 30s** and the **years 1950-60 onwards a bit 'all over the world, was born a new and different type of support structure**: the system beam / pillar reinforced concrete or steel and cement mix for floors and roofs. Consequently concrete has been used as mortar in wall partitions, as structural concrete and as plaster.
This meant that a large part of our **built heritage 'old or antique'**, which must be **identify and protected**, and that includes all the 'historical', major and minor, from palaces to simple homes, in addition to the bed, the walls supporting rural, **belongs to a 'type' in its own right and physically that has almost nothing in common with the new build**.
To intervene with respect on the ancient artifacts therefore involves **working with materials and technical skills simply quite different from current techniques by which you no longer familiar**: means entering into the mindset, knowledge and craftsmanship in the way of thinking of those who preceded us.

The first act of this attitude, since all the old buildings were built using **hydraulic lime mortar or air**, should be re-employ only this: The cement material is totally unknown in the ancient. But this 'consciousness' is absolutely not a fact. The use of cement has spread in a huge way and was accepted as 'normal', always, everywhere, and for all uses. Although miscible with the old lime, cement is **not 'a better lime ', will certainly be a 'binder' better, but it is a material chemically very different from the old lime.**

When cement is used in old masonry, behaves according to **its own characteristics** that, in many situations of use it isn't **compatible with lime and above all it is almost never compatible with the antique masonry. This non-compatibility is absolutely not perceived, often with disastrous consequence**.

Cement based conglomerates is considered thoughtlessly and simply as 'a better mortar ', that is stronger, more rapid-setting, with more adhesion, more waterproof characteristics, etc. and as a substitute of lime in the

03_04_ *Cement plaster applied to buildings in the center of Jeddah.*

common usage and in many cases for operations on the building considered more or less old. Any concrete based mixture diluted could look like as a replace of lime and especially implies lower costs, and therefore its use on construction sites has become progressively a consuetude.

Not only for cultural reasons in respect of the "old" the use of concrete actually isn't recommended in any case, there are reasons of an objective nature, such as the different characteristics in comparison to traditional grout since we had verified that its applications in the past has been absolutely damaging to historic-antique buildings.

Some simple considerations can fully convince about the need to exclude cement especially for interventions on historical and on the architectural heritage that reached us from the past:

1. There is no need to use cement. A normal mortar of cement is about four or five times stronger than a **pure hydraulic lime mortar** (compressive strength of at least 150 kg/cm compared to about 30 kg/cm). Such resistance not only is not needed in the ancient walls masonry that work to a maximum of 7-7.5 kg/cm (or even less), even if used for compensation and continued to unstitch and sew in old walls, produces **discontinuities behavior in the wall structure** as you introduce it with the areas of greatest strength and rigidity that are still surrounded by the original weaken parts.
2. Any old material once walled with cement mortar is lost forever. Can never be recovered in full for re-use. In fact, the adhesion of the mortar material is always rare exceptions, higher than the resistance of the material, stone or brick it, while with the old traditional mortar the opposite occurred. You will need to break the material to free it from the cement mortar.

3. The cement mortar is much less permeable to water of stone or brickwork. This means that in the presence of rising damp (moisture ascending) the saline solution will evaporate from the material rather than by the courses as happened with the old mortar. Consequently, where as before you deteriorate the joints, now the material consume for first, stone or brick, leaving intact the jointing.

4. The tri-calcium aluminates, a chemical characteristic of the cement, not in the old lime, reacts in a humid environment with **sulphate** present in the walls forming a complex salt **ettringite** which crystals have a volume twice the original materials, this expansion **breaks the material.** The sulphate is almost always present in the old mortar in the form of plaster

but other sulfates may nevertheless be brought inside the masonry from ‘rising damp. Even more, it is evident that the ettringite can form wherever there are suitable conditions: inside the wall or at an interface between the old mortar and the ‘cement plaster.

5. A plaster of cement mortar is much less breathable of a lime-based plaster. This will result in an increase in the first level of any rising damp in the walls and, in any case, a lower internal livability and comfort, even giving the plaster a longer durability.
In a commonly and utmost good faith historic buildings masonry and modern buildings in armored concrete hasn’t been psychologically separated. On one hand, no one cared, or was thought to consider, the effects in the medium-long term of the co presence of lime and cement in conditions of use, on the other hand, the non-categorization result of cultural unawareness is implicitly reflected in the laws, where it is always held in high regard the technical aspect using metrics based on the quality of the material, including the **resistance was predominant.**

The interior has not gained wide diversity between the two ‘kind’ of buildings resulted, with regard to the preservation of ‘ancient’ extremely negative consequences, in legislation, in the protection, as well as in the approach design in general, that in that of the operators.
Unfortunately, very often also the assets under special protection have suffered this, for example mortars and plasters containing cement components are authorized or tolerated, or worse, not even notice, for

04.

05a_05b_ *An ancient wall in stone and brick built with old lime and subject to water rising which contains soluble mineral salts that has suffered the loss of the mortar of courses for the formation of crystals of salts caused by the evaporation of water only from the courses. When consumed courses of old lime were re-grouted with the 'good and strong' cement mortar, much less permeable of the bricks, the result has been that the saline solution has now evaporated through the bricks instead of through the courses: having result in the loss of clay material instead of the mortar courses. And the same goes for the stone.*

Figures illustrate the classic examples of the commonest mistakes as consequence educational and cultural ignorance.

compensation of masonry and plaster normal or 'restored'. Not to mention the non cure with **which are readily accepted new concrete elements such as slab floors and stairs**, among other things included in without any particular attention in older masonry,

This type of interventions has resulted in serious damage and tampering for the heritage, which is not observed by the insertion of the brutal 'new' recklessly and unaware: the new plaster mortar on old walls reduce breathability fostering damp rise, it is not uncommon re-grout cement courses in stones or bricks, with the result of making them unrecoverable and let them gradually disappear in the presence of moisture from rising. The use of white cement (the best, and therefore the most harmful) mixed with yellow sand produces a pleasing effect from a chromatic point of view, but with a worst damage to be revealed only later. These real 'serious damages', rather than reasons of speculation, are the consequence of a culpable **failure of the skills training at all levels**, which does not generate a real and conscious culture of restoration.

'To recognize the autonomy of the ancient to respect it as such', seems to be taught by too little time, and only at the highest levels of academic training, while at the lower levels, relative to the industry (unskilled) still seems to be culpably ignored: you pay a daily **lack of cultural preparation** of those who preceded us and you persist in error to widespread inertia assuming awareness of this aspect.

An absolutely critical moment is during the implementation of the engineering systems in historic buildings: the attenuation of the impact of factors relating to the electrical and plumbing is easily achievable in new buildings because they can be inserted in the hollows of the brickwork. Unfortunately, this concept is transferred to the buildings also unconsciously 'ancient' causing serious damage: burglary do enormous damage to the walls, and are usually physically compensated with cement mortar.

In recent years it seems there are some positive signs in the sense of 'respect' of the ancient artifacts, but in many cases, unfortunately, the old lime reappeared on the market, not as a proper material for use, but rather expensive material as 'fashionable' reasons.

In conclusion, there are cases where the use of concrete can be taken into account when the status of the masonry is extremely damaged (anti seismic foundations, reinforced plaster, edge beams, etc.) But the 'generalization' of these interventions can become inadvisable if not even harmful: you can achieve the same results without the use of structural concrete, by means

of other 'lighter' methods and less invasive such as steel chains and cross linked carbon fiber solutions.

After all iron has always been a 'traditional' material since the ancient times today there are better features available as stainless steel and epoxy resins in small quantities which are certainly preferable to the large quantities of cement solutions, however, considering that the use of both invasive and irreversible consequences.

The extent of restoration, recovering and re-use has become very important and is on the increase, both to preserve the existing from further deterioration and above all to avoid the irreversible loss of a major cultural heritage is evident great responsibility assumed emergency responders on Cultural Heritage and therefore should take all precautions to ensure that this happens.

06_ *This photo exemplifies mechanisms in action and the sequence of events described before, with the aggravating circumstance of a lack of technical conscience. The new edge angle made of light colored bricks which today is in disintegration phase was entirely rebuilt in the past in place of the original wall, after several attempts to fill the courses with cement based mortar. The new wall is disintegrating, and most likely it will be again replaced with an identical process. The original missing courses will probably be re-grouted with cement mortar, persevering in error and losing this part of the wall.*

07_ *The facade of an old building was plastered with mortar made with the old lime on top of a waterproof stone plinth. The rise of water containing soluble mineral salts has evaporated from above the stone mass and the old lime plaster has been consumed for the formation of crystals of salts caused during the evaporation. The plaster original was taken with a 'strong', but not very permeable, cement-based plaster. The saline solution in lifts was pushed to evaporate in the old plaster and consume higher than the new plaster. It's obvious that this sequence of events is repeated at least twice and is continuing with gradual disappearing of all the old plaster, and without solving the problem, but only moving it higher.*

08_ *Gradual disappearing of pillar sandstone due to displacement at a higher position of the point of consumption of rising salts due the re-grouting done with cement mortar.*

09_ *Consummated courses of old mortar between the stones of the walls because of sea salt.*

10_*Missing of stones of the wall portions re-grouted in the 1930s with cement mortar.*


06.


07


08.


09.


10.

SECTION 1 |
JEDDAH CITY RESTORATION

1 | Brief description of the city's evolution

Brief notes on the development of the city: the History

For an effectiveness of the treatment during the earliest phases, from the origins and the first descriptions of the City, the activity related to the birth of international trade and the development of Jeddah from the **13th** to the **15th** century, to the profound changes that have occurred in **16th** century and the decline of the city in the **17th** and **18th** centuries. the turn due to the opening of the Suez Canal in the 19th and the events of the early 20th century that led Jeddah to become the gateway to Mecca with the pilgrimage 'the Hajj', it is useful to mention briefly the development of the modern city since the end of World War II, in the period 1948 to 2008 which saw the steady growth of the country and particularly in Jeddah due mainly export of Saudi oil.

In 1947 has been traumatic for the ancient city: the old walls were demolished to prepare the city to the first phase of expansion.

Over the next eight years after, 1948-1956, Jeddah has recorded a significant growth rate both in infrastructure and there has been a significant increase in population in eight years the city has increased by ten times its size (300 to 3,300 hectares)

In **1956** were completed the oil refinery and the airport, generating a huge increase of the employment requirement.

Between **1956 and 1964**, the development of the city had a stop because

01.

of the decrease of the oil prices. From **1964 to 1971**, the improving economic conditions have led to the growing of the city, its expansion, limited to the south by the salt pans, developed to north along the coast, and inland to the east limited by the mountains of the Hijaz who formed a backdrop to city.

In **1976** the port was established Islamic completely altered the relationship between the sea and the historic center of the city.

Over the past 20 years, the city has received a continued incentive for expansion, reaching today an extension of 1,000 square kilometers with 3.5 million inhabitants.

Beginning in 2005, and this is the fact that most interests us, the City has launched a comprehensive study to provide a vision and a framework for the growth and development of Jeddah, **taking into account the revitalization of the historic center, with the drafting of a strategic Development Plan for Jeddah, with the definition of objectives and global initiatives** that will guide the decision-making process: land use, planning and policy development, infrastructure planning, investments.

The urban regulation approved by the City in 2011 aims to control speculative movements that caused the loss of many historic buildings in the last twenty years.

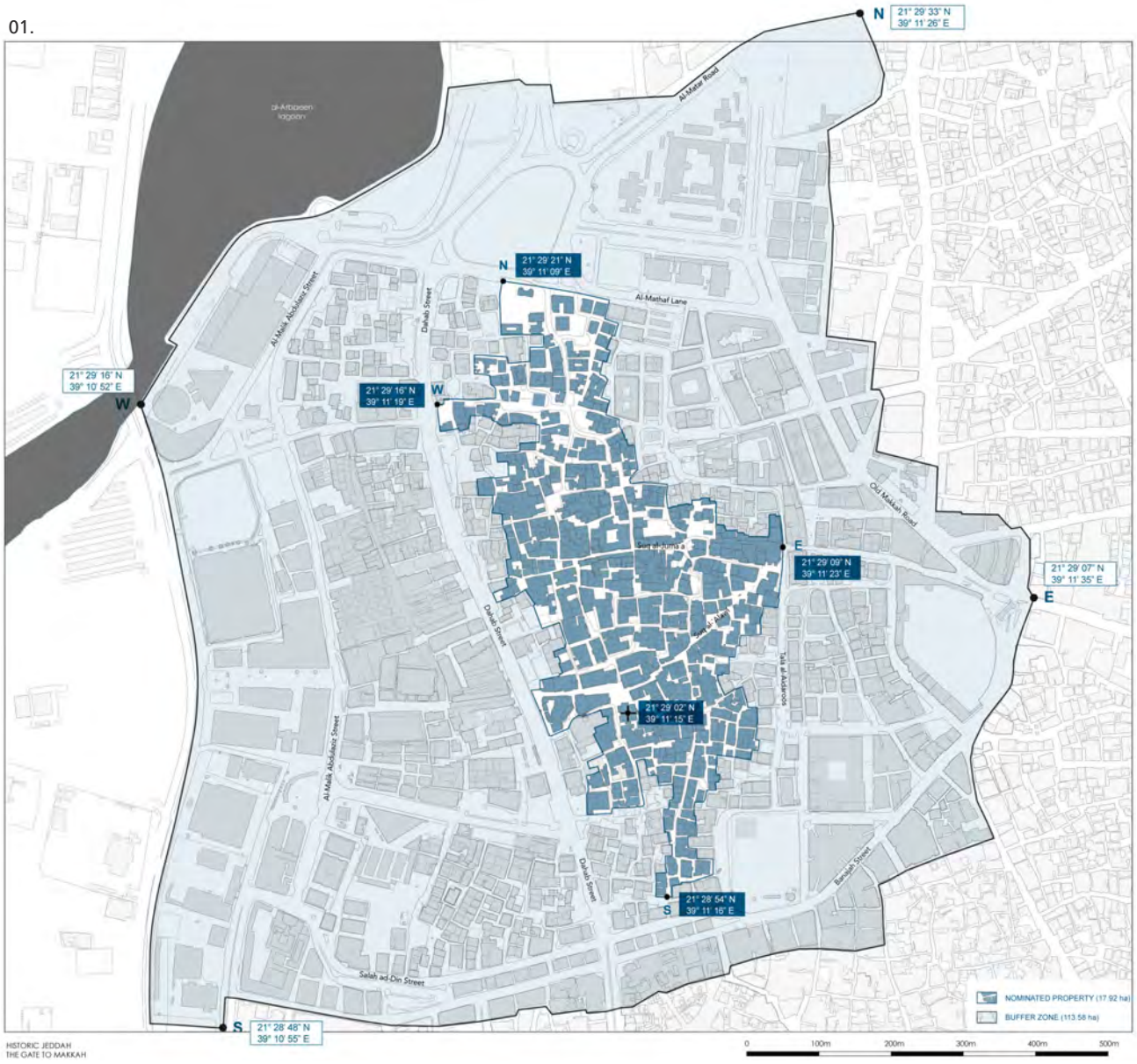
01_*Aerial view of the coast line.*
02_*The port in 1933.*

2 | Traditional building in Jeddah

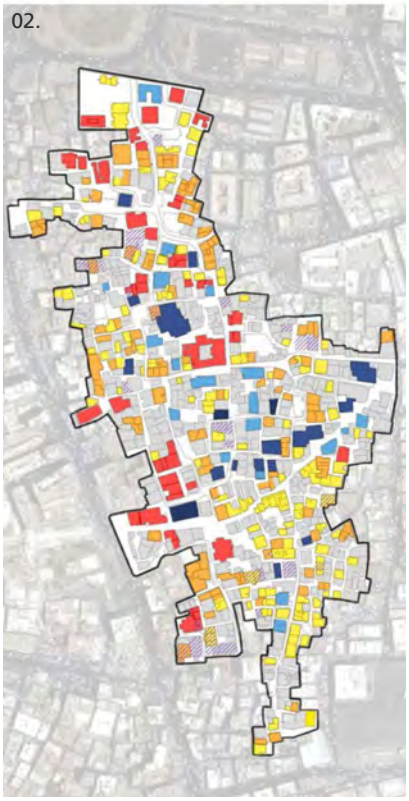
1. Traditional Construction in Jeddah: typological architectural-construction

The historic center of Jeddah has been the subject of numerous studies, which were included in the document prepared by the 'Saudi Commission for Tourism and Antiquities' for entering the city's list of World Heritage protected by UNESCO (World Heritage List); such registration, as repeatedly pointed out, comes from the awareness of his undoubted value as a testimony of the value of urban-architectural testimony to the culture of the

01.



02.



01_*Geo-referenced image showing the limits of the nominated property and buffer zone.*

02_*The map shows the historic buildings listed in the early 1980s by Robert Matthew in red, orange and yellow and the position of the 40 'problematic' buildings within the nominated property.*

- Collapsed building
- Modern high rise buildings (A level)
- Modern high rise buildings (B level)
- Historical buildings (class A)
- Historical buildings (class B)
- Historical buildings (class C)

area of the Red Sea: 'Historic Jeddah, Makkah to the Gate'. Get-together of cultural exchanges, technical knowledge, materials and construction techniques in the region and along the routes of maritime trade, the Indian Ocean leading to the Holy City from the sixteenth to the early twentieth century.

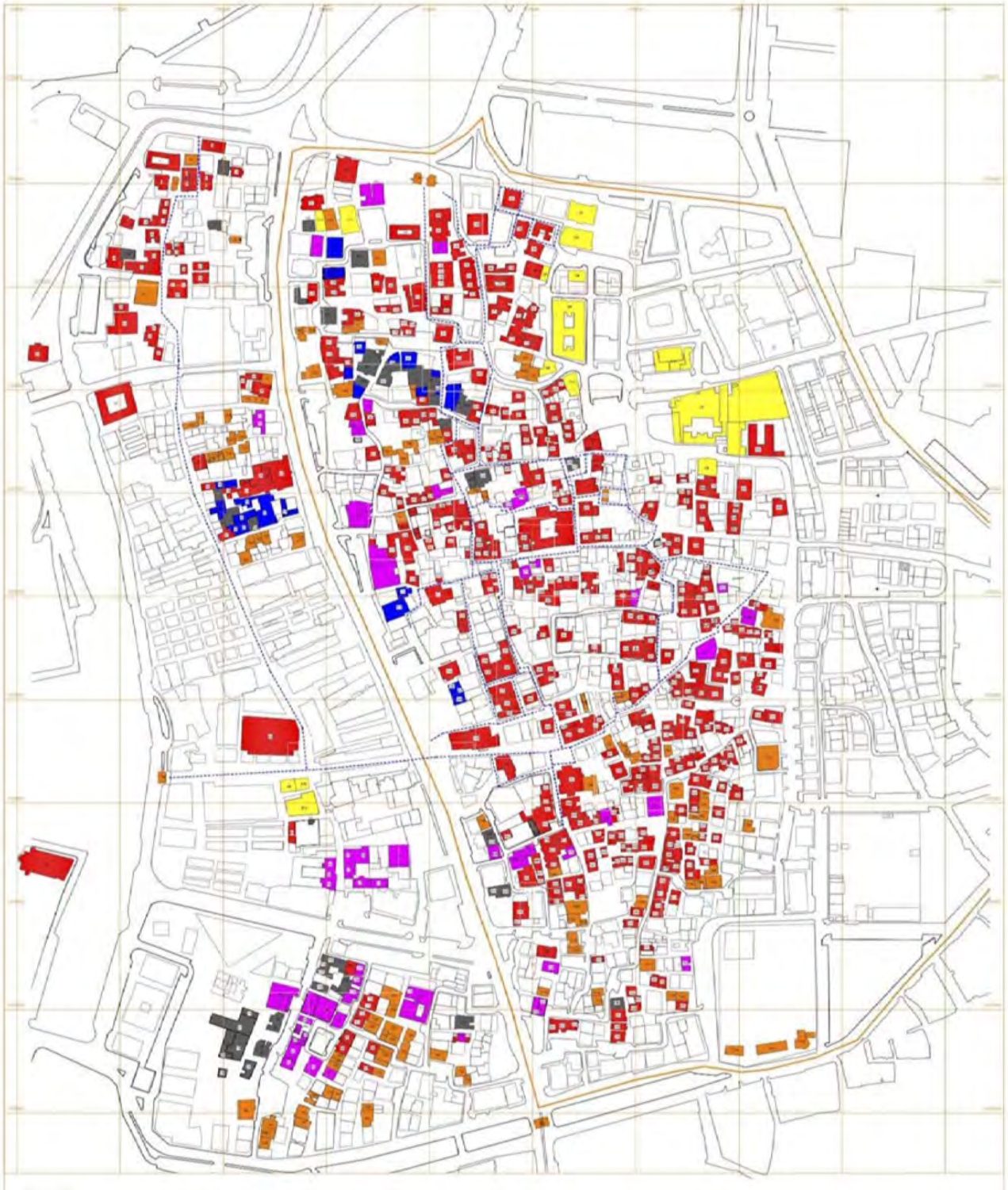
At BALAD is the only urban center remained in the Red Sea coast that preserves important examples of this culture. **The axes of the souks** are still entirely preserved in this part of the old city as the rest of the road network was not affected by the transformations of the city: the only discontinuity is detectable in the spaces arising from the collapse of the buildings 'historic'.
It is to be stated as in some areas it becomes very important _ both for the public safety that for the preservation of the characteristic buildings and in any case considerable by a architectural point of view _ stop the further deterioration of the collapsed parts or in the process of collapsing through works to set the situation in a safe state in a way that does not involve the neighboring buildings.
In the area 'protected' by UNESCO there are about 240 buildings of historical and architectural interest; There are other buildings built more or less recently totally disrespectful of the environment outside the traditional urban regulations dating back to 1980, while still others are less 'impactful' as in 'scale' with the size of the historical city although made criteria not adequate. Very interesting and extremely useful for an understanding also 'quantitative' of the housing stock is the plan of the city realized thanks to the study carried out in 1980 by Robert Matthew.

As known since the end of 1970 the City of Jeddah has funded a number of studies of the old town in view of its conservation and regeneration. The first and most important of these is the work done by **Robert Matthew**. his study, which formed the basis for the regulations in force in the Old City, including a complete list of the old houses in the city and a classification based on three levels of the traditional buildings based on their architectural and historical significance:

- Class A buildings were considered of national relevance,
- Buildings Class B buildings of regional importance
- Buildings Class C buildings of local significance.

Many new studies were added to this. An important step was the preparation of an updated version of the classification of Matthew, built by al-Turath Foundation with the punctual registration of the current condition of the remaining historic buildings of the old city, in which are shown the buildings of particular interest according to the classification

03.



Robert Matthew classificaton

Other traditional buildings

Concrete buildings built before 1950's

Half-Collapsed buildings

Collapsed buildings

Buildings that are in Matthew's classification but demolished and replaced with the new structure

Other buildings
Buildings that are not in classification
Concrete buildings

Tourist trail

03_*Assessment of Historic buildings, general map realized by al-Turath Foundation.*

the English scholar, the other buildings of the traditional type that still form the connective tissue of the city, but also concrete buildings (built before 1950) that still deserve in some cases, particular consideration despite having 'disturbed' the continuity of the fabric 'old' both for the quality architectural-compositional, that as evidence of the evolution of construction of the city, especially if located in the peripheral areas of Al Balat.
In the same plan are shown collapsed buildings in addition to the buildings not classified.

Naturally, the continuous updating of the studies and documentation are essential in order to operate properly: for this purpose by the City of Jeddah is preparing a **GIS** of the old town with the registration of all its lots that will become an **essential tool for the management of the city and allow effective monitoring of changes within the old city**.

The typology of the traditional houses.

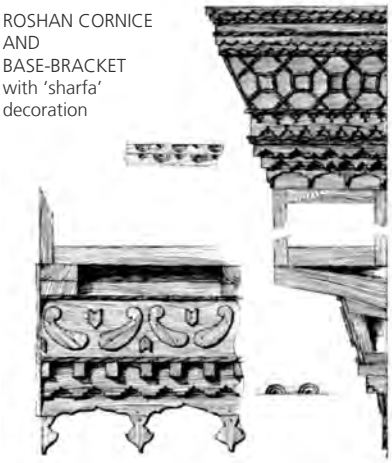
The design of the interior spaces throughout the Arabian Peninsula reflects the need to maintain the privacy of the women in their homes:

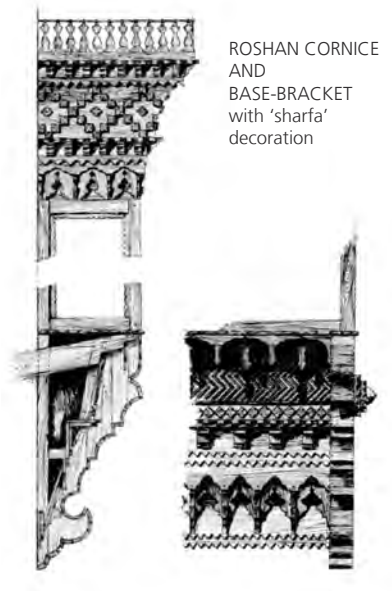
- the windows are generally located above the level of the road
- on the roof terraces are divided by high balustrades
- the reception rooms for male guests are isolated from areas used by women.

Extremely interesting for the knowledge and understanding of the topic on the traditional house in Jeddah is the documentation and evidence in the research conducted on 'House Hedjazi' in which they are made of real interviews with families. customers for which the houses were built (belonging to the most important families of the region) and the manufacturers _ **the mu'allemin = master builders_ custodians** of the art building that was transmitted from generation to generation through oral transmission, which then transformed in building practice. Testimony of a real '**Guild**' whose members have worked in the construction, renovation, maintenance and renovation of the cities in the region, at least until they were alive **mu'allemin** who contributed to the research cited above, that is, until the 'beginning of the nineties of the last century, providing valuable knowledge that you are united to written documentation, the existing historical research.
With their disappearance is cut the umbilical cord of the culture and local building traditions period leaving a gap of experience that is reflected in subsequent unfortunately many times little judicious and respectful of tradition.

04_ *Roshan-s constructive and decorative details – in Greenlaw, 1976.*
05_*Tower house type.*

04.





Research has contributed to the reconstruction of data and information related to the construction process on the 18th and 19th century in the region and particularly in Jeddah.
Next to this type of construction there were also more structured self-built houses (at -shukkol) inhabited by poor families or poor. The Layouts still clearly identifiable in Jeddah are extremely interesting and consist mainly in **Case-Tower-Roshan**, remarkable example of unique buildings in the Arab and Muslim homes in 3-4 floors simpler and **Ribat 2 storey** houses characterized by a courtyard intended for reception of pilgrims. In addition to these examples typologically very characteristic, there is a whole building minor web, indistinct, difficult to understand because they has not been detected on time and not accessible even for an initial statement of knowledge, most likely has born and raised 'spontaneously'.
The survey of these parts of the city would be required in addition to the preparation of the necessary design of interventions, also for understanding and cataloging of any typological and constructive.
Other notable types are found in the many Mosques and Zamiya _ religious school and monasteries in the city.

House Towers - Roshan
The typology of tower-houses (they could reach a height of 7 floors) is characteristic only of Jeddah and born to the 800 and then develops in Hedjazi city of Medina, Mecca and Taif, but in the latter there remains no evidence of them, deleted from the modern city.
In Jeddah the House Towers are still present, and there is no archaeological or documentary evidence indicating their presence before the end of the 800: **the birth of this type is therefore linked to the economic boom that followed the opening of the Channel Suez in 1869**. Jeddah port served as a link between East and West became a thriving center for commercial activity. The rich merchants of Jeddah built high and elaborated decorated houses that were to reflect their new status and their wealth.
House Towers are characterized by the absence of a court, usually present in other residence examples of the Islamic world, also distinguishable for the facades decorated by Roshan structures, from the rooms on the ground floor dedicated to offices and trade.
The house was then a mixed-use building that housed residential and commercial activities. Commercial spaces housed offices, warehouses but they were also used as rooms for rent during the **hajj, the annual Islamic pilgrimage to the holy city of Mecca**; the latter phenomenon has meant that the type of these houses take on a urban character with the opening of the ground floor space of the city.

05.

Architectural features of Tower houses

The architectural characteristics of the houses are combined with the functional needs and comfort of the inhabitants climate-related: they are, in most cases, independent units and then isolated by roads with the fundamental effect of increasing the air flow and ventilation cross in this area warm and humid for the proximity to the sea.

Their proximity and their height also protects the roads from sunlight and heat. These tall houses work as true 'wind towers', catching the breeze and allowing continuous vertical circulation of the air inside the house.

The internal air circulation is favored by natural upward movement of warm air along the stairs, drawn through the windows, which in turn cools the rooms. In some cases there is provided a real well of light at the center of the house, which is open at the top to serve as a real ventilation shaft pushing the hot air and increasing the flow of air inside the house.

06a_06b_06c_ *Different kind of Roshan in Jeddah.*

07_ *Naseef House's terrace.*

In general, as we have said the houses are without a yard, but are divided vertically and organized around the space of the stairs.

The **Roshan**, or bow window in wood, is one of the characteristic features of Jeddah for its richness and complexity, although the window bay window wood is a common feature of the houses across the Middle East, particularly in Cairo and Istanbul.

It isnot uncommon that the Roshan in Jeddah are connected by one floor to another, forming a second curtain, which varies greatly in the technique of carving and decoration. The average size of Roshan is such as to accommodate a person standing in height and a person lying in length, with a depth of about 60 cm.

Ventilated space from which it was possible to watch the road, drinking tea, smoking where to sleep without being visible. We must emphasize the importance of functional **Roshan** along with the body of the stairs for conditioning and natural ventilation of the house, with an effective cross ventilation and cooling water: clay pots containing the 'water were in fact placed in Roshan and shadows and cooled by the air flow obtained.

A further significant architectural solution for the control of microclimate is **'al-Mabit'**, the **bedroom**, located in the coverage area, usually consisting of wood panels with slits and light coverage, used on summer nights for sleep. A real airy pavilion, whose walls with wooden louvers or shutters on

07.

08_ *Interior of the khushk on the roof of bait naseef.*

09_ *Main house location map..*

two or three sides, allowing air to circulate freely for the comfort of the occupants. The same occurs in the scope of 'kharjat', the terraces where the high parapets drilled demarcating coverage facilitate the flow of cool breezes at night refreshing also adjacent interior spaces.

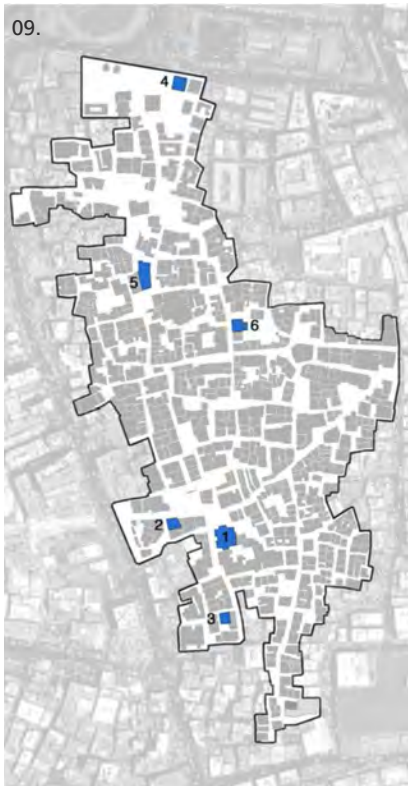
Accommodation and spatial distribution

As we said previously the upper floors in the tower-houses and the most important buildings were private, reserved for family use, while the ground floor was semi-public and commercial: the ground floor rooms were used as offices and stores, sometimes rented to pilgrims.

Still generally the ground floor is accessible by two entrances, one for male guests and the other for family and guests.

The front door is decorated and usually centrally located, often flanked by niches that form a tripartite common in Islamic architecture.

09.



1 Bayt Naseef
2 Bayt Noorwali
3 Bayt Nawar
4 Bayt Sharbatli
5 Bayt Ba'ishan
6 Bayt ash Shafe'i

The door leads to dihliz, or vestibule. And 'flanked by one or two **maqa'ads**, or reception rooms, where men welcome guests and make business meetings. In the back there is a kitchen, bathrooms, the servants, and possibly a bedroom for guests.
The upper floors are reserved, a plan for every household. Their plans are similar and are repeated. Each floor has a central living, called **Suffah**, which is connected to the kitchen and the bathroom and that was used for family meals and its entertainment.
Each floor is characterized by a majlis, guest room of the family, which faces the street through the front side: the room catching the breeze through the windows Roshan. Built-in cabinets and shelves decorated with niches are characteristic of the Majlis. Each floor also has smaller rooms for families disposed towards the rear area, called al-Muakhir, with access to the bathrooms.
The top floor, the roof, presents **Mabit**, or summer living room and bedroom, and **Kharja**, the roof terrace, surrounded by a high wall with a parapet, sometimes with arched opening with wooden frames, others with grid type of balustrades. These roof parapets are high as to prevent the view from the other roofs. The roof has been widely used during the summer nights for various functions such as family reunion and to sleep, as a place for parties, such as a birth celebrations or a wedding. The roofs are also used to collect rainwater, which is directed toward large tanks located below the level of the entrance hall (the dihliz), and is used only when needed, to wash but also drinkable.

It's interesting to consider the description of some of the most important **Tower houses of the historic center** of Jeddah contained in the dossier submitted to UNESCO for the inscription to the World Heritage List: a detailed analysis of their structural characteristics may emerge elements valuable for the definition of maintenance. Unfortunately, the existing documentation for the ancient city is definitely not enough to be able to understand the complex issues related to the recovery of the center of Jeddah.

12a_12b_12c_*Bayt Naseef:photos.*
13a_13b_13c_13d_*Bayt Noorwali: drawings and photos.*
14a_14b_14c_14d_14e_*Bayt Sharbatli: drawings and photos.*
15a_15b_15c_15d_*Bayt ash-Shafe 'i: drawings and photos.*
16a_16b_16c_16d_*Bayt Ba'ishan: drawings and photos.*
17a_17b_17c_17d_*Bayt Nawar: drawings and photos.*

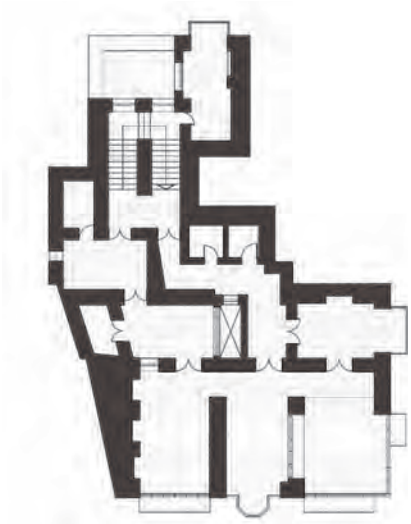
Among the examples cited in the dossier, UNESCO includes:

Bayt Naseef

It is one of the buildings of which we are proceeding to an indepth restoration planning and for this purpose it was decided to realize the survey work and designs and then consequentially a first campaign of investigations related to the materials and where possible, to the conservation and structural aspects.
The house was built between 1872 and 1881 by the landowner, Sheikh `Umar Effendi al-Naseef. The architect was probably Turkish and the house is unique in Jeddah for its scale, the ground floor disposal and the design.
In December of 1925, when Sultan Abdulaziz Al-Saud (now King Abdulaziz) entered in Jeddah, he moved into this house chosen for its importance.
The main entrance to the house is on the northern side, preceded by a small ramp and opens onto a square with a tree, unique element in the 19th century. The secondary entrance to the west was used by women. A ramp, very important on the back of the house, reaches the top of the house also enhance the circulation. There are **two cisterns on the ground floor and toilet at each level**. Cover at the center, surrounded by a terrace (similar to Bayt Baghdadi), is a khushk, a private lounge consists, as mentioned above, by a wooden structure to take advantage of a special ventilation (it was the coolest part of the house used for rest). The house belonged to the **family Naseef until 1975** was transformed into a private library; Bayt Naseef today houses a museum and a cultural center needs, because of its public functions, a general audit of its static conditions as well as in integration and testing plant.

12a.

12b.



13a. PLAN

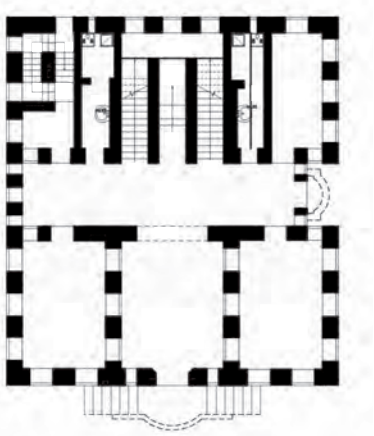
Bayt Noorwali

The house is located near the Bayt Naseef and overlooks the main east-west commercial axis of the old city.
Built in the mid 19th century a rich family was subsequently purchased by an Indian merchant, from which the present name.
The ground floor of the building, according to a frequent use in Jeddah, is still partially occupied by office space, and shops.
The house is organized according to the type characteristic, four upper levels and a terrace protected by high walls. In the inner part of the house, a double staircase leads to the upper floors, each divided into two separate apartments, with kitchen accessible from the stair landings. On the fourth and fifth floor there are two terraces and hammam covered by domes.
The most valuable and distinctive consists Roshan-s, colored in green, that almost completely cover the main facade; in the center, on the first level, a beautiful polygonal Roshan embellishes the architecture of the building.
Its importance is highlighted by a series of studies and surveys published in 1981 and the building survey carried out in 2012 by the University of Vienna.

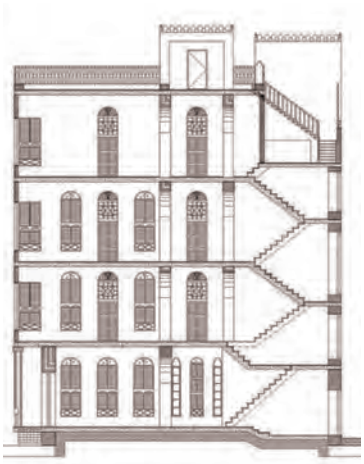
13b. ELEVATION

13c.

13d.



14a. PLAN



14b. SECTION

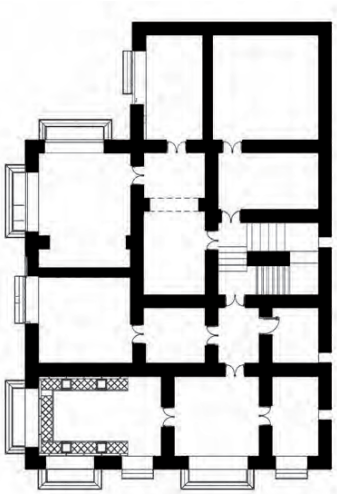
14c. ELEVATION

Bayt Sharbatli

The house was built about 150 years ago, was originally owned by a merchant (Sharif Abdulelah Muhanna at Abdali), who traded regularly between Jeddah and cities on the Red Sea.
Placed at the edge of the old city, near the North Gate is very special for both the wooden balconies to the north and west that for decoration carved wooden doors. It has two entrances on the sides corresponding to the balconies and four levels, connected by two large stairs at the rear of the house - and two symmetrical rooms on the roof.
The lobby entrance was to the meeting room, for this became characteristic of the Embassy of Egypt before becoming the home of a prominent merchant, Abdullah al-Sharbatli.
The building is in poor condition of preservation is shored for safety but it should be consolidated and restored because of its architectural importance and its location.

14d.

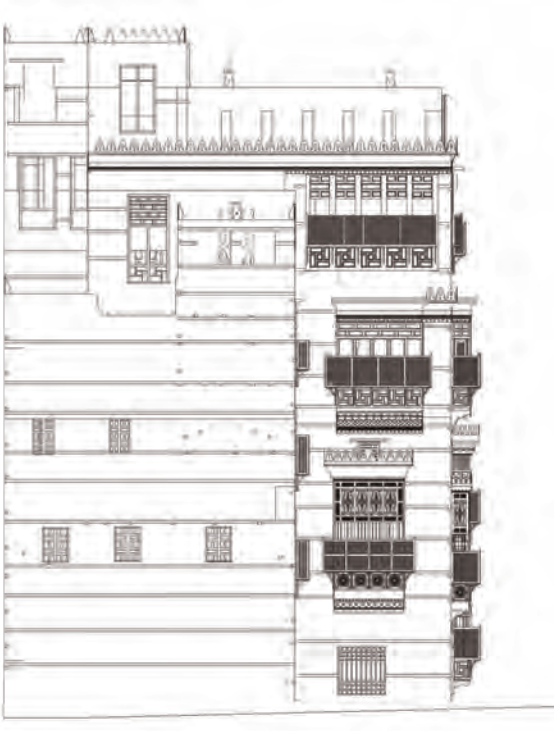
14e.



15a. PLAN

Bayt ash-Shafe`i

The house, located in the Old Town district Mazloum, was built in 1800 by Sheikh Abu Saleh Fidda, a merchant and owner of properties.
It has a compact plane with two entrances, one scale square.
The house has five levels and is characterized by its blue-Roshan's and carved wooden doors, particularly valuable.
Its use has been converted into a Muslim endowment to support the Mosque Ash-hafe`i.
Among the few Bayt of which has even a small description and that are interesting for typological solutions having the inner courtyards of different sizes, unusual for residential buildings in Jeddah.



15b. ELEVATION

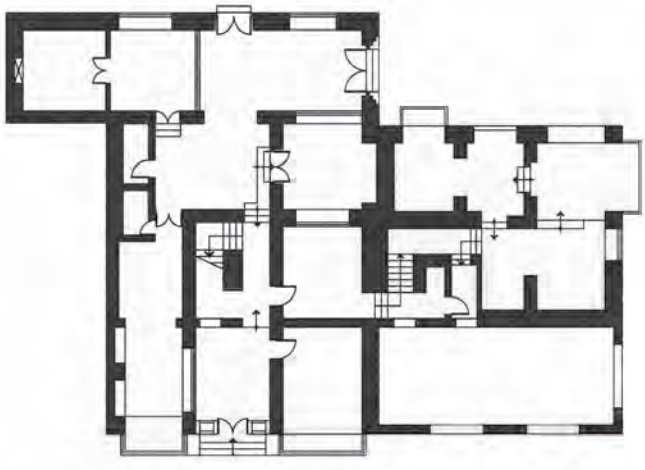
15c. ELEVATION

15d.

16a.

Bayt Ba`ishan

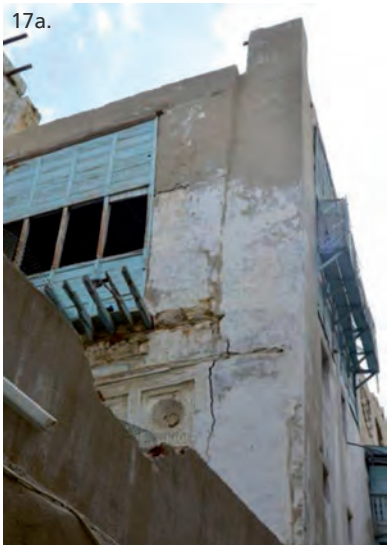
Located in Mazloum, Bayt Ba`ishan was built in 1923.
It has two entrances, one overlooking a courtyard, the other has a small flight of stairs in front. The entrance doors, richly decorated, are perfectly preserved.
It consists of two separate parts each with its own stair system.
The two courts are central and acts as ventilation shafts inside areas.



16b. PLAN

16c. ELEVATION

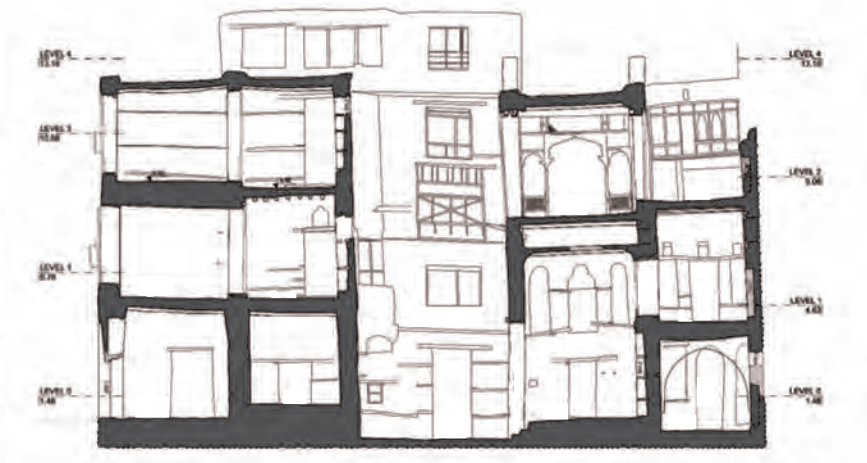
17a.



Bayt Nawar

Building on three floors, it's distinguished from the typical palaces of Jeddah for the presence of a courtyard.
The main entrance of the building is long Mekhlevan Lane and leads to the courtyard, which overlook the two main rooms of the building. The southern part consists of a large space of representation on the ground floor with an elaborate plaster decoration and a wooden ceiling painted.
Currently it is in a poor condition and in the need of an urgent consolidation intervention.

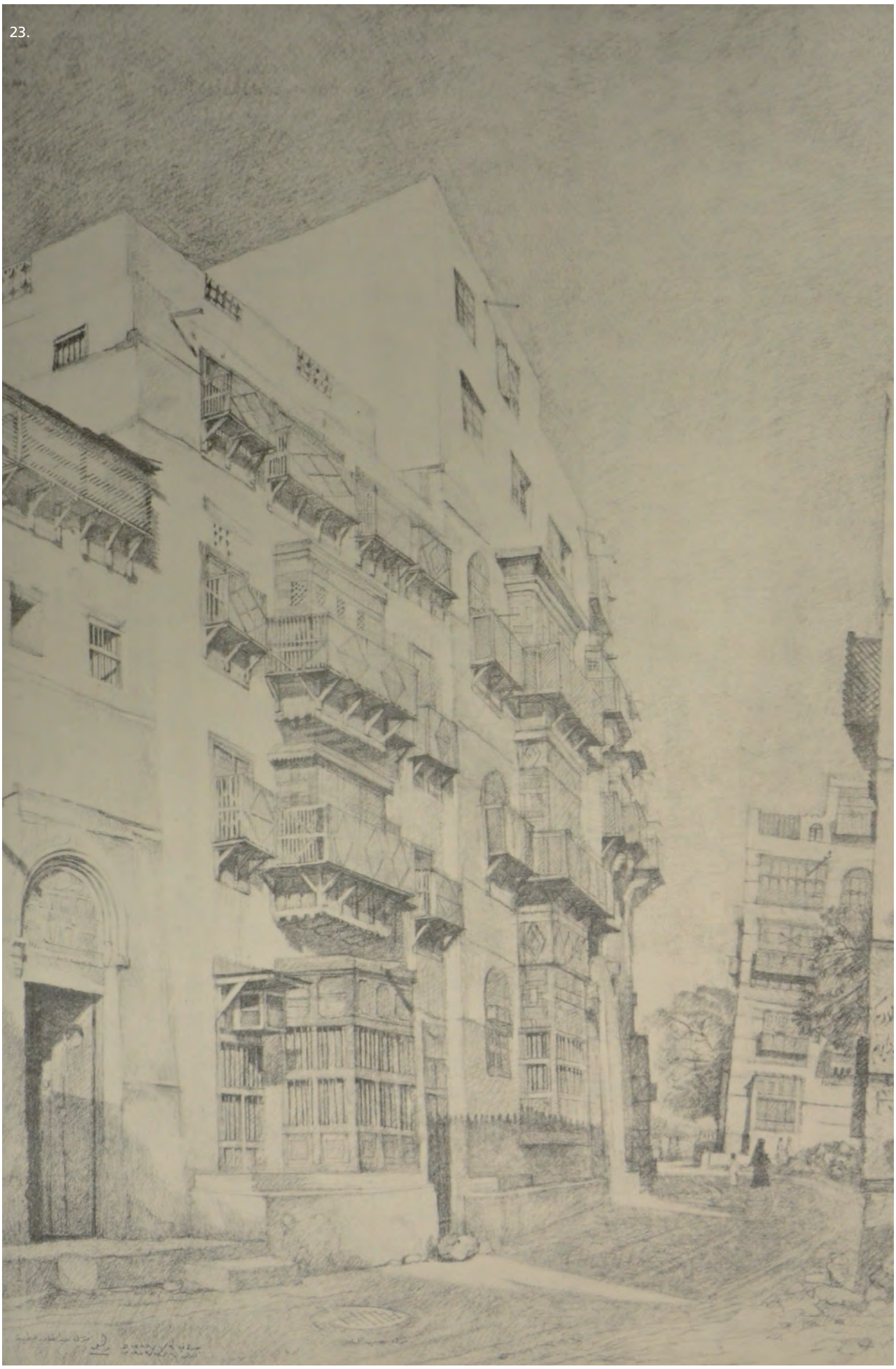
17b. PLAN



17c. SECTION

17d.

23.

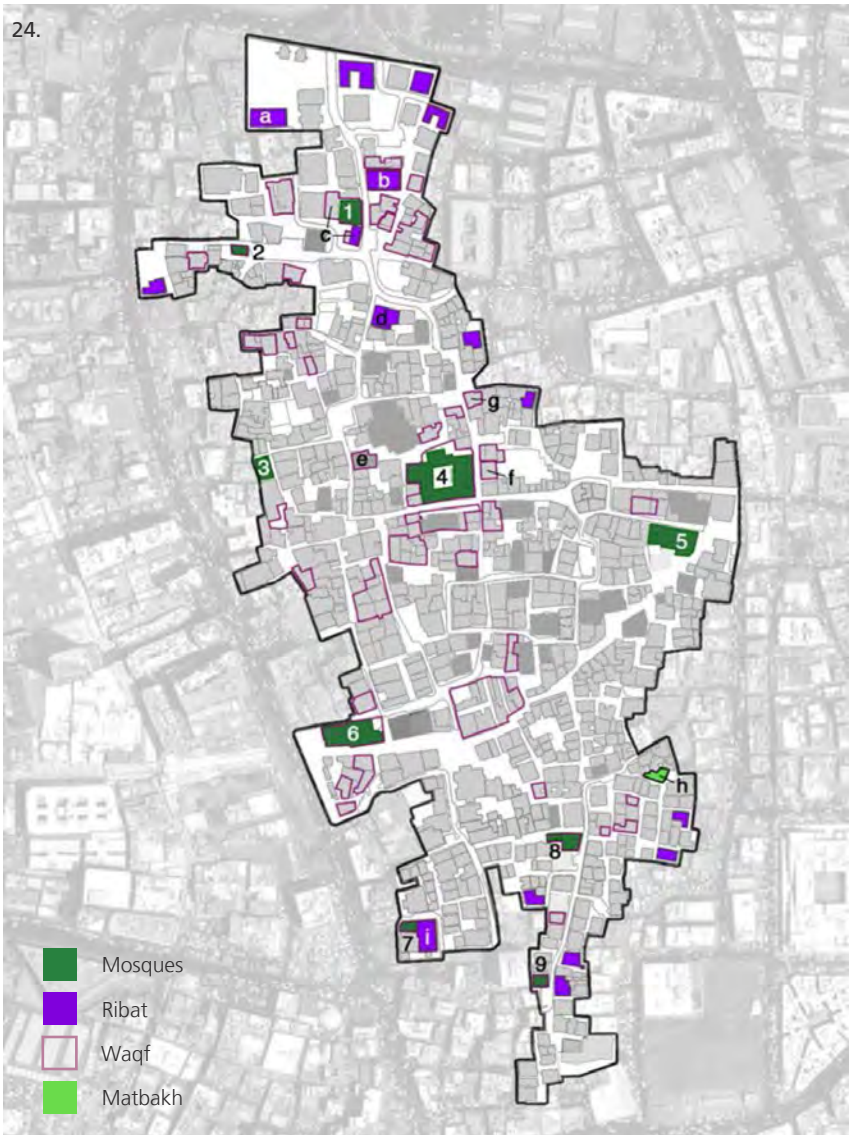


‘RIBAT-S’

In addition to the mosques, in the Old Town, there are also other religious and charitable institutions. In these buildings, the pilgrims who arrived in Jeddah stationed here waiting for the caravans heading to Mecca.
Traditionally in Ribat free meals were prepared for the poor inhabitants of the old city. The Ribat has as typological and architectonic characteristics:

- Crenellated walls finished with a kind of lance
- Low volumes, one or two floors

24.



23_*Hand drawing perspective.*
24_ *Nominated property: mosque and ribat-s*
Mosques
1. Abu `Unba
2. Al-Jilani
3. Al-Barqali
4. Al-Shafe`i
5. Al-Maghrabi
6. Al-Mi`mar
7. Hasuba
8. Zawiyet Al-Suleymaniah
9. Al-Fateh

Ribat-s
a. Ribat Banaja
b. Ribat al-Khonji al-kabeer
c. Awqaf building
d. Ribat al-Wilaya
e. Waqf ash-Sharif Ghaleb
f. Awqaf building
g. Bayt Shaikhoun
h. Matbakh al-Aidaroos
i. Ribat al-Manoufi

3| Traditional materials

STONE

In the research mentioned above reveals that one of the most important mu'allemin operating in Jeddah since the late 40s of last century had four factories producing stone blocks Hadjar baharj and Hadjar manqabi they are thus described:

Hadjar baharj grayish blocks of hard stone cut from madrepore stones consist concretions reefs of the Red Sea and other tropical seas. These in particular has been excavated from the shallow waters of the Red Sea coast in the city of Jeddah.
For the buildings were it used more occasionally even blocks of coral (Coral blocks). These have similar specifications to the stone Mangabi (for insulation and resistance), but are lighter; more expensive to extract, was not used as a standard material, even if the blocks of coral are often found mixed with limestone.

Hadjar manqabi = Stone coral limestone resulting from consolidation of coral reefs: the place of extraction of this type of stone is the lagoon Manqabah north-west of Jeddah. The Stone coral was extracted from the immediate vicinity of the old town and was known just as the stone "mangabi". Traces of ancient quarries are still visible to the north of the old city. It's a stone relatively easy to cut and work especially if taken for a short time, as it tends to harden when exposed to air. It is porous with good insulation properties and relatively light (on average 1.5 t / m3). To withstand the aggression of salt air of the coast of the Red Sea, stone walls mangabi must be covered with a layer of plaster as was customary to do in the old Jeddah.
Both types were cut and shaped into building blocks by skilled artisans.

MORTAR

The term was used to refer nurah generically to the "mortar", while in reality it was different types of binder:

- nurah tabi aiyyah (mortar natural = mud)
- nurah Baladi (local- lime mortar artificially composed - crushed limestone = CaCO3)
- nurah afrandj (foreign cement mortar: a mixture of alumina, silica. lime, iron and magnesium)

The most common type used throughout the region was the Hedjaz Nurah baladi.
The production techniques of nurah baladi depended on the mixing of clay, different types of lime, crushed limestone and clay. These were boiled together for a number of days and then crushed to get to a powder component, or cut with different types of lime and used as bricks for construction of walls (especially to Mecca and Al- Madinah)

To define the exact composition of the mortars, as well as plaster and paintwork present, it is essential to perform a series of laboratory testing, as well as discover the composition and verify their originality.

Plaster and stucco decorations

The effect of the moist and of salty air of Jeddah on the masonry constrains to protect both internally and externally with plaster; in this regard the campaign of essays and investigations carried out recently (the annex to the report on the investigations carried out with the interpretation of the data obtained) has been focused on taking samples of the plaster and stucco of several buildings listed by local officials that will be analyzed for understand its composition and in order to choose the most appropriate methods of consolidation and restoration of surfaces.

In the descriptions we have received it seems that the houses were whitewashed or painted in soft colors: pastel yellow, cream, blue and pink
The sampling and analysis of plaster will be made inquiries to verify the originality always keeping in mind that it could not guarantee a suitable extension and ubiquity of such samples.

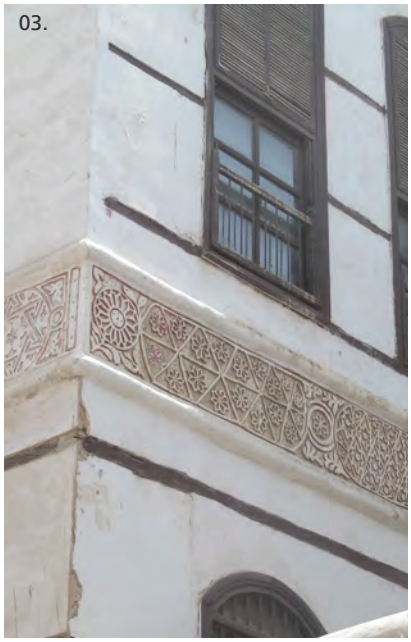
From what we have learned of 800 and early '900 in the habit of plastering the buildings was not very widespread in the Hejazi Region; this use had no consequences in Makkah or Madinah built in stone (the dark stone), while in Jeddah, for its proximity to the sea if the walls are not protected by a plaster coating they will deteriorate rapidly.


01.


02.

The local workers realized of having to protect the external surface of the buildings (stone Mangabi for the most part) with a material resistant to the sea climate: the first attempt was to use the powdered lime, sand combined with wood sawdust which, however, proved to be quite suitable only for internal plasters, where as for the outside did not give a good feedback, presenting crazing even in the presence of a minimum temperature change, and therefore this technique was soon abandoned.
Subsequently he tried another technique which consisted in applying a layer of preparation consists of lime and sand which is left to harden before applying the next layer consists of lime, crushed stones and sometimes Zahra _ which gave the buildings a blue color (which agrees with what we said before about the color of the houses).
In the '900 other attempts were made to improve the quality of plaster by adding to the first two layers of a treatment consisting of a layer of mortar of lime and sand to fill cracks and discontinuities, and then add a finishing layer, a sort of "glue" (first used in the construction of the boats, stones mixed with finely ground lime mortar and sand. Of course the description is very vague and can be misleading; for more there seems to be an explanation of the rationale for using these materials there is even less safe than any news or paintwork on their composition. However, all these types of plaster had problems chalking moist air in Jeddah, so that it was usual practice to re-plaster buildings.
We hope that the samples of plaster can give us answers to clarify the nature of the plaster themselves even if sampling did not affect a substantial number of cases as many times repeated, given the limited time available.

01_02_*Buildings in Jeddah: stucco characterize the facade.*
03_04_*Naseef House: detail photo of the frieze.*



The need to protect the walls from the humid air and the salt contained in it is then developed with the addition of the decorative inlay. The decoration tends to focus on the bottom of the exterior facades, around doors and windows to the main, rarely on the upper floors. The stucco was applied to the walls and worked immediately, while still wet, deeply engraved with decorative motifs creating chiaroscuro effects in contrast to the non-etched surfaces.
The decorated surfaces are presented as panels of rectangular or square shape, rarely in a frieze as in the case of Bayt Naseef. In Bayt Jokhdar and Ribat al-Khonji as-Sareer there are notable examples of carved stucco decoration.
The technique has been abandoned progressively from the start of the 20th century.

WOOD

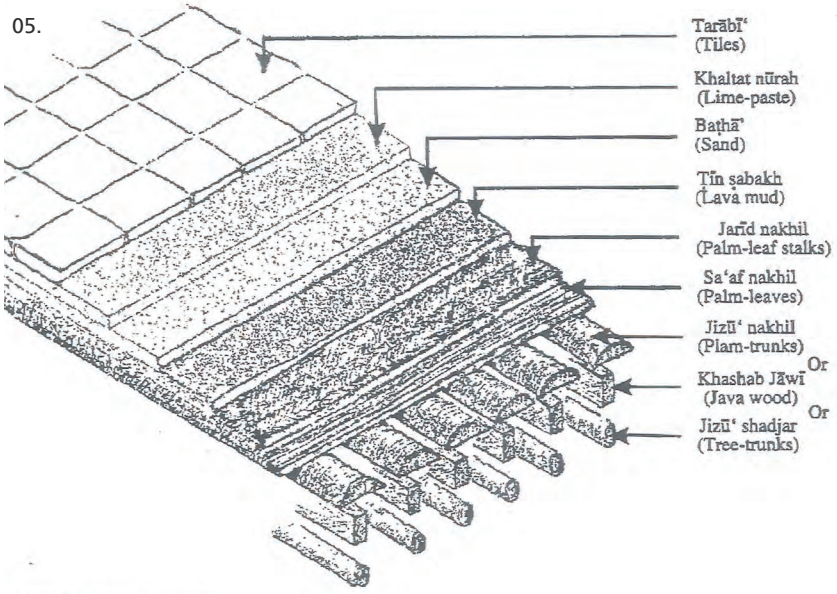
The use of wood is more interesting and particularly that relating to the implementation of **bearing walls of buildings**: the walls are in fact reinforced by elements-wood placed chains typically every six courses of stones (each application is approximately 20 cm.) both outside and inside of the wall and connected transversely to it _ not always this link seems to exist.
These chains may be constituted by joists, of square section or planks, generally made of teak wood from India with the task of load balancing, while also providing a greater resistance to the structures and stability by counteracting sagging settling. Furthermore, the wall structure of the buildings was connected by a kind of "belt-edged wooden" horizontal absolutely essential to resist any shock waves that characterize the area.
The wood was bedridden with a mortar mixed with fragments of stones to create a kind of bed for subsequent action of blocks.
This construction technique was known and applied from 16 ° -17 ° century and which was adopted following the teaching of the builders Syrians.
From the descriptions of the construction methods provided by **mu'allemin** it seems that before 1860 these inserts were made from simple wooden logs placed between the stones of appeals; later it was decided to make them with boards.
A problem arose relatively to t**ermites aggression of wood**, the "**masters**" tried to solve by treating the wood with a kind of glue / bitumen used in the construction of boats. There remained, however, in Jeddah, the problem of high humidity.
It was attempted to overcome both problems, termites and moisture of the wood using particularly resistant (also with regard to the pillars and the beams constituting the floor slabs) as the **palm** tree trunks from a site near Mecca or particular **teak** imported from abroad .

Floors

From the descriptions consulted in relation to the maximum length of 8 meters that could reach the wooden beams (the section with a diameter of about 20 cm), the maximum size of the environments was 5 meters x 5 meters for fear of excessive flexion wooden structures. He later used the technique to **choose curved logs** (of course, the curvature was disposed above) to increase the flexural strength of the floors.

Since the thickness of the walls varies from 85-100 cm at the base of the buildings at 55-65 cm of the top in many cases the wooden beams

05.



06.

05_*The drawing shows it was made a typical floor in Jeddah.*

06_*Wooden floor photo.*

07_08_09_10_ *Roshan windows and wood are the elements that distinguish the architecture of Jeddah.*

11_*Details of wooden traditional decorative.*

protruding from the thread of the building.
The **thickness of the floor** (with the supporting structure consists of tree trunks, or palm or by wooden joists Java) could vary from 10 to 40 cm and was composed usually from palm fronds and stems, from a lightweight fill (lime mixed with coral stone fragmented mud and lava) by a layer of sand and paving thin stone slabs bedridden with lime.
Floors and ceilings of coverage seems to be made in many cases with wooden boards called **"Gandal" and with palm fibers from India**.

07.

Another type of superior quality wood favored by local workers as a building material was "Jawi", wood imported from Java. Although more difficult to work, it **is much more resistant to insects and moisture. It was usually used for doors, windows and Roshan.**

Decorative elements

The oldest buildings are usually characterized by Roshan (bow windows) of lower type, but more carved than the newer ones.

This appearance is due to the remarkable maritime traffic for the transport of pilgrims, which resulted in an increase in imports of wood from the production areas in the Far East made it much cheaper and easily available compared to the 17th century and earlier.

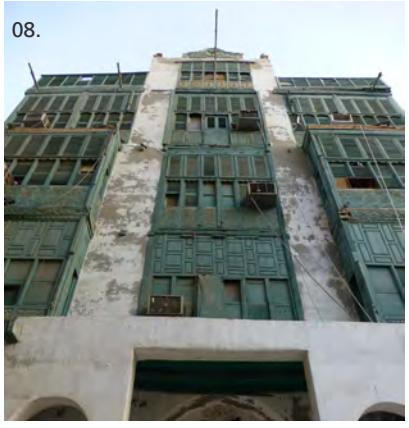
The oldest buildings, as they said a carpentry very elegant and elaborate, but since the wood became more available the amount used in buildings increased gradually until the **early 20th century, when the Roshan-s were extended to cover the entire height of buildings.**

The local building tradition was enriched with characteristic wooden screens designed and made by artisans from different parts of the world.

Then the craft had a decline. The Roshan-s came to be characterized by motifs gradually less complex to simple useful ventilation slits.

This relationship between the increased use of wood and the decline of craft shows that the wood was not difficult to find a good and its use was

08.

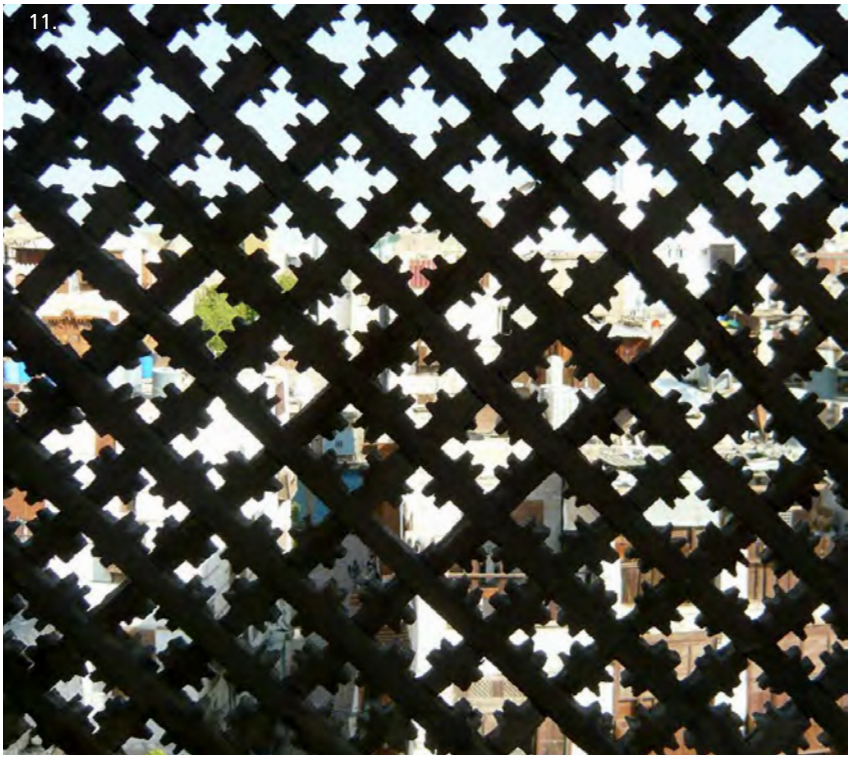


09.

10.

no longer a sign of wealth as it had been previously.
In surveys recently concluded special attention was paid to the analysis and sampling for the works in wood is to understand the different types of wood used for construction work, and for parts of the decorated windows and doors (doors, Roshan) checking the correspondence with descriptions and testimonials available.

Particularly interesting is the definition of **protective "treatment" for timber**, important for its conservation given the area's climate: it seems that the oldest Roshan had a brown-brown, recently obtained erroneously with enamel or paint (for more lucid) that in the descriptions were obtained with treatments derived from the maintenance of the boats (the most obvious thing given the proximity to the sea) but not further defined. The windows-Roshan relating to more recent buildings are colored a beautiful green color: hypothesis to check is that the original color was blue, then turned into green and that therefore it was used or products similar to the copper carbonate or azurite (that with time through a chemical change, and then becomes malachite green).
It is hoped that the development of the tests are being conducted on samples taken to clarifying these questions, or at least give you a starting point for the definition of further investigation campaigns calibrated both size as an extension and punctuality.


11.

4 | Static and conservation problems

The ancient center of Jeddah is affected by the inevitable decay of historic structures intimately linked to the **characteristics of the same building materials** and technologies used, compounded by the frequency of **earthquakes in the area, and the instability of the soil.**
The traditional buildings of the historic center of Jeddah have shallow foundations (about 70-80 cm deep) made in the same way the walls (stone masonry laid with mud mortar) laid on a calcareous soil and sand, containing a large amount of fragments silt and coral.
In many cases the **foundations** are not able to adequately support the building, then the lesions appear related to differential subsidence of the soil, which shows how the walls are not supported in a uniform way, and the building - or part of it - tends to yield and may collapse as evidenced in the many buildings collapsing in most parts of the old center.
The main causes of foundation settlement or instability are due to:
Overload on the ground because of the excessive height / weight of the house (in many cases caused by elevations after the original construction);

- Overloads concentrated in correspondence of "pillars" (in some cases the walls of stone masonry have large openings and for this act, from the static point of view, as a series of pillars where the loads are concentrated) causing differential settlements in the soil;
- Presence of water under the building, near the surface, which affects the efficiency of the foundations (you also remember how the ancient city is not equipped with a sewer system and therefore there may be leakage of water directly into the ground)
- Demolition work in nearby buildings

A deeper analysis of these problems, is presented later in the manual restoration indicating the measures to be taken.

The walls of the historic buildings often show horizontal damages at the level of the floors. Horizontal movements and structural stresses are caused by the lack of actual clamping in the walls. Damages often appear in the corners of the buildings, where they meet the load-bearing walls.
The walls are traditional stone masonry with mortar of mud, linked by wooden elements nailed between them, which confer to the masonry the necessary resistance to tensile stresses.
Sometimes the two faces of the wall are connected by wooden elements.

One of the most common causes of fissures and instability in the walls is the combined effect of a relative failure of the soil / foundation, and clamping of the wooden beams that may fail to play their role because of their poor condition (wood subject to diseases of aging: break, rot, yield strength of the wood, termites ...).

Careful consideration must be made regarding where many buildings are deformed or out of plumb that could belong to the time of construction.

For these and for other cases where it is not possible to understand the structural situation due to continuous interventions of puttying and repainting that may have concealed any significant damage then it would be necessary to proceed with more appropriate survey instruments (such as the use of screw jacks dishes to investigate compulsions in the structures and thus in the resilience of the structures themselves).

The same problem also exists for knowledge of the structures of the wooden floors of great extent in which the structures are not accessible even for a first survey (presence of suspended ceilings etc.) Being able to reserve the hazards deteriorations warheads, in the presence wood-boring insects or under sizing of the beams with serious consequences for the building and for the safety of the inhabitants.

It is to be stated that the "knowledge" of the building is the first step for a correct protection and preservation and subsequent restoration.

SECTION 2 |
RESTORATION OPERATIVE PROCEDURES

1 | Construction analysis

The correct processing of the restoration project can't be separated from an exhaustive analysis of the artifact, the knowledge of the construction must guide the choice of interventions supporting the project both in terms of theoretical orientation as at the procedural level, reducing the "risks" arbitrariness of the of the design: it shall be the opera itself, if investigated with historical-critical perspective to direct their executive choices.
Otherwise the risk is to be unable to perform an operation of restoration but only an alteration of the status quo.

The phases of the acknowledgment can be described as follows:

- The historical analysis: identification of the evolution of the factory through indirect investigations (analysis of historical and archival sources) as direct (reading of the building, stratigraphic analysis)
- Identification of the building as a whole and in relation to the surrounding urban context, identification of the sensitivity of the factory in respect of the various risks and in particular of the earthquake.
- Finding the cadastral documentation and acknowledgment of existing planning tools.
- Photographs of the building
- Development of geometric surveys, architectural and structural building in its present state, with a strong focus on techniques, identification of materials to construction details. The surveys of the status quo is a historical document depicting the work in an interpretation as possible "objective" and rigorous basis for the formulation of any hypothesis that seeks to re-read backwards evolutionary processes events of time.
- Diagnostic investigations study of the damages and elaboration of the "deterioration picture"


01.


02.


03.

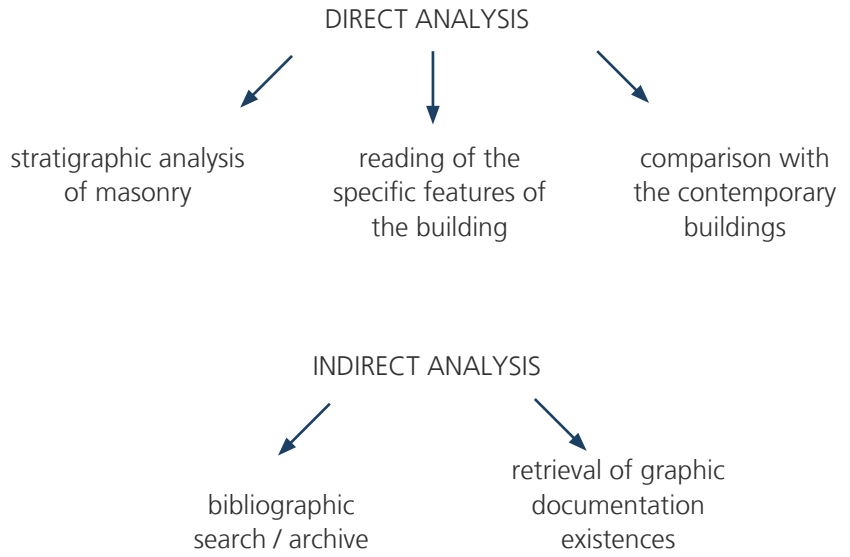
Historical research

The study of an old complex must start from data collection performed from the building itself:

- signs details such as inscriptions, coats of arms, initials, dates
- how building specifications, materials and techniques used


05.


06.



Direct observation should consider all parts of the building including the decoration, the furniture and the environmental context in which it is immersed. In this context the inspections becomes reconnaissance that shall follow a survey methodology aimed to gather information on:

- allocation territorial relationships visual / conceptual with the city
- contemporary functions of the building
- features dimensional and constructive
- historical events and physical changes over time
- state of preservation

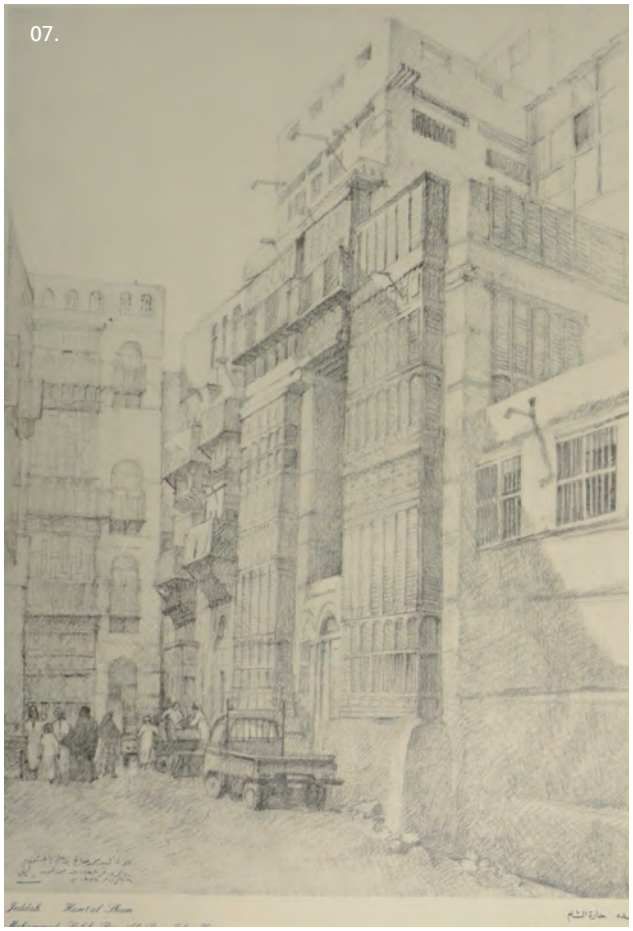
Important information can be found by comparison with structures from the stylistic and technical characteristics comparable.
The survey is based on the indirect search for documents relating to the history of the building, on the descriptions made in the past, changes of the ownership, changes which have occurred over time.
Particularly useful is the iconographic research that analyzes the historical illustrations from which you can derive valuable information on the

01_02_03_04_ *Historical photos.*
05_06_ *Hand drawing perspective.*
07_08_ *Comparison between historical images and contemporary photos.*

evolution of the buildings over time and changes in the living environment. Special attention should be paid to the seismic history of the site that can be detected from historical or scientific publications and from direct sources.

Data collection should be organized in a systematic way so as to make them available at any time to all those involved in the design. We recommend organizing information into tabs divided by fields (urban / construction procedure / technological aspects / analysis of the deterioration) related to photos, drawings and references to sources of information.

07.



08.

Geometric survey

↓

Technological and structural survey

↓

Survey of materials and surface deterioration

↓

Survey of the "fissure's picture"

↓

Investigations diagnosis

↓

Detection of failure mechanisms

↓

Hypotheses about the causes of damage

↓

Choice of the type of intervention

Survey operations

Is the basis on which to set the restoration planning and will respect the pre-existence features in its peculiarities in order to ensure its transmission to the future.
The survey aimed at the restoration project is not only a graphic rendering of the measures taken on site but a critical task in which we highlight the relationship between the individual parts, the material characteristics and structural building.
There are two basic techniques:

- the direct survey
- the indirect survey

In the first case the measurements are reported by direct contact with the artifact to document and are used simple tools such as metric rulers, plumb-lines, levels to measure lengths, and to set the alignments. You have to produce a sketch of the artifact (eidos-type) on which transfer measurements, from which subsequently derive the exact representation. Any measurement error can be detected during the rendering.
When it is necessary to execute a survey by indirect procedures the measurements are taken with optical, mechanical or computerized high precision tools which involve a series of calculations to obtain a graphic translation of detected objects within a system of spatial coordinates.
One must always bear in mind that the survey is not a photographic reproduction of reality, in front of the large amount of information that we provide the instrumentation necessary to operate an action interpretation, select among the many signs that make up the image of an object that define those its morphology and its changes over time and to give a more appropriate graphic representation.
Survey follows the phase of restitution, the charting data using plans, elevations and sections indicating the detection methods used (trilateration, polygonal, fixed points, etc.).
The purpose of the analytical part of the project, of which the survey is the very core, is to build an adequate knowledge of the structure, which allows to develop the diagnosis of ongoing instabilities and types of vulnerabilities, a real list of factors to counteract with the intervention.

Photographic Survey

With the photographic survey it is possible to retrieve a first reading of the monument. We proceed by making photographs of the artifact from above, its elevations, its interior spaces and architectural details and the technological parts considered significant so as to be able to document with great precision the state of the building. Photos should be dated and organized so as to allow easy reference, please record on a general plan covers reference indicating the points of view.

09_ *Photographic survey of the Naseef house.*

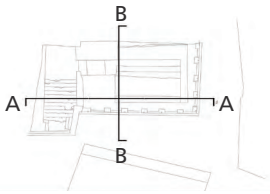
09.

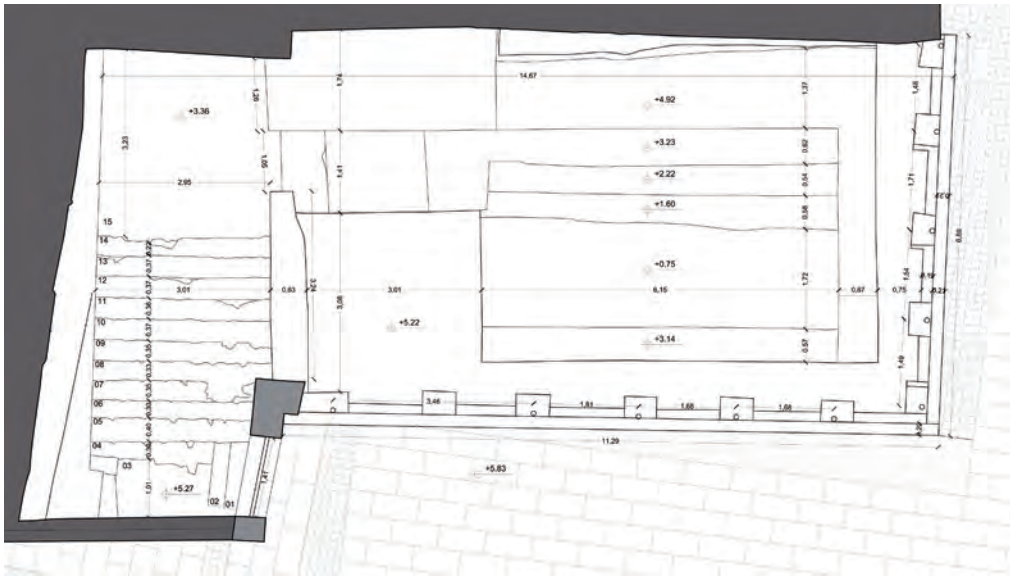
Urban Survey
Allows you to picture the artifact in exam within its context, understanding the relationships with the territory and surrounding urban centers. On the plan you can identify the main roads and pedestrian, understand the visual relationships, indicate the main views, climatic influences in relation to exposure.
It is advisable to return the data in the plan scale 1:1000 with the identification of the building in exam.

Geometric Survey
Describes quantitative traits and dimensions, is the graphic representation of a numeric-building organism through the following drawings:

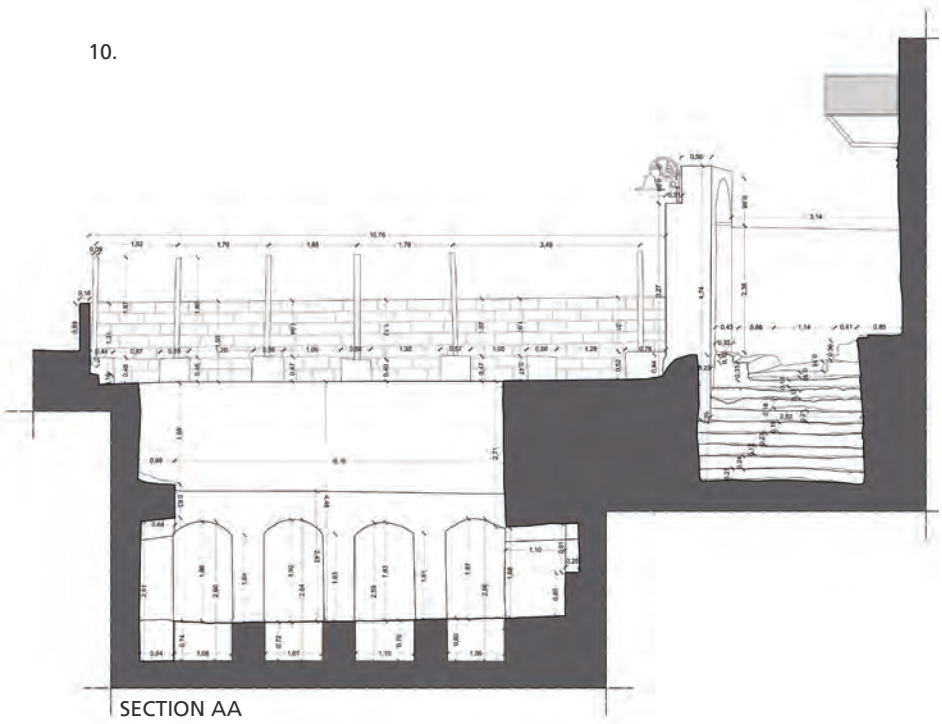
- plans of all floor levels
- external elevations
- sections

The drawings must be listed, the measures listed readable depending on the choice of the scale of representation, generally 1:50. The 1:100 scale is chosen to represent street fronts, broad indications of architectural complexes vast and sections of land with large differences in altitude; on contrary it shall be necessary to increase the scale at least up to 1:20 to represent part of building characterized by the presence of an important decorative apparatus.
Since the geometric survey is necessary to define the geometry of the model to be used in the seismic analysis, it constraints and loads acting, it should ensure that all the necessary information has been detected.
Different methods can be used for its processing, starting from the most traditional of the direct survey and photogrammetric to more advanced technologies.
A branch of the indirect survey is **photogrammetry**, a procedure that allows orthorectify photographic images relating them to a cartesian system so as to obtain graphical representations in orthogonal projection.
This methodology had great development through of aircraft surveys (aerial photography) and has found an application in the survey of the facades of historic buildings (terrestrial photogrammetry).
The most recent and advanced system includes the use of **3d laser scanners**, electronic instrument that provides the spatial coordinates of a cloud of points belonging to the detected object. Born for industrial and applied later in topography, is the latest appeared in the field of architectural survey, the instrument performs automatic measurements of millions of points that fall within its field of view returning of three-dimensional shapes in vector file.

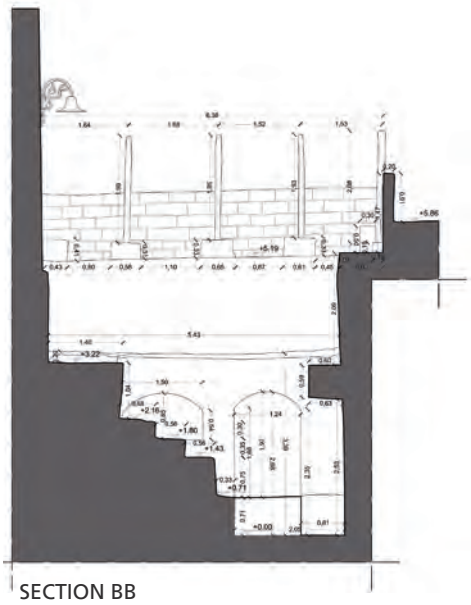




10.



SECTION AA



SECTION BB

10_ *Geometric survey of Ain Al-Qusiyah.*
11_*Building in the historic center of Jeddah: the collapse highlighted different aspects of construction, allows us to understand the texture of walls and the construction technique of the ladder.*
12_ *Pathologies and actions legend.*
13a_13b_ *Ain Al-Qusiyah plans: material and surface deterioration survey and actions.*
14a_14b_ *Ain Al-Qusiyah sections: material and surface deterioration survey and actions.*
15a_15b_ *Naseef house elevation: material and surface deterioration survey and actions.*

Architectural and construction surveys

The architectural and construction survey is an operation to understand the artifact as a whole and taking in the formal values, constructive and cultural peculiarities of spatial and surface of the article, the relationships between the parts, equipment, walls, construction details, decorative, information that encapsulate the essence of the article. The construction survey examines all technological solutions regarding foundations, walls, floors, roofs, openings, plants, the conservation status of the supporting structures and capacities. For the analysis of the vertical bearing structures, for example, from an examination of the two faces of the wall, if not plastered, it is possible to recognize the type of construction and hypothesize the internal composition. It may happen that the work is facilitated by the presence of collapses that make visible the inherent characteristics of the artifacts as wall sections or textures of the floors. This study aimed to evaluate the bearing capacity of the various elements so as to identify the proper techniques of consolidation, proposing possibly the same technology executive of the existing structure, fixing the points of fragility. Through graphic devices enabling a relatively quick read, concise and comprehensive monument detected.

Material and surface deterioration survey

The deterioration of surface concerns plasters and paints, stucco, stone aggregates, wood and iron.The survey is the tool that allows us to study the state of actions, through visual inspections and specific diagnostic tests, we can categorize the various instabilities and identify the causes so as to direct the design choices. This fact strongly binds specific map to the formulation of the subsequent provof intervention, this should be designed and prepared as an instrument of knowledge and diagnosis.
For the realization of the projects we recommend to follow the sequent procedure:

- realization of close-up pictures of the specific phenomenon that is being analyzed
- denomination unambiguous phenomenon
- identification of the material on which is localized deterioration
- identification of the causes of the phenomenon and its mechanisms of deterioration also
- Introduction of the pattern or symbol corresponding to the deterioration in the abacus

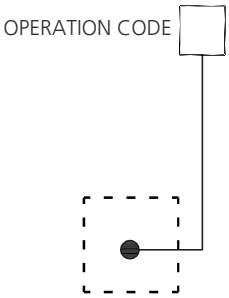
The drafting shall ensure readability and accuracy of the localization of the phenomena on the drawings, in order to make identifiable both the type of deterioration that the material on which it is manifested. We recommend a graphical schematic, synthetic and bounded.

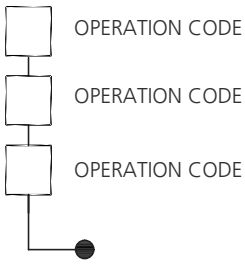
11.

DECAY PATHOLOGIES LEGEND

	DECAY	CAUSE
GENERAL PATHOLOGIES	 MISSING	• mechanical, phisical-chemical action • human action
	 INCOSISTENT ELEMENT	• human action
	 PATCH	• human action
	 WASHED OUT SURFACE	• mechanical, phisical-chemical action
	 PAINT VANISHING	• mechanical, phisical-chemical action
	 RISING DAMP	• disrect contact whit the ground • stalled in rainwater
	 HUMIDITY STAINS (ABOVE)	• no cover • lack ok piping for rainwater
	 EFFLORESCENCE	• lack of maintenance • humidity
METAL	 OXIDATION AND DECAY	• mechanical, phisical-chemical action
	 GRATE DECAY	• mechanical, phisical-chemical action
MASONRY	 MASONRY DECAY AND ROTTEN SURFACE	• mechanical, phisical-chemical action
	 STONE EROSION	• mechanical, phisical-chemical action
	 MORTAR EROSION	• mechanical, phisical-chemical action
	 CRACKS	• structural damage
PLASTER	 PLASTER DISTACHMENT	• mechanical, phisical-chemical action
	PLASTER DECAY	• mechanical, phisical-chemical action
WOOD	 WOOD DECAY AND ROTTEN SURFACE	• mechanical, phisical-chemical action
	WOODEN WINDOW DECAY	• mechanical, phisical-chemical action
	 SHOP SIGNS	• human action
	 GRATE AND WOOD DECAY	• mechanical, phisical-chemical action
	 DECAY	• mechanical, phisical-chemical action

MATERIALS





- STONE
- MASONRY
- PLASTER
- WOOD
- METAL
- WOOD/METAL
- GLASS
- CERAMIC
- TEXTILE
- CONCRETE
- EXTERNAL ELEMENTS

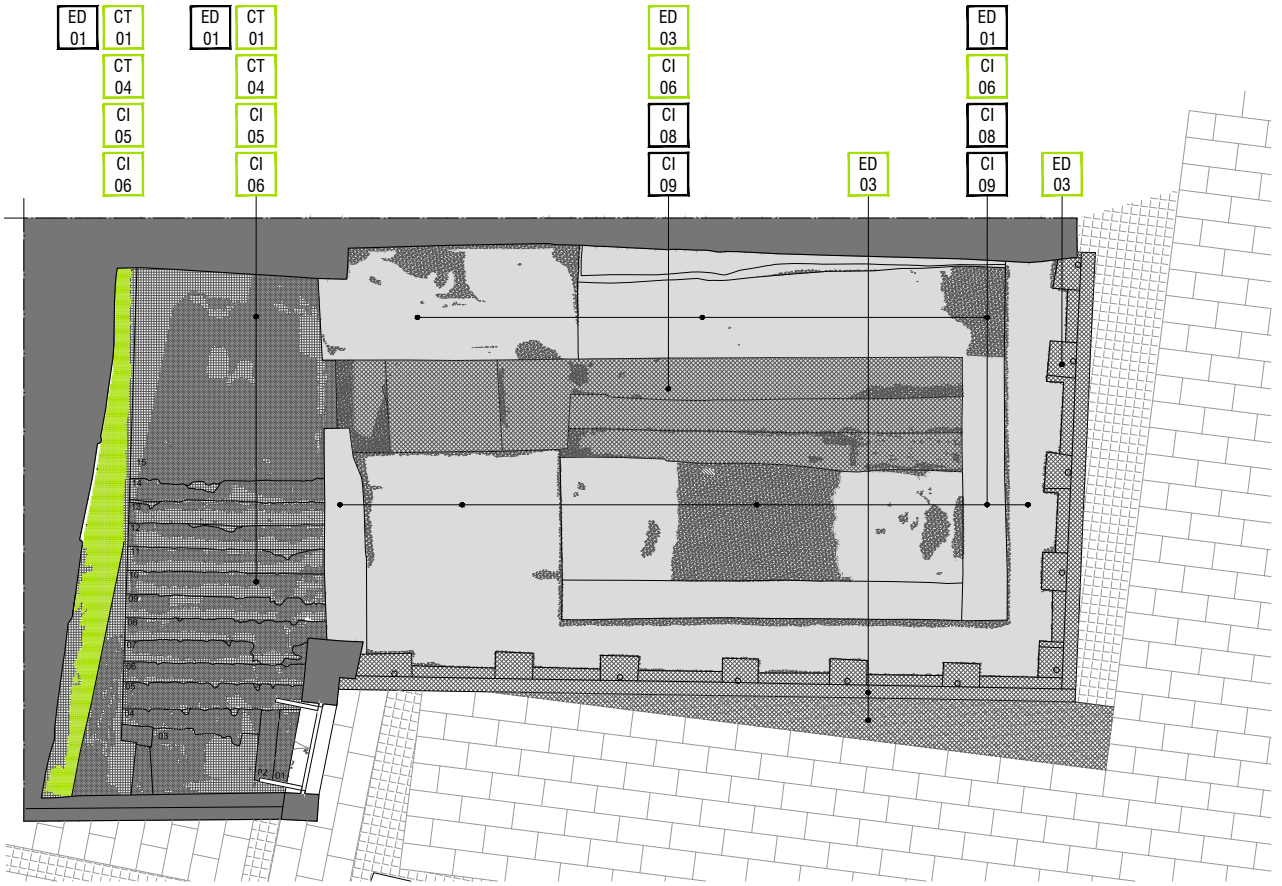
CONSERVATIVE RENOVATION PROJECT ACTIONS LEGEND

ACTIONS

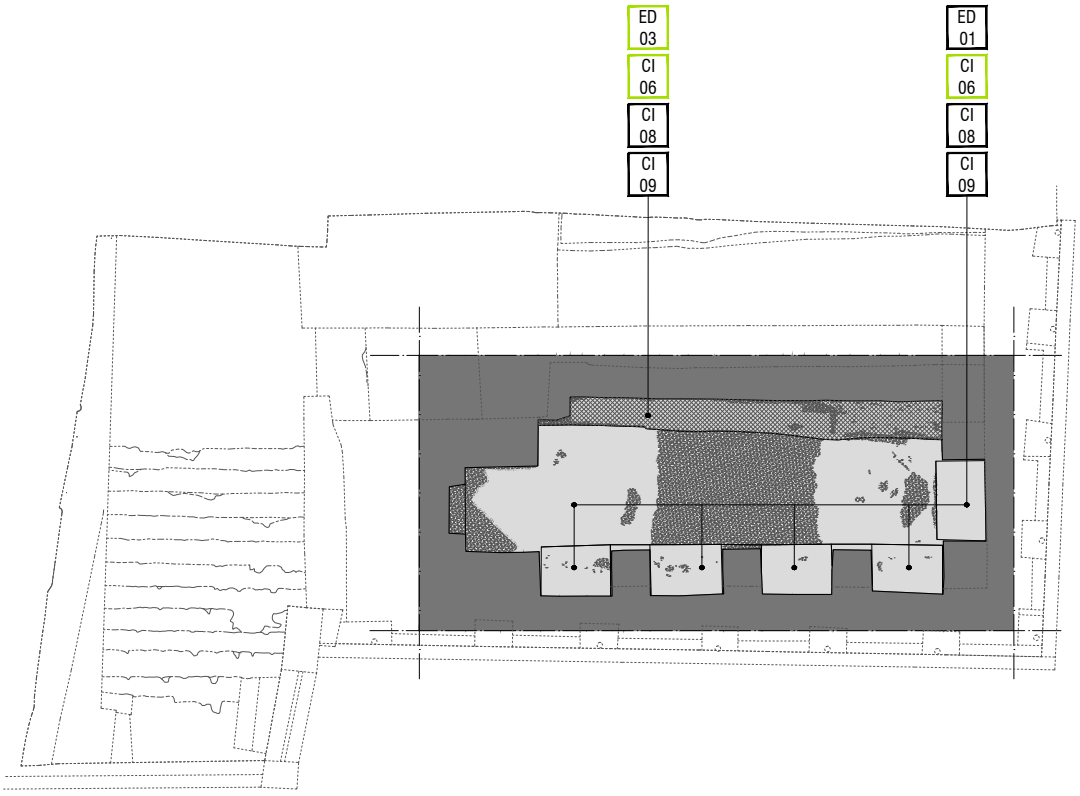
ED ELIMINATIONS & DEMOLITIONS	ED 01	MATERIALS ELIMINATION
	ED 02	TECHNOLOGICAL ELEMENTS REMOVAL
	ED 03	ADDED ELEMENTS REMOVAL OR DEMOLITION
CT CLEANINGS AND TREATMENTS	CT 01	CLEANING AND REMOVAL OF THE SUPERFICIAL DEPOSITS
	CT 02	BIOLOGICAL LAYERS ASPORTATION
	CT 03	EXTRACTION OF SOLUBLE SALTS
	CT 04	PRECONSOLIDATION AND PROTECTION OF STRUCTURE ELEMENTS
	CT 05	PROTECTION OF FRAME ELEMENTS
	CT 06	CHEMICAL BARRIER AGAINST RISING DUMP
	CT 07	ELECTROSMOTIC BARRIER AGAINST RISING DUMP
ER ELEMENTS RESTORATION & RENEWALS	ER 01	RESTAURATION IN SITU
	ER 02	DISASSEMBLING-RESTORATION-REASSEMBLING OF ELEMENTS
	ER 03	ELEMENTS REPLACEMENT
CI CONSOLIDATIONS AND INTEGRATIONS	CI 01	ELEMENTS WALLS INTEGRATION
	CI 02	MORTAR INTEGRATIONS
	CI 03	ROTTEN OR DAMAGED ELEMENTS INTEGRATIONS
	CI 04	LESION BLENDINGS OF STONE ELEMENTS
	CI 05	STRUCTURAL CONSOLIDATION
	CI 06	SURFACES CONSOLIDATION
	CI 07	FILLER AND PATCHING OF PLASTER SURFACES
	CI 08	NEW PLASTER
	CI 09	NEW PAINTINGS

NOTES:
All conservative actions shall require to be preceded by an accurate inspection of the elements and there shall not be any removal without the director's approval;

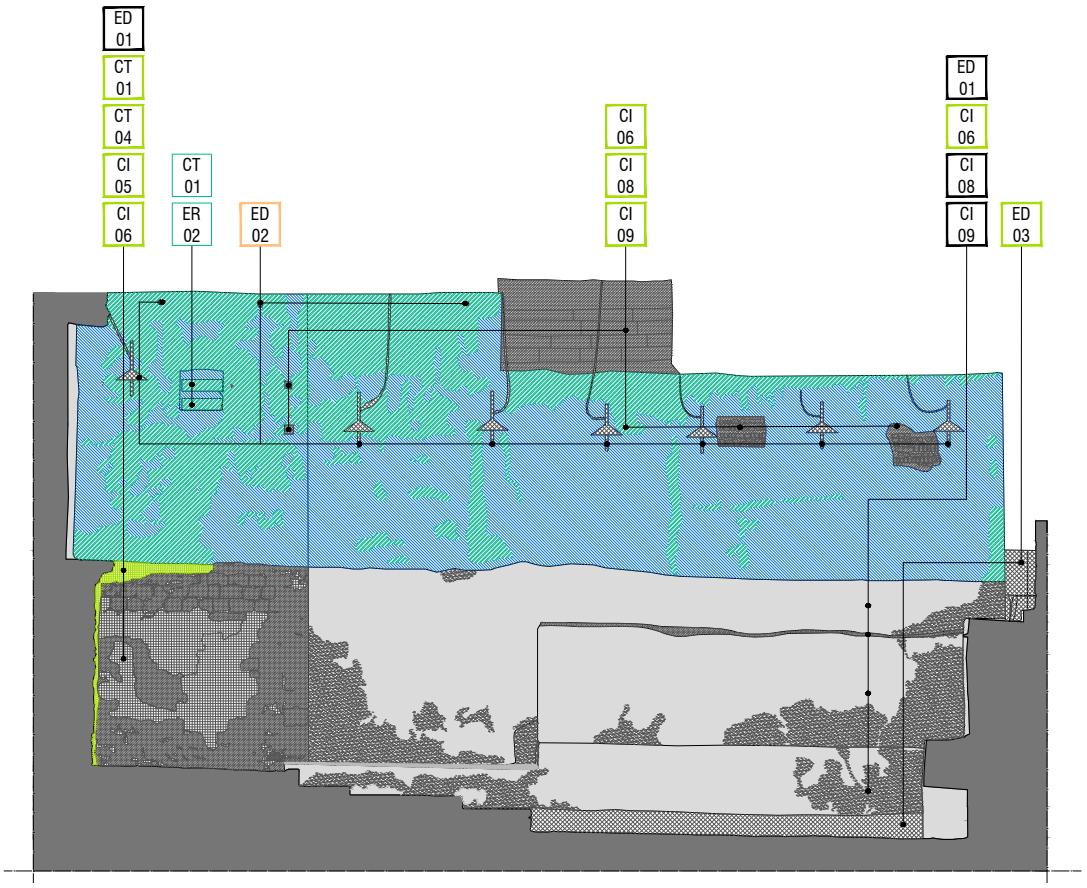
Plaster portions detected ad a not cement-based type shall not be removed but treated as to comply specification section 09-03-00


ED 01
CT 01
CT 04
CI 05
CI 06
ED 01
CT 01
CT 04
CI 05
CI 06
ED 03
CI 06
CI 08
CI 09
ED 03
ED 01
CI 06
CI 08
CI 09
ED 03

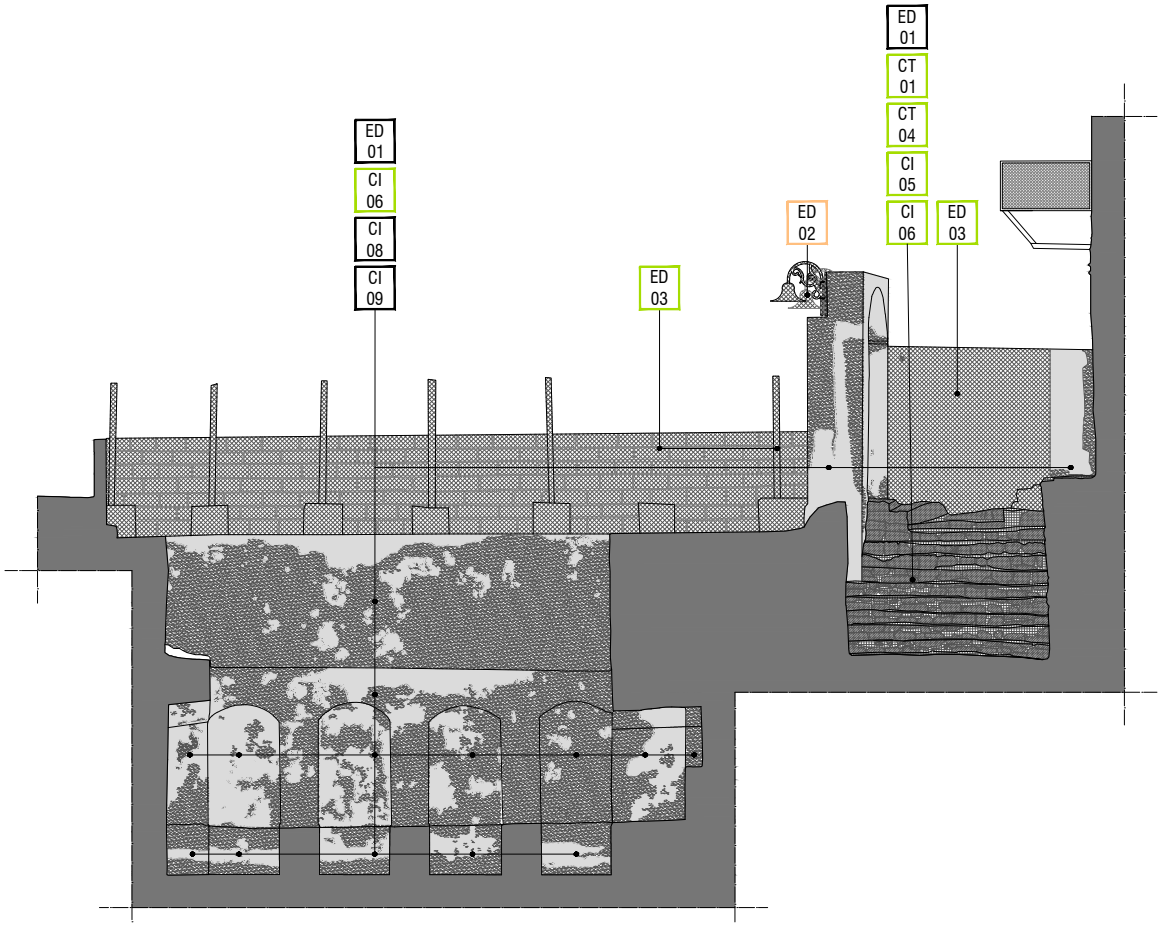
13a.


ED 03
CI 06
CI 08
CI 09
ED 01
CI 06
CI 08
CI 09

13b.


ED 01
CT 01
CT 04
CI 05
CI 06
CT 01
ER 02
ED 02
CI 06
CI 08
CI 09
ED 01
CI 06
CI 08
CI 09
ED 03

14a.


ED 01
CI 06
CI 08
CI 09
ED 03
ED 02
ED 01
CT 01
CT 04
CI 05
CI 06
ED 03

14b.

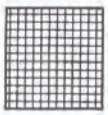

CT 01
CT 02
CT 04
CI 02
CI 03
CI 04
CI 05
CI 06
ER 01
CT 01
CT 02
CI 06
ER 01
ED 01
CI 06
CI 08
CI 09
CT 01
CT 02
CI 05
ER 01
ER 02
CT 01
CT 02
CT 04
CI 03
CI 05
CI 08
CI 09
ED 01
CT 06/07
CT 03
CI 06
CI 08
CI 09
CT 01
CT 02
CT 04
CI 03
CI 05
CI 08
CI 09

15a.

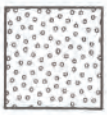

CT 01
CT 02
CI 05
ER 01
ER 02
CT 01
CT 02
CI 06
ER 01
CT 01
CT 02
CI 05
ER 01
ER 02
ED 01
CI 06
CI 08
CI 09
01
CT 02
CT 04
CI 03
CI 05
CI 08
CI 09
CT 01
CT 02
CI 05
ER 01
ER 02
ED 01
CI 06
CI 08
CI 09
ED 01
CT 06/07
CT 03
CI 06
CI 08
CI
ED 02

15b.

Classification of some of the main deterioration that can be found on the surfaces and its graphic symbol:



Discoloration
Natural variation, dependent components of the material, the parameters that define the color. It is generally extended to all the material concerned; if the alteration is manifested in a localized way is preferable to use the term stain



Alveolus deterioration
Presence of cavities of variable size and shape (alveolus), often interconnected, and with non-uniform distribution

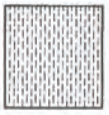
Crust
Modification of the surface layer of the stone material. Of variable thickness, generally lasts, distinguishable from the underlying parts for the morphological characteristics and, often, for the color.

Deformation
Variation of the shape or form, which affects the entire thickness of the material

Differential deterioration
Loss of material from the surface, which highlights the heterogeneity of texture and structure

Surface deposit
Accumulation d1 foreign materials of various nature. such as, forexample, dust, soil. And has variable thickness. generally, lack of consistency and adherence to the underlying material.

Disintegration (sputtering)
De-cohesion with the fall of the material in the form of powder or tiny fragments due to minimal mechanical stress



Detachment
Solution of continuity between layers of a plaster, both among themselves and with respect to the substrate, which preludes, in general, to the fall of the same.

Efflorescence
Formation of surface appearance crystalline or powdery or filamentous, usually whitish. It knows if efflorescence. it, in crystallization can sometimes take place inside the material often causing the detachment of the most superficial

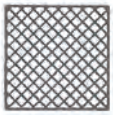
Erosion
Removal of material from the surface, which in most cases is compact

Exfoliation
Formation of one or more laminar portions, of very small thickness and sub-parallel to each other, said layers

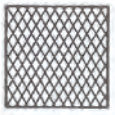
Fracturing or cracking
Solution of continuity in the material implies that the mutual displacement of parts of ceramic materials: in the case of incomplete fracturing and without fragmentation of the object we use the term clique or the term crazing

Lack
Loss of continuity of surfaces (plasters, wall paintings, portions of dough or ceramic coating, etc.).

Stain
Chromatic variation of the surface localized, related both to the presence of certain natural components of the material (eg. In the pyrite marble), both to the presence of foreign material (products of oxidation of metals, etc.).



Pellicle
Natural modification of the surface, not connectable to phenomena of deterioration and perceptible as a variation of the original color.



Biological pellicle
Thin layer, homogeneous, mainly consisting of microorganisms, variable texture, color and adhesion to the substrate.

Film
Surface layer, a transparent or semi-transparent substances mutually consistent and unrelated to the substrate (protective film, with aesthetic functions, etc.

Pitting
Formation of blind holes, and denser. The holes have tended hemispherical shape, with a maximum diameter of a few mm.

Swelling
Lifting surface localized, shape and texture.

Spalling
Presence of pieces of irregular shape, consistent thickness and non-uniform (flakes), generally in correspondence with solutions of continuity of the original material.

Fissure's Picture Survey

This type of survey procedure records various forms of structural deterioration that the building has undergone over time by collecting the information for the diagnosis. The survey of the damages is extremely useful in the study for the consolidation planning and seismic improving, in addition to this the damage's recurrent characteristics, considered as an overtime result of a substantially behavior's repeated sequence of events, with the frequent presence of cumulative damages, makes an important information record for the behavior of future damage.

Has to report:

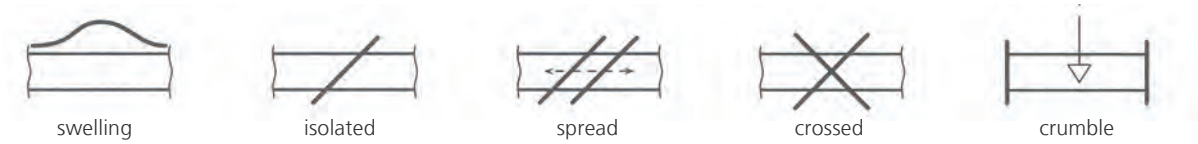
- damages related physical structural deterioration (fractures, loss of material, collapses)
- modifications of geometry, partial geometric changes that the construction had previously the damaging, such as displacements and deformations. It doesn't have, in general, of surveys of sufficient accuracy prior to damages, against which to deduce the differential displacements can be estimated as a deviation from the geometric regularity predictable.

It is essential that the person making the survey has a thorough knowledge of construction techniques which the building was made, each piece, according to their construction methods and of their static operation, is exposed to certain damages characteristics, more or less important, requiring specific insights. The survey process has to be critic and deductive aimed at the understanding of instability phenomena typical of a particular artifact that has its own history and specific construction techniques: further investigation are necessary to choose the proper intervention.

Any damage must be interpreted, for example, in extensive structures, subject to thermal excursions, the lesions may be physiological, due to the spontaneous formation of an expansion joint. In this case their saturated and filling probably could be harmful. To have a complete and comprehensive picture it is essential to have a proper graphic rendering of all the deteriorations. It has to be recorded with appropriate notation, the presence of fissures and damages detected, their size and behavior, differentiating, if possible, the most recent from the most distant in time.

The deterioration not related to static instability may be due to several factors:

- The rising damp or infiltration of raising water
- Atmospheric agents, such as rain, wind, acting on the exposed surfaces
- Biological phenomena, due to the presence of parasites, fungi or roots of shrubs.
- Man-made phenomena, such as removal, theft, dirt, vandalism.



Diagnostic Tests

Investigations, just like the survey, are designed and programmed by considering:

- problematic present on the substrate
- objectives
- recourses
- time available

During the inspections can be assessed, in a simple and deductive, the conservative state of the building, identify the deterioration, but for further reading on the nature of the materials and the causes of instability must perform analyzes requiring the intervention of specialized personnel , the use of specific instruments and chemical analysis.
The diagnostic surveys are based on physical methods and chemical-physical properties with which it is possible to extract information on the chemical composition and physical characteristics of the work of art, allow to obtain preliminary data essential for the design of the restoration.
The selection of tests, tools and operators must follow the criteria of minimal invasiveness.

Project phases diagnostic:

DATA GATHERING
choice, collection and cataloging of the samples

↓

DATA PROCESSING
Polls and analysis

↓

INTERPRETATION OF DATA
Collection of data, comparison of the information obtained and the drafting of a final report

It shall be reported, to follow, some of the major essays that can be done for diagnostic purposes on buildings.

Non-destructive Surveys
Are the sequence of preliminary tests and surveys that makes use of methods that don't alter the materials and don't require the destruction or removal of samples from the examed structure aimed at research and identification of defects of the structure itself.

The methods of non-destructive analysis have the following characteristics:
- preservation of the integrity of the object under investigation;
- speed of the survey;
- ability to provide both qualitative and quantitative data;
- simplicity of restitution.

Sonic Surveys
Category of investigation that is based on the type of propagation of elastic waves, specifically those of sound, whose performance and speed vary with changing of the material traversed. Instrumentation interpret the path of the waves within the structure extrapolating information in particular on density and compactness, identifying the presence of gaps and inhomogeneities.

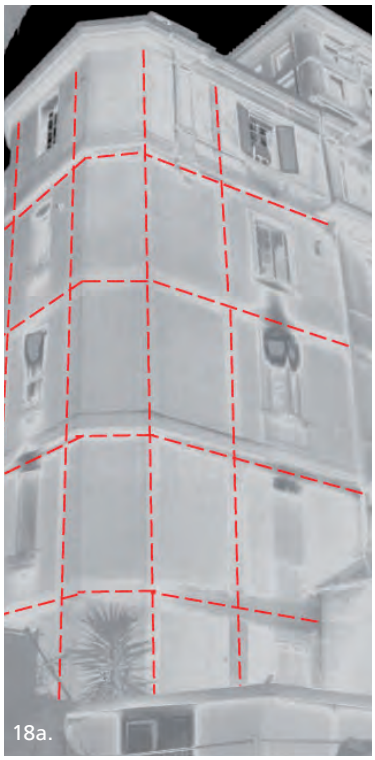
Thermography
It consists of photos made with film or glass sheets sensitive to infrared light. By the usage of a camera equipped with infrared sensors, able to sense temperature differences of less than 0.1 ° C, it is possible to detect different temperatures, which occur with various colors (blue - cold, red - hot), that the materials assume thanks to their different physical and chemical characteristics; these differences can be enhanced even artificially forcing the equilibrium of the structure with a thermal stress. The uses of infrared thermography are multiple: identification, location and extent of the structural elements and their geometry; survey wall weaving, the clamping of the masonry, emptynesses, survey of detachments of the coating; information on the distribution of moisture on surfaces.

Load Tests
We carry out particularly elastic element such as slabs, and allow, through the positioning of the loads from the known value, to assess the lowering (arrow) in the center line before, during and after the application of the weight.

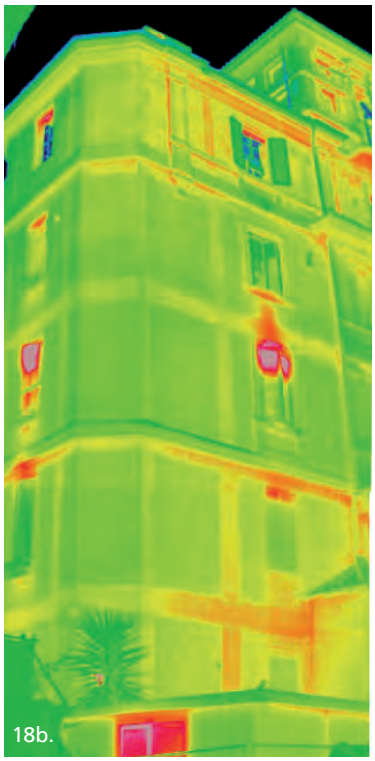
Monitoring
Consist of a measurements, prolonged in time, characterized by periodic readings, often automated and sometimes remotely, which allow to determine existence and terms of variations of surfaces. They allow you to find out if some deformations that are cyclical, how often they occur and whether they are reversible at the end of each period. Surveys are particularly

16_ *Graphic set of rules proposal: damage description*
17_ *Sonic surveys performed by a specialist*
18a_18b_*Thermography in Black and White (a) and false color (b)*


17.



18a.



18b.

useful, it would be desirable to use a quote, but unfortunately often not viable for the long lead times that require application.

Destructive Surveys

Provide for the removal of minimum portions of material, if possible already flaking. Their execution must therefore be limited and evaluated case by case.

Survey with jack dishes

The use of the flat jacks for in situ evaluation of the mechanical characteristics of the masonry, is a method that allows semi destructive:

- the importance of operating voltages;
- the survey of the deformation characteristics

Interventions of static consolidation of masonry structures is essential to know the mechanical characteristics of deformability and strength of the materials from which the structure itself.

Flat jack single tests

The test with single flat jack allows the estimation of the state of local tension state present in the walls. The test technique is based on the variation of the stress state at a point of the structure caused by a cutting plane created by hydraulic saw with diamond blade circular performed in the direction normal to the surface of the masonry. The release of tensions that manifests itself causes a partial closure of the cut, which is detected by measurements of the relative distance between pairs of points placed in a symmetrical position with respect to the same cut.

It is then inserted inside of the cut a flat jack, realized with thin steel sheets welded, which is connected to the hydraulic circuit of a pump.

The internal pressure is gradually increased to cancel the deformation measured after the execution of the cut. In these conditions the pressure inside the cylinder is equal in a first approximation to the stress existing in the wall in the direction normal to the plane of the jack, less than a constant experimental which takes account of the ratio between the area of the jack and the area of cutting, and less than a constant that takes into account the intrinsic stiffness of each jack.

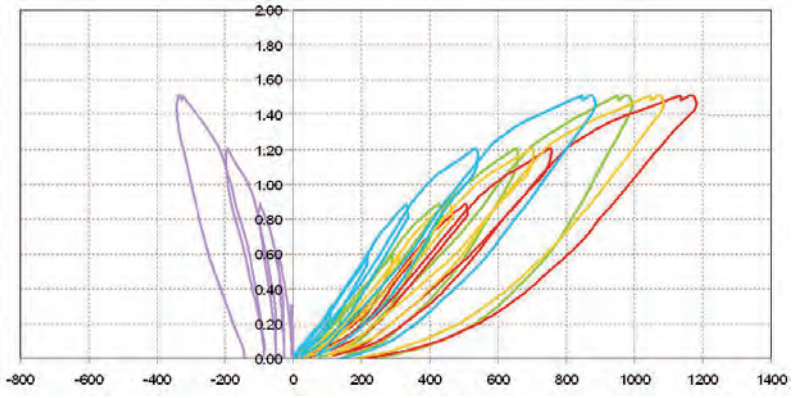
The test results of flat jack individual are generally represented by a diagram in which the abscissa is read tension, or the oil pressure inside the cylinder multiplied by the constants of area and of the jack, and the ordinate is read the relative distances between the bases of measurement positioned above and below the cut.

The test is deemed completed when - in response to increase of pressure in the cylinder - is obtained by restoring the initial measurements (measures relating lowered to zero), and the corresponding pressure jack is read at the local voltage in the masonry, unless the multiplicative constants.

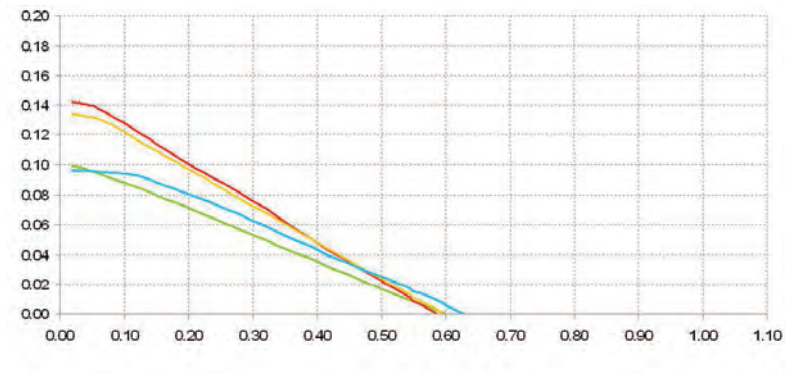
Double flat jack test

The test with double flat jack allows you to determine the deformability of the brickwork and to provide an estimate of the strength of walls to the elastic limit. The test consists of making two cuts in the wall, by means of hydraulic saw with diamond blade circular, parallel to each other, at a variable distance (which depends on the resistant elements of the masonry and investigated by the width of the jack used). Inside the cuts are placed two rams, made using thin steel plates welded. This procedure allows you to define a representative sample of masonry for the mechanical behavior of the same size. The two parallel cylinders, suitably placed in the pressure applied to the sample interposed a state of un-axial stress, and the deformation resulting in the portion walls are measured by a suitable number of displacement sensors in a direction perpendicular and parallel to the planes of insertion of the jacks in order to determine the voltage diagram deformation of masonry investigated.

Usually the load is applied cyclically, with load cycles in increments of increasing pressure in the cylinders interspersed by full discharge of these. The test is pushed up to a pressure higher than the state of local compression, limiting the maximum voltage reached in the load cycles to a value sufficiently lower than the breakdown voltage of the material.



19.



20.

19_*Typical representation of the results of a test of single flat jack: in ordinate the relative distances between the bases of measurement positioned above and below the cut, the abscissa represents the voltage applied to the masonry*

20_*Typical representation of the results of a test of double flat jack: abscissa deformation recorded in the bases of measurement (positive - shortening - vertical units; negative - stretching - horizontal bases), ordered in the voltage applied to the masonry*

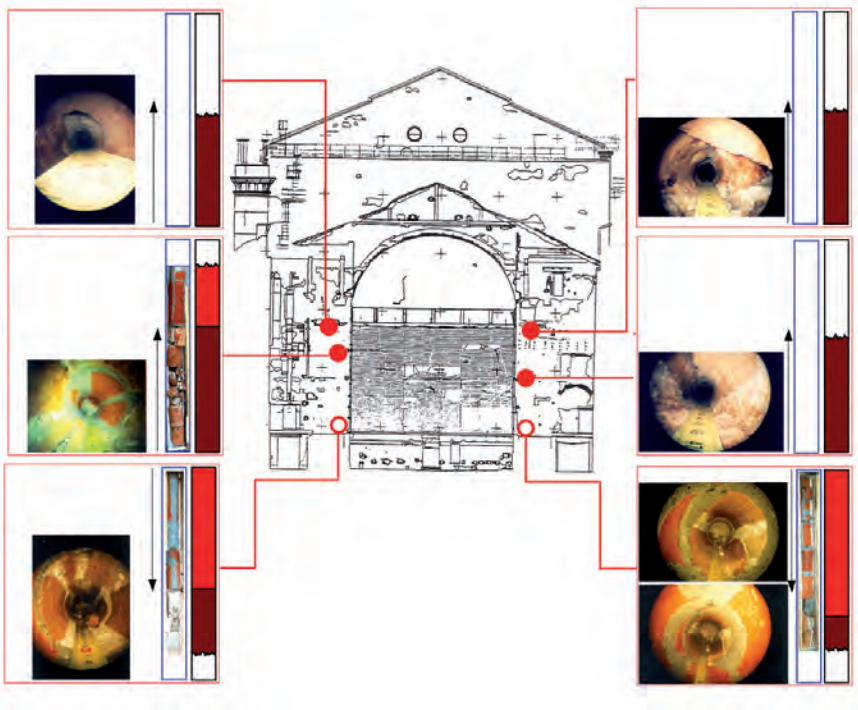
21_*Walls observation through coring*

The test results of double flat jack are generally represented by a diagram in which the abscissa you read the deformation recorded in the bases of measurement (positive - shortening - vertical units; negative - stretching - horizontal bases), ordered in the voltage applied to the masonry between the jacks, or the oil pressure inside the cylinders multiplied by the constants of the box and the jack

Coring

Consists of extracting a cylinder to pass the structure, thereby having a direct view of the inner layers and their state of conservation and aggregation. The extraction of the core is done with specific cutting tools, with diamond bits thin wall, which work without impact. The hole can be used to conduct other investigations complementary, especially endoscopies introspective, which can employ tools articulated arm or fiber, all linked to the photo or video cameras to record the images. As regards the operation of these instruments, which are used successfully in the diagnostic applied to statuary stone and metal and wooden artefacts, it is interesting to note that the minimum diameters input range from 4-8 n1m for more agile fiber optics instrument, to 10-12 mm for traditional optical instruments, which are in fact disappearing from production. L 'evolution of this type of instruments is continuous, and pointing to the kit of devices which perfect and enrich the information, such as zoom and cannulas calibrated to the depth reading.

21.



2 | Temporary works for historical masonry buildings

01_ *Bayt Sharbatli: detail of shoring steel.*
02_ *Bayt Sharbatli: the building today has serious static instability, we note shoring steel plant floor and wooden upper floors.*

In the recovery of historic cities the first aspect to be addressed is the execution of temporary works for the safety of structures (demolition, shoring, installation of metal rods, hoops, etc.) heavily damaged.

Interventions are needed in order to:
- Avoid the progression of the damage;
- Protect physical injury;
- Restore normal social and economic activities.

The most complex of these works are related to the choice of the optimal type of intervention, the proper performance and cost optimization.

The design choice is to follow the following procedure:
1) Recognition of the building type;
2) Assessment of the damage;
3) Recognition of the damage mechanism;
4) Evaluation of the necessity of provisional operations;
5) Identification of the type of intervention (total demolition or structural parts or not structural, construction of temporary works to support the vertical loads and/or retention compared to horizontal actions, etc.) and the right technology to the particular situation;
6) Draft provisional work;

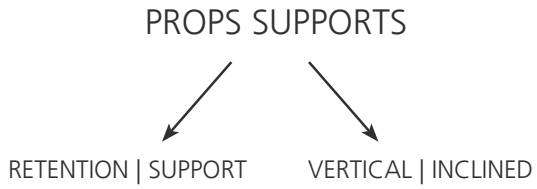
Each situation must be studied case by case and should be examined by several factors:
- The type, the geometry of the building and, if necessary, of the aggregate which it belongs;
- The collapse mechanism activated;
- The size, the location of the damage, the accessibility inside in a safe condition;
- Materials, labor, the means of work available and accessible to the yard;
- The urgency of the operation and life expectancy;
- The conditions of use of space surrounding the building.

These factors interact in a complex manner, tending to favor also solutions, which, in terms of absolute effectiveness of the intervention, may appear not optimal.

The subdivision of the provisional works is based, usually, on the definition of the types of principals, regardless of the type of collapse that prevent, since, for the same type of damage, there can be different types of shoring.

02.

Elements of the protection formed by rods that works exclusively or predominantly by compression. They are divided into retaining props and/or to support, the former have the purpose of retaining any failure that can show up with rotations or overturning of structural parts, the latter shall instead to support the load. Depending on their arrangement, also, you can make a further distinction between vertical and inclined props.



Props support

Props, usually vertical are made with one of the three traditional materials, steel, wood or masonry. The use of the classic steel props offers considerable advantages for rapidity and ease in the installation, when the heights do not exceed 4-5 m, being conceived and designed specifically to fulfill this function. An alternative, although more laborious and less rapid to install, consists by the support with wooden rods. Instead the usage of masonry, in the form of pillars or walls, is limited to cases in which the considerable dimensions of the supports doesn't constitutes access difficulties or limits to the usability of the rooms. The high weight of the masonry, related to a reduced efficiency ratio of resistance/weight, limits this type of intervention

03_ *Props support.*

04_ *Scaffolding retainer (crop).*

to the only ground floors. An exception for this type of shoring intervention as a optimal choice is for the support of window and doorway openings, for which this type, applied as continuity of the walls, is the most widely used and also among the most efficient for the purposes of the global solidity of the structure.The struts are used mostly in masonry buildings, to support slabs, beams, lintels and other secondary elements damaged and to help support the forces actions distribution, they are placed as to work in parallel columns or to support walls that has lost their loading capacity.

An evolution of the props of support for arches and vaults walls consists of the crowning systems. In buildings in the armored concrete props support are effective application in support of horizontal structures damaged or flanking of damaged pillars, which have lost part or all of their carrying capacity.

Props retention frame system

Props are generally inclined with the purpose of counteracting tilting mechanisms of the walls and, more in general, the mechanisms of a global collapse of the entire structure or major parts of it.
The complexity of the solution is related to the size of the damage, the collapse mechanism that the system of shoring must oppose and object to the work of the intervention, from single prop up the realization of real network structures, necessitated by limitation of light buckling of struts. The type most commonly used for this type of intervention is undoubtedly that of wood, preferred for reasons of practicality, assembly and cost with reference to the types of steel.
Alternatives more or less valid, especially in masonry buildings, consist of rods, chains or cerclage global, spurs and buttresses.

04.

Vertical props

The vertical shoring serves essentially to face the instability by vertical translation, can be obtained with elements in timber, steel pipes or masonry structural.

The state of the wall area directly concerned must be relatively serried to ensure the absorption of these localized actions, otherwise it is necessary to locally consolidate the area subjected to the action by the installation of a shore and/or elements to allow a less punctual distribution of effort.

Actions that are commonly used in these cases:

- Prevent the downward shift of parts of masonry;
- Provide support to end floor beams, when the original no longer exists or has lost its effectiveness;
- Provide an intermediate support to the floor beams in order to reduce the bending stress in the span, when the excessive deformation or cracking recognizes a critical state of flexural scheme for these items.

Benefits:

- The installation is quick and does not require skilled labor;
- It can adapt to different geometries of the systems with the possibility of preserving the transit-ability of the compartments;
- They are mass contained compared to rear.

Disadvantages:

- The installation requires adequate constraint conditions to the base and to the foot of the props;
- Require accessibility within the structure to supervise and stay for the duration of the intervention;
- Their contribution to horizontal is null.

Stages of implementation:

- Check the seasoning of the material;
- Preparation of the base;
- Pose of the "dormant" element; vertical shore installation
- Strengthening of the shore.

After the implementation of the shore, it must be verified its verticality. This is especially important for wooden props which, being more slender, can have problems of instability (the control can be executed with a normal level). It should also check the effective mass in strength of the system, if the prop is in compression it must have any horizontal movements, this can be checked by trying to force the shore gradually to flow so as to test the loading.

05a_ *The shoring must be carried out upwards, from bottom to top: from the ground floor to the last storey.*

05b_ *Demolitions should be carried out from top to bottom: from the last storey down to the ground floor. rubble shouldn't be stored: it is to be evacuated as the demolition.*

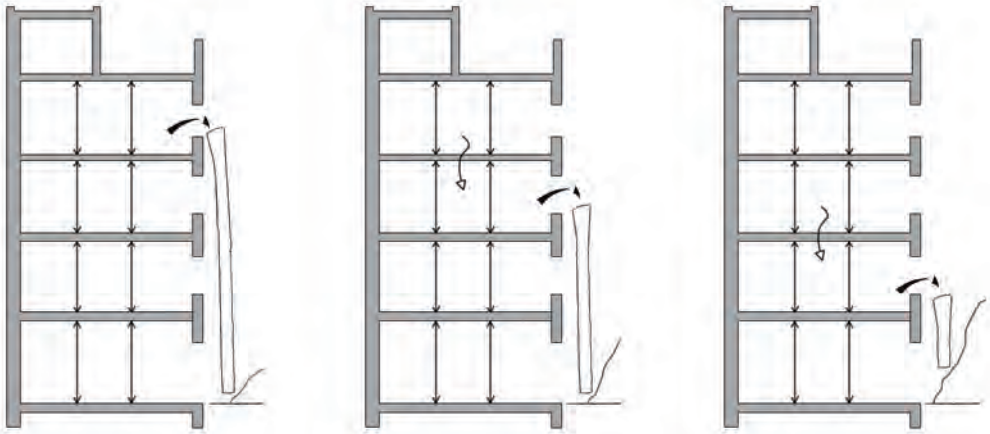
05c_ *The disassembling of the shoring starts on the last floor, then continues downwards, level by level, to the ground floor.*

05d_ *Vertical shoring can sometimes get in the way of the works.oblique shoring is an option, as long as you control the sideways forces involved,using straps,stutts and pads. vertical shoring is adapted to floors,for horizontal elements. this shoring is simpler to prepare when compared to more complex vertical structures. In every case scenario, shoring must be calculated carefully.*

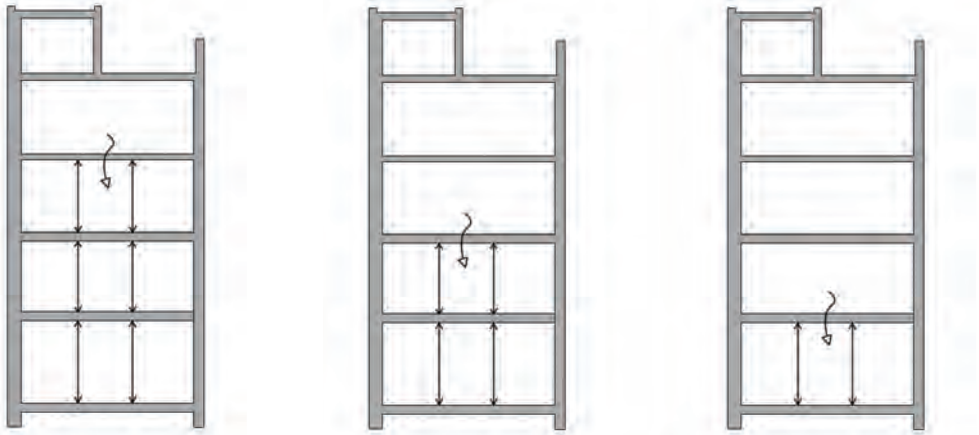
SCHEMES SCAFFOLDING

05a.

05b.

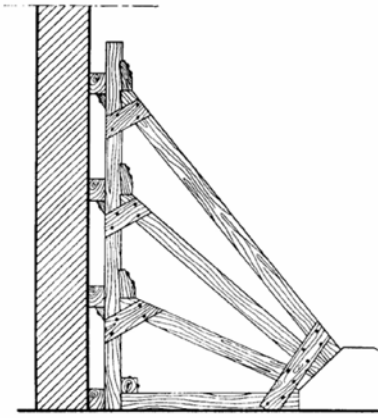


05c.

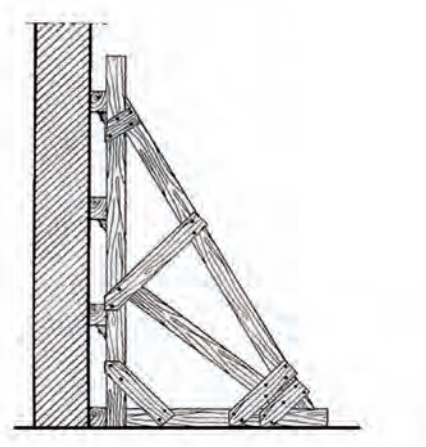


05d.

06.



07.



06_ *Fasteners inclined wood only check valves, the type convergent beam.*

07_ *System triangular retaining only: not to incur in the sliding on the masonry, the individual props retainer can't be placed in work with an inclination to the horizontal exceeds a certain limit, calculated based on the coefficient of friction masonry-shore. A configuration that allows the adoption of inclinations is stronger than that of the triangular system of props, with a vertical rod which opposes the sliding of the inclined prop and a horizontal rod which is inserted in the masonry. (redesign)*

08_*Photos consolidation mosque*

Inclined props

The inclined props supports the protected masonry with a perpendicular action on the surface plane, are similar to actions that subjects with axial stress because the connections are considered as static hinges. The aim of the intervention is to provide constraints that prevents rotation movements as translation towards the building's wall plane. If shoring small masses of masonry it is possible to intervene with a double symmetrical shore, one inside and one outside, to provide support piers or basal full wall portions showing signs of crushing. In the case of props for the support of large masses must have a mass supported with remarkable resilience and stiffness, which means providing the system of adequate support bases on which to distribute the load actions. The base must be large as to negate any deformation of the ground.

To direct the load mass to an appropriate distribution on the platforms below the prop supports must be in compression, to ensure a good contact between masonry and the prop since their installation. It is usually used in the following cases:

- Provide to entire masonry walls or parts thereof of the constraints to the rotation.
- Reduce the buckling length of the wall elements in danger of instability, made evident by the bulging of the wall.
- Absorb the horizontal thrust of arches or sometimes on the walls tax, applying a activity, in correspondence of the center of pressure for the arches and along the line of thrust for the times.
- Absorb horizontal thrust spread over the entire wall.

To achieve the objectives listed, using multiple systems consisting of strips of props parallel or converging or real reticular systems, arranged so as to obtain the maximum benefit static.

Benefits:

- The installation is quick and does not require skilled labor
- The installation does not require access inside the damaged buildings;

Disadvantages:

- Requires appropriate border conditions at the base and the head of the props.
- Produces a consistent footprint and reduced possibility of transit in the area in front of the work silently.
- Presents a reduced durability for continued exposure to atmospheric agents, in particular for wooden props.

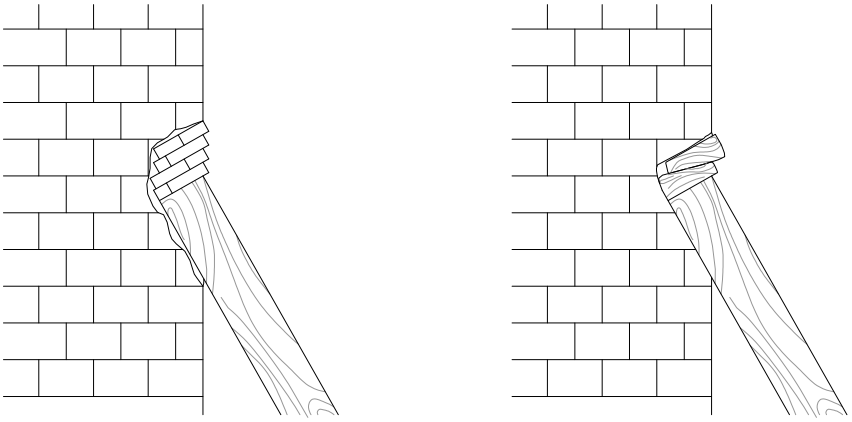
08.

Stages of implementation:

Wood props
- Control of the aging of the material;
- Excavation of the bottom site;
- Preparation and provision of the base bottom with the realization of a raft foundation in wood;
- Preparation of the seats in the wall for mounting the head of props;
- Arrangement of dormant and current contact mass manned;
- Positioning commissioning force props;
- Locking the head and foot;
- Placement of boards bracing
- Control of the Mass in force

Steel props
- Excavation of the seat bottom
- Laying of the formwork and reinforcement of the plinth
- Casting of the plinth, which must take place separately from the rest of the structure as to contain the withdrawal
- Waiting hardening and disarmament of the plinth
- Preparation of the seats in the wall for the collection of the head of the props
- Peeling of the masonry in correspondence props retaining
- Pose props contrast between mass and mass protection
- Putting into force of propping-retention

09.



09_ *Props individual support and retention: they differ from those of only support for the head embedded in the masonry. (Redesign)*

Chains and Retreading

Chains and rods are among the oldest work on existing walls, to improve connections between different structural elements (such as orthogonal walls, floors and walls), make a masonry building behavior as close as possible to that box and contain the instability of arches and vaults.
These interventions can be used as temporary structures for the safety, but also as definitive, and as such it will be deepened in subsequent chapters.
In a logic of work provisional immediate intervention simplest is the application of tie rods outer perimeter in the form of hoops overall structure under consideration. This choice is more suitable if applied to manufactured in small size, while it can only represent a first step of securing, to complete with successive entries of tie rods inside, in buildings more extended.

The material used is steel, thanks to its high characteristics of resistance to traction, both for the realization of the tie rod true that the anchoring system; recently introduced are the polymeric materials.

Hoop strips that belts local structural elements is recommended to intervene on structural elements such as columns or beams subjected to excessive stresses in compression, shear and bending.
The interventions of local cerclage are equally effective on masonry elements and elements of reinforced concrete.

3 | Finishing and plaster preservation procedures

01.

01_02_03_*Plaster deterioration which disfigures the building's facades in the center of Jeddah.*

Walls surface preservation procedures consists in keeping an artifact in the state in which it is, avoiding any alteration. The integration consists in adding to a plastered surface finishing a missing portion; a substitution consists in removing an element and replacing it with a new element. The preservation, integration and substitution of an element or architectonical part corresponds to distinct operations that determine the restoration of the artifact; the difference between these operations isn't related to the difficulty of the intervention but to the relation between the artifact status before and after the restoration, all the procedures that shall modify the esthetics of the artifact from before and after the restoration.

The materials used for the structure and the finishes are common and easy to confuse when the building is particularly deteriorated. A material can be used as a structural element or as a finishing when it is used in manner or the other it could have distinguished characteristics in each case. An architectonical organism in any time and in any location is usually constituted by a core part that is structural and by a coating part that is usually protects and decors the structure. The architectonical surfaces constitutes the interface between the architectonic organism and the environment, functionally it protects from the deterioration agents, and at the same time it completes the building chromatically and in a decorative sense.

The surfaces are made of natural materials such as marble and stone or artificial as clay based elements, tiling ceramics and mosaics. The plastered surfaces color is chosen in reference of functional and decorative criteria: from the imitation of precious materials to hygienic - functional, till the criteria properly decorative, of the representation purely pictured, illusionistic or symbolic. In this perspective the mural paintings are nothing else than a particular finishing of the plastering surfaces. The coloring can be realized by two techniques: 'a fresco' (fresh support - the pigment is fixed by the carbonatation of the plaster that is a calcium based mixture) or 'a secco' (dry support - the color is applied on dried plaster surface).

The operations comprehend indirect actions which function is to improve the thermo hygrometric conditions of the environment and eliminate or dilate eventual external causes of deterioration and actions directly on the material of the architectonical surfaces with the finality to arrest the deterioration in progress, reestablish the mechanical resistance, fill the missing parts and prevent future damages. With this scope it is necessary that the restorer has preventively acquired a punctual conscience of the opera as base for a formulation of a rigid intervention planning which shall be followed during the maintenance. The choice of the adequate material for the conservative operations and a correct application method shall be induced at an exam of the surfaces and significative samples of plaster and colorings.

The specific case of the historic center of Jeddah city, the surface problems are relative to the plaster deterioration, of the 'stucchi' and the wooden elements that are united to the deterioration of the masonry structure built

of local stoneware (Mangabi stone and coralline stone) which is poorly mechanically resistant, but especially about the coralline stone which presents characteristics of lightness, workability and has major resistance to the brackish water since the closeness to the red sea.
From an accurate analysis, direct and photographic, it has been noticed that the surfaces of the buildings are plastered leaving portions of wood elements visible, both for the longitudinal and the transversal elements, disposed with regular intervals as to distribute the loads and give more resistance to the masonry structure
In the premise of this manual it has been described the historic evolution

02.

03.

of the surfaces treatments which since the XX century has been completely protected by the plaster coating covering all the structural parts (masonry and wooden elements) to protect especially from the bracken air. Once resolved the causes of the deterioration and consolidated the structures, it shall be required to plaster the surfaces preparing the wooden parts that has to be covered with a specific net for plastering.
The preventive analysis are fundamental to skill the composition of the calcium based plaster and generally of all the materials of construction to be able to decide in a proper manner how to intervene in the various cases that shall occur.

To ensure optimal results obtainable it shall be necessary to amplify the investigations to a significative number of buildings to have an ample casuistry of situations as exhaustive as possible, insulating the cases which are still present and visible the traditional local constructive techniques. These techniques are object of Unesco preservation and bequeath planning.

A_INSTABILITY CAUSES | PATHOLOGY ANALYSIS

The deterioration of the surfaces is a process of negative modifications of constructive materials that determines a failure of their chemical - physic as structural characteristics. This deterioration is caused by two types of factors:

- **Intrinsic causes** - if the design is missing reference to the environment and to a adequate preparation to planning and execution it may contribute to a significant deterioration phenomena intrinsic to the building (the missing of crucial building parts, as waterproofing on the foundations) 'in this manner the individuation of locations adapt for building, the choice of material criteria, the correct design and technological principles, can be read reverse, as the report of the most important reasons of the deterioration'. (D. Fiorani) Since the conceptual phase of a building design it is possible through secure planning choices and with a good execution, guarantee a long life to the building. The intrinsic reasons of deterioration can be a consequence of: the site - design deficiency - the construction phase - materials and construction techniques applied;
- **Extrinsic causes**, related to the surrounding environment and by the contest (usually permanent) represent all the factors that effectively intervenes externally, that explicit an alteration phenomena principally referred to a buildings constitutional vulnerability. Environmental conditions - humidity, solar radiations, wind, rain, pollution, micro and macro organisms presence (bacterial and fungal); Anthropic conditions - dereliction, neglect maintenance, impairment, incorrect intervention, missing maintenance.

The distinction between the extrinsic causes is:

04.

Natural causes

With long extension in time**:**

- **Humidity:** the major part of alteration phenomena and of deterioration is related to water presence, prevalently as humidity in the materials. The presence of humidity inside a construction can be related to the sequent causes:
  - *Rising damp* (ref to chapter 3);
  - *Infiltrations* (ref to chapter 3);
  - *Hygroscopic*
  - *Atmospheric humidity condensation*;

  To these it is possible to add occasional phenomena (as floods) or the presence and the growth of vegetal organisms.

04_05_06_*Deterioration caused by the rise of humidity damages the lower course of the facade affecting the plaster coating as the masonry itself.*

- **Meteorological and climatic factors:** the atmospheric conditions usually affects the health state of the building: wind, rain and solar are the principal factors that facilitates and determines the deterioration of a building, or in some cases contributes to aggravate deterioration process already in place.
  Essential factor:
  - *Meteoric water*: mechanical action, water surface runoff, polluted agent fixating that is contained in the atmosphere;
  - *Fog:* damaging presence for the polluted atmosphere;
  - *Wind:* engraves on the surface mechanical stress, on the entire structure as on specific areas;
  - *Solar irradiant;* chromatic alterations of the surfaces, thermal dilatation of the materials, erosion;

In hot-humid climatic the building usually are more subjective to deterioration caused by the winds and the solar action.

- **Natural pollution:** it is defined natural pollution elements (gaseous or as particle) that isn't comprehensive (or with higher percentages of the standard) in the 'natural mixture' composed by carbon dioxide, carbon monoxide, ozone and ammonia. Among the particle pollutants falls:
  - *Living substances* suspended in the air which dimensions varies between 6·10□4 to 103m μ (pollen, some types of insects and microorganisms, which trigger processes of biological attack resulting in degenerative phenomena);
  - *Nonliving substances* consisting of fibers and compounds of organic metabolisms, which in the process of deterioration of the construction consists in the visible 'black crust' surface.

Other pollutants not present in pure air are: sulfur dioxide (SO2) and trioxide (SO3), chlorides based, (marine environments), hydrocarbons (combustion result), nitrate (derived from organic decomposition or atmospheric chemical reactions).

- **Biological aggression**: macro vegetal organisms as plants has as harmful effect the mechanical action of the roots, added to chemical activity in relation to the exchange of hydrogen ions between the roots and the mineral constituent the soil. Insects aggression and macro organisms from the marine environment as fungi works for example particularly aggressively on wooden elements '[…] it should be mentioned bird guano, which alterative action is caused by the same chemical composition-5-15% of ammonia and nitrate nitrogen containing - […] other soluble salt is potassium phosphate, contained in a percentage of 5-14%'. (D. Fiorani)
- **Geological factors** which has a progressive trend: bradyseism and subsidence (ground movement) are the main geological alterations with a progressive character. These phenomena reflects on the buildings with consequences difficult to control and prevent. The most obvious effects, produced by the displacement of the ground masses, consist in static instability of the building, consequentially to the subsidence of foundations. In this case, the intervention on the individual building is not sufficient and must be considered, to restore, if possible the conditions geological and environmental.

Short time actions:

- **Meteorological factors:** the stress produced by meteorological actions (typhoons, tornadoes, hurricanes) acts along directions and axes that do not coincide with those in respect of which the building itself was designed and built. Actually, the horizontal components of this type of structural stress produce tensions which the building could not be able to resist and therefore determine a partial or total collapse of the structure. Among the meteorological factors to sudden action must also consider the action of electrostatic lightning, the damaging effect derives from the presence of moisture in the materials of the building and could transform into steam. The phenomenon causes the formation of lesions in the masonry and could frequently be followed by fire triggered from the wooden elements.
- **Geological and hydro-geological instant action factors:** sudden manifestations of geological as hydrological phenomena has simultaneous causes, natural and artificial. The natural manifestations are earthquakes and volcanic explosions, while landslides and floods, are attributable to human responsibility. Earthquakes create stress intensity normally higher than the resistance of aged buildings. In addition to direct damage due to the earthquake, a risk associated

with this phenomenon is related to the posthumous demolition, done by man, of the remains of the earthquake damaged buildings. In this case it is of primary importance the action of control and prevention, which is a valuable tool to combat deterioration that can determine a total demolition of an architectural artefact.

- **Fire**: often consequence of human action, is a natural phenomenon, it is the leading cause of death of the aged housing heritage. A further source of damage is the extinguishing systems effects; water sprinkles, cooling suddenly the materials, causes a strong thermal shock leading to fissures and structural weakening.

Anthropic causes

1) **Direct actions:** neglect and abandonment are two of the main causes of deterioration of aged buildings, this acting is to be considered as an 'negative' human intervention. The abandon process leads to a underestimated deterioration status; deterioration phenomena increases exponentially with damages on the roof that propagates from the top to the lower floors, through plants and animal infestations, by physic and chemic of natural alteration mechanisms.

2) **Indirect actions:**
   - *Interventions on the environment:* very often a direct source of deterioration of the construction is consequence of natural alteration, contributory cause of the indiscriminate land exploitation by man. As already mentioned, such phenomenon as subsidence, landslides and floods are natural changes directly attributable to human activities.
   - *Pollution*: The carbon dioxide in contact with the water is transformed into carbonic acid, consequentially leading to alteration of stone or metal materials, by the mechanisms of oxidation and carbonation. Uncombusted hydrocarbons are the major constituents of black crusts of calcareous based materials. An important role in the deterioration derived from pollution is done by dioxide, trioxide sulfur and anhydride that can be absorbed by the materials (marble and limestone), or combined with water or oxygen in the atmosphere forming sulphurous and sulfuric acid. Even these are responsible for sulfation and oxidation alteration processes. The chlorides present in the marine environment as produced from industrial scoriae, participate to the corrosive action. The oxides of nitrogen, in presence of water, transforms into nitric acid (particularly strong acid) that can trigger a corrosive action on calcareous materials and silicates. The powders tend to settle down on niche zones, leading 'dry depositions' that alters the surfaces color and may be chemically activated in presence of water.


07.


08.


09.

- *Artificial seismic stresses:* vehicular traffic, in addition to being a source of deterioration from pollution, has harmful effects as the transfer of unexpected vibrations. The presence of discontinuities or irregularity in the carriageway can produce vibrations that propagates from the streets ground to the building, determining, if particularly coherent, the compaction of the ground. The extent of the phenomenon is influenced by the geological composition of the soil.

The manifestation of visible deterioration signs on the surfaces is the first key to consider in a correct analysis, in some cases it is necessary to ensures a better understanding of the present pathology, in other it represents the effects that involves the building structure.

Deterioration processes can be of three types:

1) **Physical deterioration** determined from solar, wind action and low temperatures, causes salt crystallization on the surfaces of materials with consequential formation of freeze/defrosting cycles: alveolar action, disintegration, detachment, efflorescence, erosion, exfoliation, fracturing, gap, absence, swelling, flaking;
2) **Chemical deterioration** is caused by dust deposition, gases and suspended substances in the atmosphere that react with the surface layers of materials.
   - *chromatic alteration*: alteration which is manifest through a variation of one or more parameters that define the color: hue, clarity or saturation. It is a phenomenon that does not imply a deterioration of strength of the material but only a changes the parameters that affects the visual perception;
   - *black crust:* formed by chemical reaction of sulfur with the carbonate component of the surfaces and transforms it into gypsum;
   - *surface deposit*: accumulation of various nature (dust, soil, etc.) materials, has variable thickness, poor consistence and adherence on the underlying material;
   - *fouling:* layered deposit, compact and generally adherent to the substrate composed of inorganic substances or constructions of biological nature;
   - *film:* surface layer of self coherent substances and extraneous to the under layer material, has reduced thickness layers consequentially can be detached from the substrate that should remain intact;
   - *punctiform deterioration* that occurs by the formation of numerous 'blind' holes disposed densely. The holes have basically cylindrical shape with a maximum diameter of a few millimeters, related to the weather agents, climate and defects of the material;

07_08_09_*Physical deterioration manifested.*
10_11_ *Decorated doorways.*

3) **Biological deterioration** is caused by bacteria, parasites and microorganisms that colonize the surfaces of materials: presence of vegetation, biological patina, biological colonization;
The diagnosis is a process of knowledge related to the conservation status of the artefact; There are two levels of diagnosis of the materials, the first is a direct analysis (macroscopic analysis), the second, by an observation with precision instruments (microscopic analysis) directly on the material or by sampling analysis in laboratory.

10.

11.

B_METHODOLOGICAL PREMISE

Stone surfaces

Stone, used since ancient times as a building material and wall cladding for buildings (in blocks, slabs or as sculpt support material) had the function of transmitting aesthetic, political or spiritual values and over the centuries had become a passive heritage of natural and historical events that occurred in the surrounding contest.

The original design characteristics, the working tools traces on the stonework, the material residues used for the original and subsequent maintenance, modifications of use and reuse, associated with the deterioration of material consequence of the exposure to the natural events, constitutes all together the monument's historical consistence.

These stratifications that hasn't had the necessary attention and analysis, has been not historically isolated and in some cases confused as products of alteration and consequentially removed.
During the twentieth century it has been used for the science of restoration the most diverse tools, starting with the chemic based applications (acids and strong base) the usage of mechanical equipment (sanders, pressure washers, whisks, etc.), and lately after the acquired experiences in biology, with l 'use of enzymes, and finally the electronic procedures as laser applications.

The same operations can be extended to so-called 'protection treatments and consolidation' performed after cleaning: often it is in use operations based on the application of commercial products, chemically and physically unrelated to the original material on which they are applied. Designed for applications on new materials, these penetrate the stone, changing not only the appearance, but also the mechanical characteristics and the response to thermal stresses and humidity, with the result of aggravating the processes of delamination and disintegration.

A more careful observation and philological analysis have led to a different respect for the materials and has adequate the tools of intervention increasing to a rigorous preservation of the layers present on the surfaces of the monuments; a preservation treatment begins with the analysis and documentation of surfaces and pursues the ultimate objective of protecting and preparing the building to an adequate fruition.

Plaster

Plaster is a mixed compound, alone or mixed with the binder, consists in a mortar type of product (a mixture which consistency is plastic) that has the ability to grip on a support, solidify and then harden. The binder materials can be three: the clayey soils, gypsum, calcium; while the fillers (inorganic or organic) have the function of providing supporting reinforcement to the mixture and a rigid skeleton, balancing the parts between the mortar and the aggregates, adding or reducing the amount, increases or decreases the shrinking of the final paste.

The mechanisms of mortar hardening vary in function of the binder used; it may be effected for water loss (clay), for water intake which crystallizes together with the material (gypsum), by chemical reaction (calcium). The laying of plaster, mainly for the calcium based, subjected to shrinkage and thus to the formation of surface cracks, as well as the dual requirement to establish an excellent adhesion to substrate and an appreciable surface smoothness imply the application of several mortar layers: the first (sbruffatura) constitutes a basic rustic thick and coarse grain size; the second (curl) regulates the surface; the third (finishing), of a finer granulometric, realizes a homogeneous surface, compact and smooth ready to receive the color or by itself, constitutes the 'skin' of an architectural organism.
Operations of plastering includes indirect actions to improve the temperature and humidity conditions of the environment and remove any external causes of deterioration and direct actions on the architectural surfaces support in order to stop the deterioration process, restore the mechanical resistance, compensate deficiencies and prevent future damage.
For this purpose it is necessary that the restorer has previously acquired a detailed knowledge of the work to formulate a rigorous plan of action, and consequentially ensure the pursuing of an maintenance intention. The choice of materials for the preservation and the correct method of application will derive from the examination of the surfaces of a significant number of plasters and colorings samples. For this reason it is necessary to make use of laboratory analysis to know with certainty the original plaster composition and its color: stratigraphic sections indicating precisely the nature of the charge used for the mortar and the succession of color layers. To be valid, the sampling must be performed in a sheltered and not wet (under the overhang of a roof), which still conserves the layer of the last and most recent color applied and on this, a thick strata of atmospheric deposit. From the stratigraphic section it is however not possible to distinguish the chromatic value of the color, which can instead be identified on site, creating a 'ladder' that turns out from the top, with delicate operation scalpel, layer by layer, the various colors applied in time.

10_*Example of the U.V. fluorescence analysis that higlights not visible elements and defines a mapping of the different patinas' distribution, leading to futher more focused surveys and to reduction of execution times.*

Stucchi

The buildings of Jeddah are coated with plaster that were colored and decorated in polished bands and often engraved with geometric motives of graffiti technique.
Historically the 'stucco' used since ancient times originates from a special calcium based mortar and powdered travertine or marble. In the sixteenth century the term indicated the grout mixture was used in decorative reliefs, and as plastering of the walls; the frequent use of this mixture in surface coatings made it almost synonymous of plaster. Subsequently and it referred to designate only work in relief executed with hard thin mortars; the same word designates reliefs made with gypsum pastes.
Regarding the installation there are 4 main steps:


11a.


11b.

- Preparation of design (layout with the technique of synopsis or with a fine point);
- Drafting made with a core of bricks arranged so as to anticipate the final design (for projections contained were used nails and wires of iron and copper, and also toggles wood);
- Defined the armor it is laid the first mixture (rough and coarse, full of inert type pozzolan, sand, stone chips), which then follows an intermediate layer with thinner inert left visible as background of the final molded;
- The final figures were made with molds (typically matrices wooden carved in negative).


11c.

In Jeddah the use of stucco is common but its complexity and execution time make it expensive: it is usually reserved for decoration (surface engraving) in the string courses and/or large frames around doorways, for special technical purposes as waterproofing and coating of water tanks or when improving solidity and resistance of floors or claddings.
The plastering is used in many buildings of Al Balad, developed probably along with other traditional techniques of stone masonry, also this traditional technique was interrupted in the twentieth century when the mortar and these procedures has been abandoned.


11d.

The surface is very smooth to the touch, the aggregates are invisible because they are coated with the binder material. The surfaces are mostly white colored by calcium; the layer is thin (about 1 mm) and the associated finishing is a incision made with the metal to create geometric patterns.
We have no specific information on what tools have been used originally, for the application of stucco in Jeddah: probably spatulas or semi-precious stones, as was practiced in other regions equivalent techniques.
The climatic conditions for its realization is the mild climate with mild

11a_11b_11c_11d_12_13_14_15_
Examples of stucco decorations in the center of Jeddah.

temperatures between 5 and 30 ° (ideally between 10-20 ° C) for the whole period of application and hardening of the layers. During the hardening phase it must be protected from excessive dehydration, by wind and sunlight actions.

Graffito technique is based on the discovery of partial layers of plaster underlying to the outer, in order to obtain decorative effects. The penultimate layer is in fact mixed with dark pigments (obtained with charcoal, burnt straw) and red (obtained by pounding the bricks); extends the last layer of which is transferred, as for the fresco, the desired design and then is removed (with appropriate tools), the last layer following the contours of the plaster.
The graffiti is a decorative finish (design, engraved ornament finish made with lime) which is located on the main facades of the buildings noblest of Al Balad; is found mainly on the external walls and sometimes in the inner rooms; models are always geometrical, usually rectangular or square panels (Beit Nassif).


12.


13.


14


15.

C_DESCRIPTION OF THE INTERVENTIONS

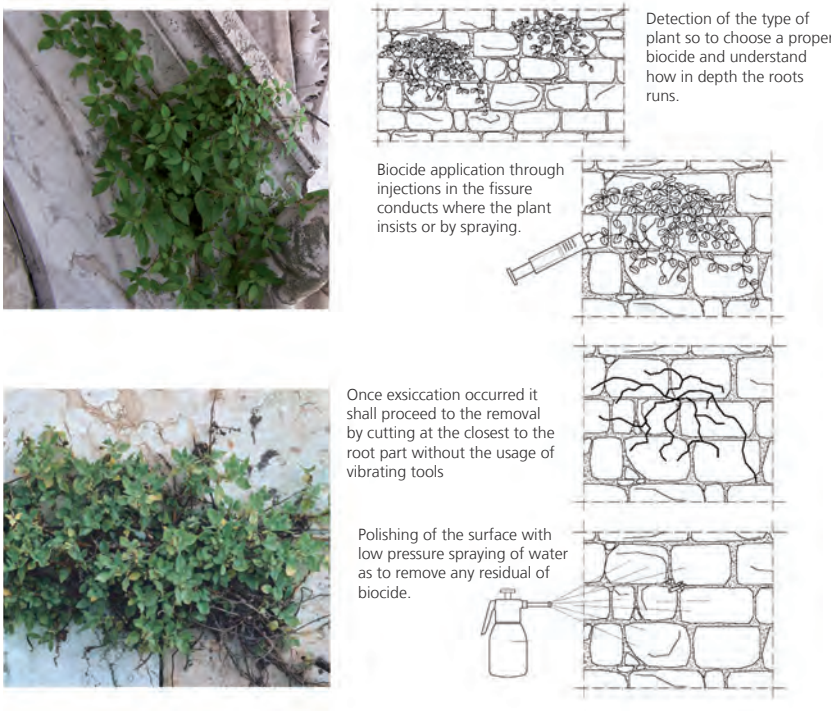
C.1_Preliminary operations on the working site

Weeding of the masonry

The seeds carried by wind and birds roots on the walls, they become a suitable environment for the survival of natural vegetation, thanks to the nutrients present inside: mortar is a calcium and mineral mixture, on the surface there are decaying organic matter and on the interior the wall is water retained by the porous structure of brick and mortar. There are many species of plants that grows on buildings and can be divided into two groups according to the ability of the roots to damage or destroy the building structures: a preliminary study of the present species is useful to limit the intervention and to reduce harmful spontaneous flora.

A herbicide product (which should be applied in spring and autumn) causes death of the plants and the reduction of the volume of roots so that they can extract from the masonry without causing damage: obviously the timing of effect varies depending on the size of the plant, the quantity of the product and the rainfall. After the operation will proceed to the closing of the cavity left by the removed roots (where you put salt that dry roots but contemporary introduces in the wall water soluble sodium salts that is

16.



16_17_ *Herbicide operation on the masonry.*

capable to damage the stone structure), closing holes and lesions that are possible venue for the planting of new weeds.

Disinfection of masonry
Algae, mosses and lichens form on the surface patinas and encrustations which color is yellow, golden brown, brown, green, black. In some cases the biological colonies constitutes protection to the masonry: removing the colonies poorly adhered to the substrate and disinfecting the surface with chemical compounds of biocide action, specific for the different species; After these operations scattered fragments formations are cleared with chemical solutions and water solutions. Finally, the surface should be washed with water and brushes, the washing is useful for the restoration phases.

C.2_Natural stone restoration procedures
Preservative treatment begins, as mentioned above, with the analysis and documentation of the surfaces status and pursues by protecting and preparing the architectural construction to ensure modern functions.
The cleanup is limited to the restoration of proper readability with a selective removal of only the dirt deposits (eg through the use of water atomized that removes deposits without damaging the underlying material, such as whitewashing and polychrome).

The unsafe parts are pre-consolidated and, if necessary, fixed with the use of calcium based mortar; grouting the major discontinuities (gaps - deficiencies) and minor (cracks - disruptions surface) has a decisive role in the recovery of its formal values.

Currently it excludes the use of synthetic products favoring instead the hydraulic mortars for gaps more extensive and deep mortars and lime combined with marble powder of different particle size for surface finishes. Rather than resort to one-off massive interventions, the conservation strategy more prudent interventions prefers light and repeatable. A secondary role also restoring systems originating disposal of rain water or the prevention of accumulation of dust that favor the growth of weeds, and the application of whitewashing calcium based protective purposes on the exposed surfaces.

Pre-consolidation
The pre-consolidation is necessary in the case of very degraded material and in case of intervention potentially subject to loss of parts; the goal is the restoration of the properties and the compactness estimate of those portions of material which have lost all or part of their internal cohesion and at the same time to not to intervene on the overlapped materials.

Types of intervention:

- Consolidating by chemical applications (ethyl silicate, calcium hydroxide, etc.) By brush, spray, with compresses absorbent or by injection;
- Bridges mortar: grouting, spread with spatula or with trowels made in the presence of chips, fractures or fragments of hewn stone. The mortars used must be lean (reduced binder content) to be easily removed in the subsequent stages;
- Tissue applying with cotton gauze or Japanese paper, made with acrylic resin to adhere artifacts with accentuated flaking disruptions, sprays, films or paintings or flaking.

Cleaning

During the time pass stone surface is covered with dirt and different materials that reacts with the environment determining alteration processes; it is therefore necessary to periodically remove the layers of deposit. The method of action is chosen based on the nature and state of the stone, the substances to be removed and the distribution of the deposit surface. You can only perform cleanup on solid supports or on which you have already performed the pre-consolidation or re-adhesion of the material unsafe.


18.

Cleaning proposes not only to eliminate the harmful deposits for the conservation of artifacts, but also to try to understand the function of layer coatings and films pellicles, what would have resulted in their removal and what are the most appropriate technologies, according to the theory of Cesare Brandi (art historian, founder of the Central Institute for Restoration of the Italian Ministry of Culture, a key figure in the restoration and reference point for the theory and practice in working) did not want to bring the work to its original appearance when not respected the current state and the changes that occurred over time, removing only harmful to the conservation of the work.

Mechanical cleaning*:* is the use of mechanical force to break the contact between the material to be removed and the substrate, may be suitable for removing deposits, crusting, scaling, etc., But not to extract harmful materials (soluble salts, inks and paints, etc.) penetrated into the porous network, below the surface.
They can give good results even in the case of materials in poor condition that it is necessary to consolidate before subjecting them to the cleaning. Mechanical methods acting sufficiently controlled are those that make use of small instruments such as scalpels, abrasive papers, micro-scalpels, micro-drills, vibrant engravers, micro sanders (method frequently used for cleaning architectural surfaces, can be applied dry or wet mixing a jet of water to that of the abrasive, but normally runs dry: the pressure applied must not be greater than 1atm).

Cleaning with water*:* cleaning with water is useful if the substances to be removed are entirely or partly soluble in water, can be used with low risk of damage on solid supports (P%> 10%). In most porous materials and wall structures with thick joints between the segments and/or poorly preserved, the water absorbed during cleaning could mobilize soluble salts inside and trigger growth phenomena of biodeteriogens. The system with atomized water is considered basic; a water atomization is produced by nozzle diameter 0.4-0.8 uM with the pressure between 300 and 2000 kPa. The cleaning by atomized water is very similar to the technique of spraying with the difference that, in this case, the spray of water droplets is constituted by even smaller.

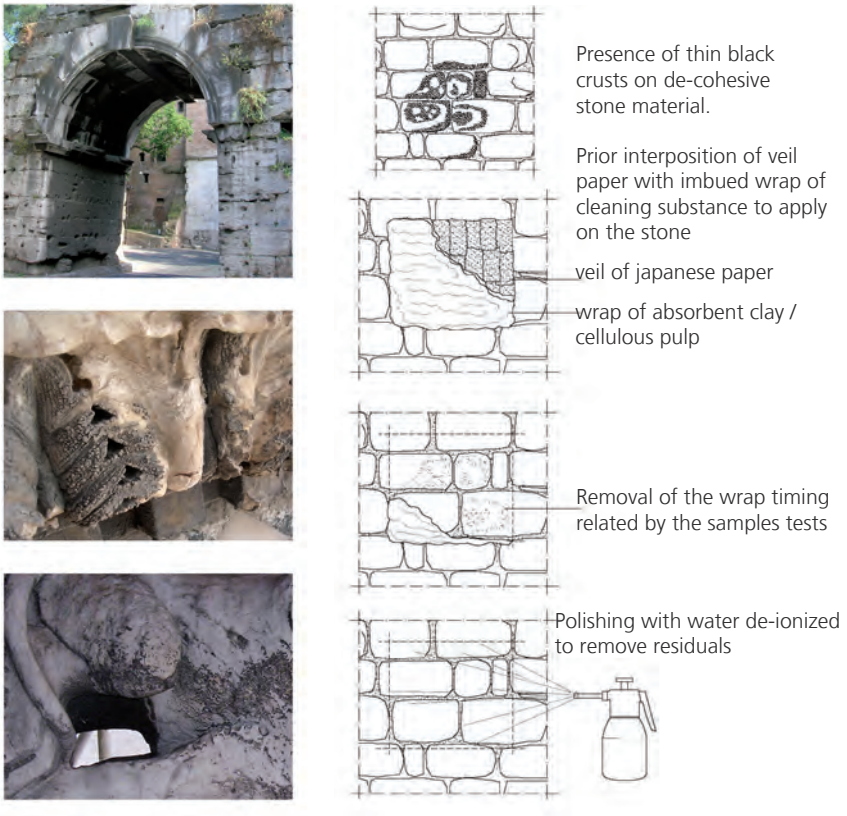
Cleaning with absorbent wraps: cleaning with absorbent wraps in particular if the substances to be removed are soluble salts can be useful to extract by applying wraps. The wrap is made from an absorbent material (clay of the type sepiolite/attapulgite, paper pulp, wood pulp, micronized silica, etc.) Is mixed with de-ionized water and applied on the surface to be cleaned for the time required to dry.
The absorbent clays (such as sepiolite and attapulgite), are hydrated silicates of magnesium, while the cellulose pulp is an organic fiber obtained from natural cellulose (available in fibers of length ranging from 40 to 1000 m); mixed together with water, this type of substances, are able to form a sort of paste capable of exercising, once in contact with the stone surfaces and suitably sprayed with water (or with chemical substances), an action of physical absorption of liquids. The cleaning with wraps absorbent be advantageous not only for the removal of soluble salts for the removal, from the stone surfaces, of homogeneous layers of water soluble or poorly soluble compounds (such as black crusts little thick, around 1 mm), stains originating from substances of organic nature, biological layers (bacteria, lichen and algal) will also be capable of reducing the spots of oxides of copper or iron.
The advantage of using this technique is in the possibility to avoid applying directly on the surface cleaning substances (especially those of chemical nature) that, in some cases, may be too aggressive for the substrate.
The type of the wrap will depend on the state of persistence and the solvency of the dirt to be removed, it must be stated that wrap technique is not particularly suitable for the removal of thick crusts and, in the case of porous materials and/or little cohesive will be appropriate, in order not to make the operation of traumatic removal, interpose on the surface Japanese paper or klinex. It may be convenient, before applying the removal of wax based layers ace using solvents such as acetone, methylene chloride, etc. and, where it will be possible, to perform a water wash (or atomized spray) so as to remove deposits less coherent and soften the layers more consistent. In presence of efflorescence it shall be required to previously

18_*Paper veil procedure by cotton gauze or japanese paper.*
19_*Example of wrapping.*

provide to their mechanical removal by washing with de-ionized water and soft brush strokes before proceeding with the operation.The preparation of the wrap will be manually soaking with de-ionized or distilled water up to the absorbent material that it does not assume a to pasty consistence such as to allow its application, with the aid of spatulas, brushes, or, more simply on the same hands (2-3 cm for clay, 1 cm for the paper pulp).
Both the attapulgite and sepiolite shall be able to absorb a large quantity of liquid in relation to their weight (one kg of attapulgite is able to absorb 1.5 kg of water without swell); the attapulgite can absorb, over the water, even oils.
The absorbent clays, with respect to the cellulose pulp, present the inconvenience of removing the water too quickly from the treated surfaces. In the presence of very porous stones may be indicated to use the cellulose pulp (easier to remove compared to clays).

- *Cleaning with wraps based absorbent chemicals*: in the presence of pathogens particularly persistent (crusts poorly soluble) packs can be added with limited doses of chemicals, after execution at the hands of experienced staff of limited tiling useful to define the timing of application and evaluate its effects. The chemic procedures (solvent-based or solvent action of suspension) with an additive which may wrap must have a limited toxicity, low flammability, adequate rate of evaporation and a pure composition.
  The substances to more or less strongly alkaline reaction (such as ammonia, sodium bicarbonate and ammonium) will be used especially to remove greasy substances of crusts in organic binder and, in concentrated solution, will be able to attack the thick dark encrustation that is poorly water-soluble.
  The detergents will be able to decrease the surface tension of water, thereby increasing the cleaning action; the use of detergents allow to dissolve the organic substances (oils and fats), to keep in suspension the particles of inorganic deposits not soluble or dispersed, to make a bactericidal action having the advantage of being able to be removed together with the dirt without leaving any residue. The contact time may vary according to the specific cases in case it will be appropriate to extend it over time will be required to cover the affected area with polyethylene sheets so as to prevent the evaporation of water present in the compound. After removing the compound, it will be necessary to clean with de-ionized water facilitated, if necessary, with a light brushing. For removing rust from stone surfaces reagent used will be different depending on whether you retract to operate the cleaning of limestone or siliceous rocks; stains of iron, on the latter, it can be removed by phosphoric acid and phosphates, fluorides or citrates while, on limestone rocks, you may use a saturated solution of ammonium phosphate, taking care to minimize the contact time.

20.



- *Cleaning with wraps based absorbent carbonat*e and ammonium bicarbonate: are water-soluble salts, in percentages from 5% to 100%; shall be used either alone or in compounds. The carbonate and ammonium bicarbonate decompose spontaneously rise to volatile products, the liberation of ammonia confer detergent properties to the treatment, while the alkalinity (higher for the carbonate for the sodium bicarbonate) will allow a gradual gelification of strata material and old coatings of protein and lipids, allowing removal from the surface.
  The use of ammonium bicarbonate (or sodium) will be recommended in the case of interventions on materials particularly degraded, especially for marbles (with intergranular corrosion and de-cohesion of the grains of calcite surface) and significantly porous limestone where it may be

21.

20_*Black crusts cleaning operations.*
21_*Example of wrappings to clean stone surfaces.*

present difficulties in removing residues of the wrap. In presence of visible efflorescence it shall be useful in the advanced the mechanical removal, in order to avoid their solubilization and subsequent penetration following the application of the wrap procedure.
The application of chemical wraps must be made from the bottom to the top so as to avoid dangerous and uncontrollable phenomena of run-off and at the end of each application will proceed to the removal of all traces of chemical resorting to an accurate manual rinse with water de-ionized.
The benefits of wraps, regardless of the type, do not reside in their harmfulness, in low cost (clays are reusable after washing in water) and ease of installation, but if you use a mixture of pulp paper more absorbent clays (1:1) you can take advantage of the best features of both; for against the disadvantages are the slowness of the operation and their relative non-controllability.

Consolidation

The consolidation should return the compactness and the mechanical resistance of the surfaces subject of de-cohesion phenomena, disintegration of the material, decreased adhesion, lifting and plaster parts detachment, through the impregnation in depth of the material, with the usage of a product that ensures internal cohesion, adhesion with the substrate or with non-altered parts.
To restore cohesion and improve the mechanical resistance qualities it is better to apply it in a consolidating solution. The consolidating material must meet the requirements of good aging, over time reversibility and absence of any harmful side effects.
The consolidating may be applied by brush, spray, percolation, through solutions capable of penetrating in depth, by the use of appropriate solvents at a concentration proportional to the porosity of the material and the its extent of deterioration.
To return the adherence, using an emulsion consolidator that must form on the surface a film with an adhesive effect that would allow both sides to re-adhere. The consolidator is injected between two layers detached, with the possible addition of a filler where the cavity is too wide.
Consolidation can be done with organic and inorganic products, both systems have advantages and disadvantages.

- **Organic:** (acrylic resins, silicones, epoxy resins) have poor aging resistance, deteriorate action of oxygen, ultraviolet radiation of light and have poor durability. Change the characteristics within the stone (making it less permeable to water and preventing the breath), but it improves the mechanical properties and have good adhesion and elasticity;

- **Inorganic:** (ethyl silicate, barium carbonate and calcium, water and milk of calcium) are stiff, brittle and not very elastic, have low tensile resistance but reconstructs a cement similar to the original (both siliceous that carbonate) can adhere to the minerals of the stone without creating harmful by-products. They are more durable but not having good ability to resist environmental deterioration must be protected with treatment of the surface of the stone.

Adhesion

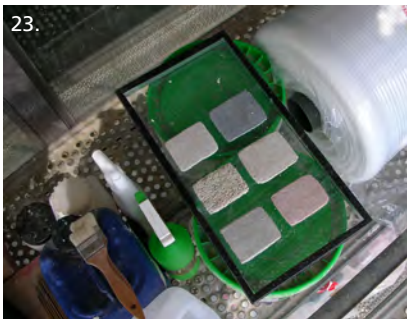
While the intervention of consolidation concerns crystalline aggregates de cohesive surfaces and 'crushed' (the problem is to connect the crystals and make compact surfaces), the intervention of enrollment for the scales and the deformation of the surface layer is affected by temperature changes where there are pockets (the problem is to connect the masses in themselves and if they were in solidarity de cohesive must consolidate the surface before the accession of the fragment).

In both interventions the material has the same function paste but varies the size of the masses are required to be bonded so appropriate products: then a glue used to adhere a flake is too strong to consolidate aggregates de cohesive, on the contrary a consolidator is too weak for adhering a flake.

Grouting ('stuccatura')

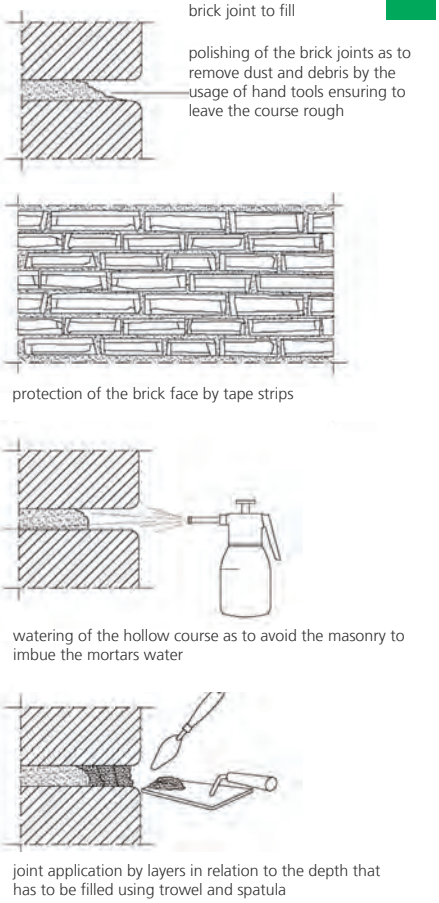
Concluded the consolidation work and re-adhesion of small and large portions of the stone, the surface of the wall is again solid but presents cracks and micro-fissures, the work of plastering compact the surface to provide resistance to deterioration. The work of grouting must be extended to all the discontinuities, even very small to avoid providing preferential pathways of input water, which would favor the disintegration of the material.

Very important to ensure at least a close-up view of the recognizability grouting. For gaps in depth is preferable to use the hydraulic lime because it makes grip even in the absence of oxygen, while the surface is more suitable for filling the slaked lime. For grouting materials are not exposed outdoors you can also use synthetic binders (acrylic resin emulsion combined with fillers chosen are the most suitable to obtain mixtures modeled and durable. For grouting soft stones (tuffs, sandstones) is recommended to grind hand, and not mechanically, the stone to get a sand not too thin, smooth and matte. Avoid the cement based grouting (as they can yield alkali ions and sulfate that may lead to the formation of soluble salts harmful to the material). In addition, the mixtures based on cement are less porous than many stone materials, so that, if it occurs a movement of water within the structure, the evaporation and the subsequent crystallization of the salts could be borne by the parties more porous and not of fillings. Finally, differences in thermal expansion between stone and concrete may cause cracks or mechanical damage.

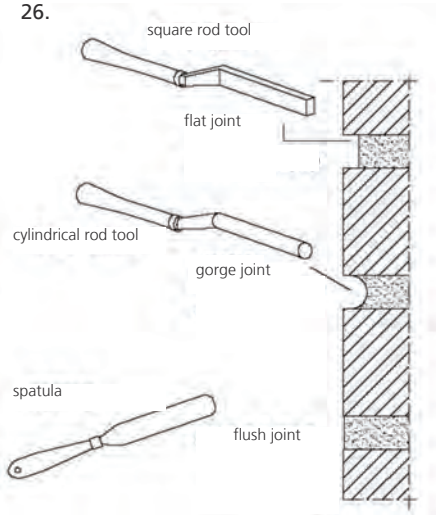


22_23_24_ *Grouting operation between the stone elements.*

25.



26.



Filling and grouting of mortar joints

The intervention shall consist in an integration of portions of mortar missing and shall be executed through lime mixtures with the mechanical resistant requirements and physical characteristics similar to those of the original material (texture, grain, color etc.) or discordant but in accordance to the execution designs. The scope of the filling process shall be to preserve the wall pattern from any possible phenomena of deterioration and restore continuity to the surfaces as to avoid infiltration or attacking of biotic agents, increasing consequentially the static properties. The operation of Grouting, on salt-saturated masonry artefacts, should be preceded by the removal of salt presence, as well as the salt efflorescence, mold, dust or not integral parts that might prevent the solidification of the mortar between the elements.

Once the verification has been executed and any preliminary operations (removal of parts not consistent and washing of the surface) the procedure shall consist in an abundant damping with clean water (especially if the substrate is particularly porous) of the joint to ensure the original mortar and to protect surrounding areas the gain saturation, to avoid that the new mortar absorbs the liquid compromising the grip. Once moistened the joint the application of the plaster shall be applied in successive layers according to the depth and length of the gap to be filled. For the mixture it can be used hydraulic lime, slaked lime, sand or other mineral aggregates; for the most in depth parts it shall be appropriate to use a mixture based on natural hydraulic lime (obtained by calcinations at a low temperature, free of soluble salts and with an excellent water vapor permeability) and sieved river sand (particle size 0.5-1, 5 mm). As an alternative to sand you can use other fillers such as pozzolan or earthenware (clay ground dehydrated derived from crushed clay fired at low temperatures); in each case the ratio of inert binder will always be 1: 2.

For grouting finishing it can be used a paste made of lime; the charge of the mixture can be stone ground and fine river sand (grain size 0.5-0.8 mm).
The choice of the aggregates shall be dictated by the preventive analysis performed on the sample material and the color depth that you'll want to get in tune or not in conformity with the existing mortars.
The integration ('risarcitura') may be more or less characterized; you may run a grouting of joints following the existing wire or slightly underline or exploiting the size and color of the aggregates we can get a result mimetic or contrast between old and new mortar.

The operation of grouting is completed with sponge and de-ionized water to eliminate the signs of the brush, bring out the size and the chromatics of the aggregate and to remove any detached fillers that may confer to the joint a dry powdery appearance.

25_*Mortar filling operation.*
26_*Different mortar grouting types.*
27_*Protection of the stone material.*
28_*Protection operation executed by a specialized technician.*

Veil layer ('Velatura')

Once restored, it can happen that the stone presents chromatic differences of color or tone; these differences can be watercolor with land and water without the use of binder, fixing will then be made by the final protection that ultimately will be made later, the dark spots can be 'lightened' dimming the tone with a pellicle veil layer of ground and water of calcium. For small corrections the veil layer pellicle can be made after the application of the protective surface.

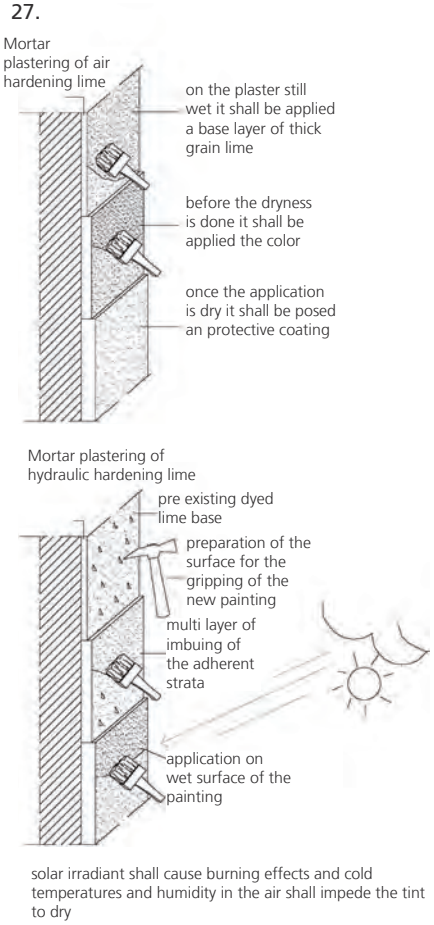
Surface protection

To limit and slow the progress of deterioration it is necessary to protect the stone surface with a product that is 'consumed' once placed; this protection is made with materials that do not modify the reflection of light, the porosity, the color and tone of the stone and have a duration of 5-10 years. The products that resists the most to aggressiveness of the environment, oxidation of the solar light and corrosion are the protective organic (silicones), these are less suitable acrylic resins and microcrystalline waxes as they attract dust altering the natural color of the stone.

The protection, to produce an effective treatment, must be applied over the entire surface, which must be thoroughly cleaned of all dirt deposits and incrustations; protection is given a brush on small surfaces, while spraying with pressure guns. If particularly fair protection should be made after the final drying of the dye solutions.

The use of protective layers must still be connected to a maintenance practice that provides for the periodic inspection and the eventual repetition of the treatment at regular intervals. The constant maintenance of surfaces will help to create a better and longer preservation of the architectural work in its transmission to the future. And this is the end of each conservation work on architectural surfaces.

27.



28.

C.3 _Operations of plaster restoration

The preservation status (reportable by observation of the damage status) is to identify the forms of alteration, the origin and the processes of deterioration going from the effects to the cause. The plaster and the building are related: the plaster finishes and protects the building, the building must be efficient in its entirety does not induce damage to the plaster. The variations and sudden changes trigger deterioration processes: every alteration is caused by a certain cause or more concomitant causes which is critical to recognize and eliminate the destructive action to thwart established, only then will take place the removal of the damage.

Preliminary verifications

Before performing any operation it shall be necessary to check the fissure picture as to identify any 'dynamic' damages (which may be due to several reasons including structural settlements not yet completed, thermal expansion inside the material or between different materials etc.); in this case it can't simply be proceeded to grouting the fissures but you will have to identify and address the deep causes that have brought such deterioration. The intervention of grouting and integration will be permitted only on cracks now stabilized (static lesion).

Removals

- **Not compatible portions removals**
  It shall be done by local brush ablation (sorghum type), spatulas, trowels, wad and chisel small hammers, vibrant incisors etc., All parts that are not compatible with the support (wood, iron, mortars or eroded severely degraded etc..), or fillings or additions made with cement mortars that can create mechanical stress with time shall be removed. The operation must be done with utmost care carefully avoiding not affect the original artefact.
- **Plaster removal**
  The removal procedure must necessarily be preceded by a preventive 'sampling' performed by a knocking percussion with the hand knuckles on the wall in order to locate the compact zones and to delimit (with a sign outlined in chalk) the perimeter of the detachment (swollen areas and formed 'pocket' hollows between the plaster and the masonry).
  The partial or total removal of plaster shall be done by removal material surface deteriorated, by successive layers, till the asportation of the entire thickness of plaster to get to the masonry stonework without affecting the building structure that must remain intact without visible grooves and/or breakage of the stone components.
  The action must, therefore, always be controlled and limited to the removal of plaster without affecting the masonry structure and any nearby areas that has to be preserved. The demolition must proceed

from the top to down direction, removing small portions of modest weight and eliminating manually detached parts of plaster also of considerable thickness, by the usage of manual tools (wad, or hammers and chisel tip, if necessary it can be allowed the usage of low power mechanical equipment, vibrant incisors and small jackhammers) always being careful not to break the wall substrate or other surfaces that shall not be involved in the procedure.

During the removal procedures it shall be necessary to avoid damage to any of the building components (stucco, moldings, profiles to be stored etc.) Near or below the area of intervention. In case of a restoration of an important decoration, (eg. Mock drafts ashlar or cornices etc.) it shall be required before the removal to perform an accurate survey of any trim by a specific mold (plaster or resin) in order to reproduce it in a proper way.

Once the operation of pick axing ends the following phase shall be the cleaning of the masonry revealed with a sorghum brush, as to remove dirt from the masonry and powdery residues.

Surface polishing

Cleaning cycle with de-ionized water followed by brushing (or other technique as indicated on the building design) of the surface in order to remove dirt, dust, oil, slag and other foreign substance from the stonework. All cleaning operations shall leave the fissure or the joint free of debris or dust, but with the surface rough finished, as to facilitate the griping of the restoring layer of mortar. If the surface that has to be treated, has a pellicle of efflorescence or other pathologies that derives from the presence of salts it shall be necessary to apply a desalination procedure on the masonry using proper methods and techniques (eg.: compresses of cellulose pulp soaked of de-ionized water). The same criteria will be used if the masonry had problems of rising damp, in the presence of mosses, lichens or higher weed vegetation: before any operation of integration it will be necessary to clean up the masonry.

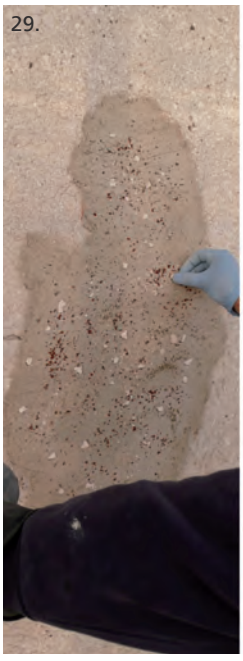
Grouting

- **Edge restoring by grouting procedures (border finishing)**

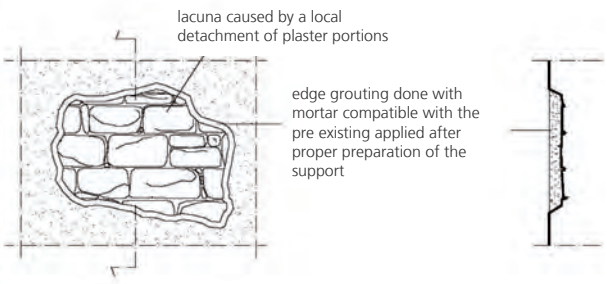
  In the presence of missing portions of plaster, in the case that there is no intention to remove the entire section of plaster, the intervention shall be directed to the protection of the edges of the missing parts by a grout application that shall ensure the adhesion between the layer of plaster and the masonry, as to avoid harmful spilling of rain water or atmospheric particles inside the masonry work that could aggravate and increase, the size of the missing portions in time. The operation of edge plastering, particularly when made on exterior walls, must be performed with extreme care; this type of protection in consequence

of its configuration of connection between two non-coplanar surfaces is particularly susceptible to atmospheric agents (rain). Mortars type that is suitable for this operation shall be similar to preparations used for the adhesion of detached plaster, it is to avoid the use of mixtures with grits and binders different from those present in the original plaster on the surface, the use of calcium and sand mortar (not very resistant to mechanical stress) or cement mortars (too hard and not very suited for this usage). The borders must be created using mortars compatible with the support, that shall let the support 'breath' (non sealers) and with proper mechanical resistances. Before the application of grouting the masonry work interested must be properly prepared, it shall be necessary a cleaning, removal of any soluble salts and the fix the uneven stone portion. In presence of moisture stains, before applying the grouting it shall be necessary to remove the cause and wait until the wall is dry.

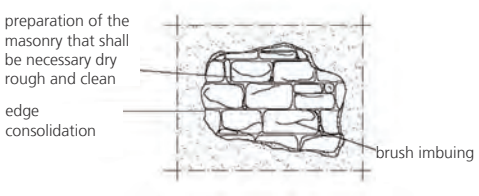
- **Treatment of plaster missing portions**
  The detachment of a whole portion (single or multiple layer) of plaster from the wall surface will reveal a discontinuity on the wall plane and the unveil parts of masonry, consequentially the wall structure would be exposed to the weathering aggression; water can penetrate deeply into the masonry mass conveying pollutants that shall deteriorate the wall's structure. In order to avoid this inconvenience, the exposed portions of the wall shall be protected, restoring the missing plaster with the same type of mixture originally located in the interested area.



LACUNA TREATMENT BY EDGE-SAVING GROUTING



LACUNA TREATMENT BY PLASTER PATCHING



29_*Plaster lacunas treatment.*

- **Plaster integration and rebuilding procedure**

  After accurate valuation of the support's preservation status, the procedure of plaster integration shall be related to two factors: the analysis of the original plaster present on the masonry and simultaneously to the type of stonework which it consists, the purpose is to ensure an effective adherence mechanically an in a physical-chemical perspective ascertain that the material implementation shall be of an analogous type of the original.

  The integration must be done with a plaster compatible with the support stonework and of similar thickness to the original coating (number of layers), as for the material composition and transpirability; the coefficients of thermal expansion and mechanical resistance shall be congruent as to ensure the same reactivity of the original plaster layer to the any sort of stress (rain, steam, humidity, etc.).

  Before proceeding with the procedure of integration, the surface should be prepared; the masonry interested by the treatment must be sufficiently dry (no phenomena of moisture) and clean (free of salts and/or coatings) in order to allow a total adherence of the new mortar to the substrate, after this caution the masonry shall be water damped with a brush, or by the usage of a manual nebulizer (a dry wall could absorb the water present in the dough excessively causing excessive shrinkage of the mortar).

  Accomplished the cleaning phase, and if necessary consolidated the plaster remaining of the old plaster's margin it shall be possible to proceed at the plaster reintegration phase as the sequent steps:

  - After damping of the wall, it shall be applied a rendering (with smooth mortar thick grain aggregates) as to penetrate well into the interstices of the masonry pattern;
  - Once this first layer has hardened this rough surface shall be damped again, it shall be possible to proceed to the plaster application (called 'arriccio'), using a trowel, in successive layers (1-1.5 cm) up to the thickness specified by the executive desgins;
  - The last layer of arriccio will be evenly disposed and leveled.

  The finishing pellicle shall be applied with a trowel in thin slicked layers with a specific sponge ('frattazzino'), lightly soaked with water.

  Particular attention should be made while laying the plaster section by section with a planar sequentiality, since a proper execution shall prevent unwanted discontinuities. In order to reduce the risk of fissures it shall be convenient to follow the following precautions: avoid to use mortar mixtures with a high percentage of binder (thick grain mortar), the mortar grain should in any case decrease while the layers are applied from the grip mortar layer to the finishing pellicle consequentially it should be the same for compression resistance; apply the mortar by subsequent layers increasingly with finer-grained aggregates.

- **Lime plaster integration (air-hardening and hydraulic)**
The choice of the compound elements (water - binder - inert) both in plaster as in mortars is important:
  - *Water*: Water is essential to the effectiveness of the mixture parts and its excessiveness or scarceness affects the material's strength. It is also important the timing for the casting since both the season as the day time influences the process it has to be preferred the days which the temperature is low (in particular for external work) it is necessary to protect the casting procedures by sunlight, wind or any external factor that may accelerate the drying process;
  - *Binder:* historically the use of the binders varies depending on the latitudes and the geographical areas (bitumen binders, the mud or the raw clay, lime, gypsum). The stone walls Mangabi may contain water vapor so the binders used for interventions of integration should preferably be done with hydraulic lime. The white lime is the cement mortar used in the walls of the old buildings in Jeddah; it is obtained by cooking limestone at 800-900 °C. The lime obtained, once hydrated, become (depending on the nature of the limestone used):
    - air-hardening lime (lime which hardens on contact with air - fat lime) is used for paints based on lime of the walls of Jeddah. And 'recommended for the construction of facades graffiti Al Balad
    - hydraulic lime (lime which hardens when exposed to water and air, powder or paste, is used for flooring and mortar joints of the walls of Al Balad.
  - *Aggregates* (sand - pozzolan - stone chips more 'or less fine): aggregates have not have a passive role, but instead have a dual function of mechanical and chemical, it can:
    - reduce (as 'fillers') the consequences of contractions volume that undergo the binders;
    - accentuate certain characteristics of the dough reacting chemically with binders (eg: pozzolan and 'idraulicizzante an agent in the composition of the mortars);
    - improve, in the case of organic fillers (fibrous plant materials), the mechanical characteristics (resistance to bending.) or increase the adhesiveness of the mixture or delay the socket to allow further processing.

    For example the use of brick dust (known in Italian tradition as 'cocciopesto') is the most ancient method (instead of pozzolan) and the most appreciated as the mortars made are more resistant

than pozzolanic based mixtures, it works as a hydrating agent (hydration) for mortars (or formulated lime).
Other inert materials are crushed stone, such as sandstone and basalt floors and pulverized; marble powder slows the carbonation and then the setting time of the mortar, facilitating a homogeneous hardening.
The components of the pozzolan replacement must be composed of alumina and silica to give the degree of necessary hydrating: for example kaolin for its white color, was used for the production of special plasters or intended to mural painting.

The air hardening lime mortar, is commonly used in the past for plastering the outer walls, consisted mainly of lime, sand and colored earth; the binder was the same for the different layers, which was varied the amount and size of the aggregates (larger in the inner layers smaller for the outer ones). The patch of plaster with this type of mortar must be performed with particular care considering the binding factors as a long maturing time between the various phases of installation and the need to spraying constantly the surface to avoid the dough to 'burn' with a consequent decrease of the characteristics of resistance and durability; during the setting process, in fact, water loss should be gradual; the quantity of water must be related to individual specific cases because more or less fast drying will depend on several factors including: the atmospheric humidity, direct sunlight and wind pressure.

It is necessary to recall that the integration of hydrate powder lime based mortar shall be not optimal for exterior surfaces for the poor resistance over time in terms weakness to weather agents, mechanical stress and as it has a tendency to absorb water by capillarity; it is advisable to limit its intervention only to interior surfaces. As regards the hydraulic mortar should be used within 2 hours in the summer (3 hours in winter) from addition of water.
When finished it shall be possible to emphasize the aggregate, dabbing the surface with sponges and de-ionized water or rubbing the surface with abrasive paste, removed at a later time with a wet sponge

Surface finishing

The finish, as well as by definition, constitutes the last layer of plaster; made of reduced thickness is obtained by using mixtures with selected blends of materials screened thoroughly and put in place following different techniques, depending on the effect desired end; in this respect important is the type and aggregate particle size chosen seen that this element binds the consistency and especially the appearance of the same finish (smooth or rough).

Chromatic integration

The purpose chromatic integration will be to fill gaps in the paint film that will cover the plaster, in order to restore the continuity of color and, at the same time, restore its protective function of the paint layer.
Prior to restore the support must be prepared by cleaning (with techniques based on the type of deposit to be removed) and then a subsequent consolidation (or any pre-consolidation where necessary).
On the support so prepared will proceed to the integration chromatic respecting the type of this painting on the wall.
The products that you can use, always in relation to the pre-existence, will be: paintings (the film will be mostly opaque), paint (although the film will be colored transparent) and colors (not form film). Painting techniques most frequently will track on surfaces will be plastered: lime painting, painting to tempera paints and silicate.

C.4 _Stucchi and moldings integration

The procedure has the purpose of consolidating, replenish and rebuild the decorative elements (eg. Eaves or string-course, the profile of arcs etc.) And fake architectural elements (element ashlar, etc. pilasters.) Present on the device walls.
Stucco is historically a mixture fine gypsum or cement used in the building industry for the coating and the decoration of walls and ceilings. The polished plaster (stucco or Roman) is used with various pigments to mimic marble surfaces. The composition can be highly variable, making the term stucco a category of materials rather than a specific product.
Sometimes additives are added acrylic or glass fibers to increase the strength properties and workability. Historically the filler consisted of a mix based on slaked lime (calcium hydroxide) seasoned and marble powder. Certain mixtures, based mainly of gypsum are suitable for internal use grieved moisture, while others are used for decorations exposed to weather.

30_*Injection of adhesives and fillings to re-establish adhesion of the wall support.*
31_32_*After possible removals of non-adequate infills (because of their composition or conservation status) new ones can be laid.*
33_*Spreading of acrylic resins to protect the stuccos.*
34_*Pictorial restoration of lacks or chromatic discontinuities of the finishing layers in order to restore the work's unity.*

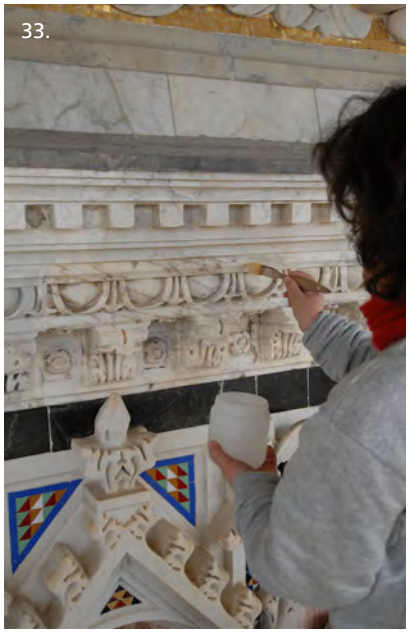
30.

The phases of conservation work are divided into:

- Preliminary operations involving cleaning by removing surface deposits inconsistent with dry brushes, brushes and vacuum cleaners, and removal of surface deposits partially adherent, with water, brush, sponges and manual sprayers, follows the partial restoration of accession cohesion of the paint film or gilding with acrylic resin applied by brush with Japanese paper or spraying, finally grouting and temporary micro structure with mortar.
- Consolidation through the re-establishment of the cohesion of the plaster by impregnation to compress with ethyl silicate or acrylic resin and the re-establishment of accession between plaster and masonry support by injection of adhesives and filler support pins Teflon or


31.


32.


33.

polypropylene fibers.

- Disinfestations achieved by application of biocides by brush, spray or with syringes and manual removal of vegetation upper and discoloration of the residues of colonies of microorganisms with applications to compress or brush.
- Finally are provided for grouting operations, micro structure and additions, and the reintegration of the pictorial gaps, abrasions or discontinuity chromatic layers of finish in order to return reading unit work.
- In order to protect the stucco provides for the preparation of acrylic resins in solution with a low percentage by means of brushes.

The surface made of stucco shall be realized continuing the structure of the existing stucco or shall be built from scratch using a neutral intervention, that is chromatically similar to existing stucco, but without the 'inlay' stucco work featuring in 'buildinge.

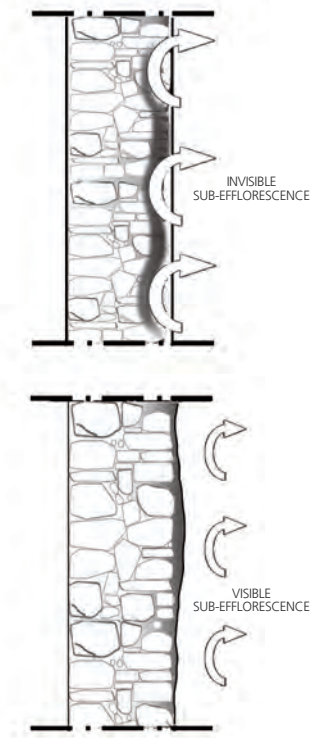

34.

4 | Dehumidification procedures

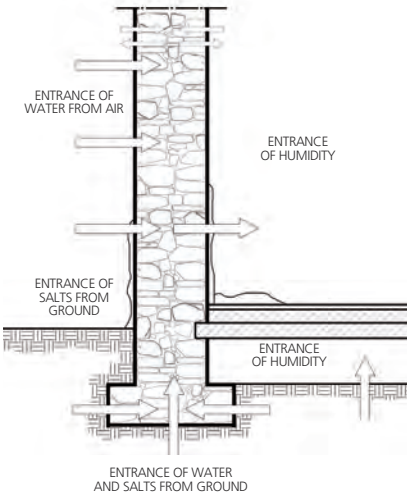
In Jeddah, the small amount of annual rainfall isn't the cause of water related damages in the buildings masonry constructions, it is mainly determined by infiltrations from the sewers and water pipe utilities near the walls (water supply, drains rainwater, sewage and air conditioning).

Perform a preliminary search of the construction and materials is preparatory to the choice of treatment.

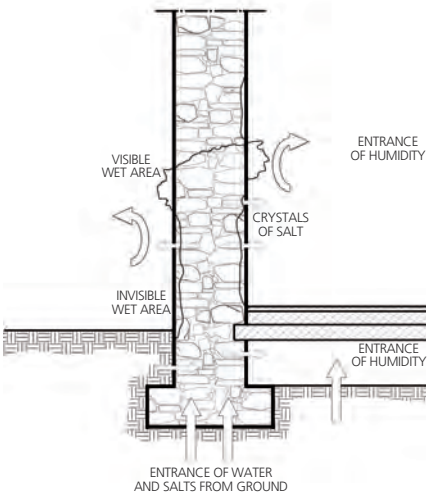
01.



02.



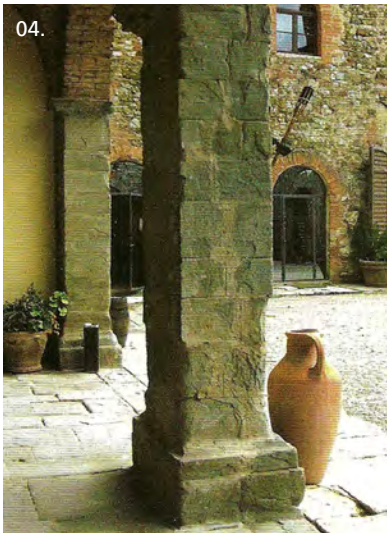
03.



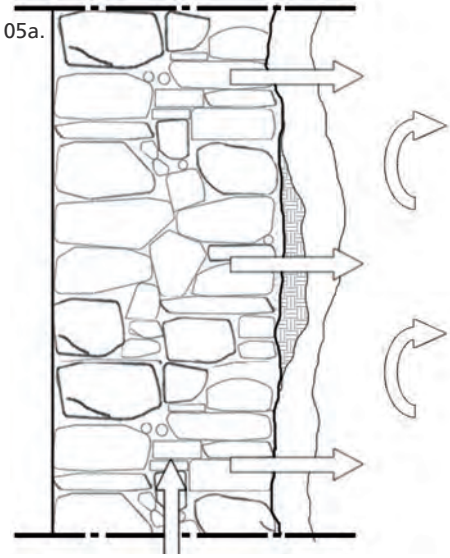
01_ *Localization, relative to the surface of the crystals of salts.*
02_ *The three sources of moisture in the air.*
03_*Situation in a wall subject to rising for some time.*

Comparing the condition of moisture and damage created in a wall to a disease it is necessary to identify the symptoms to be able to formulate a cure. The three visible symptoms are:

- moisture in the air of the room: cause evaporation from the floor and/ or walls due to infiltration in place, the presence of hygroscopic salts in the walls, condensation in the air;
- dampness from the wall: often but not always accompanied by the appearance of spots or white stripes on the outside of crystals, which are due to infiltration of water and salts occurred in time but not necessarily still in place;
- bulges and/or destruction of the surface: the cause of which can be divided into two broad categories: natural causes (seasonal temperature ranges of temperature and humidity; materials consisting of different substances with different expansion coefficients which generate internal voltages that disintegrate) - salt content in building materials (periodic re-crystallization of the sub efflorescence).



04.

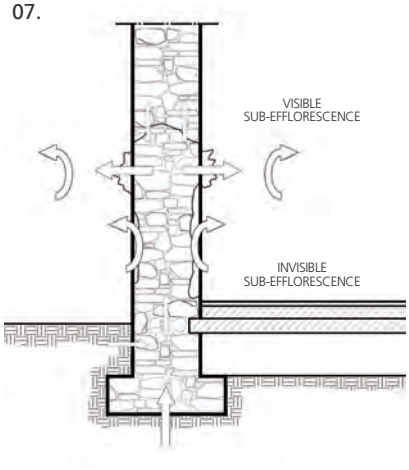


05a.

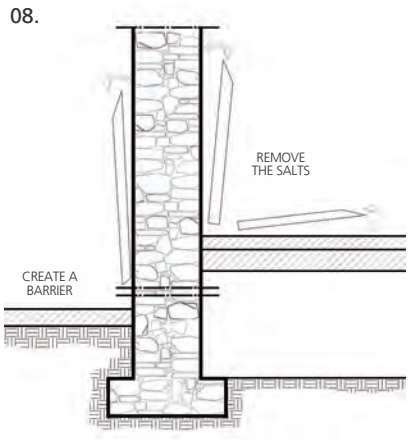
05b.

06.

07.



08.



04a_*Destruction pillar stone because of sub-efflorescence of salt crystals from lifts.*

05a_*Formation of salts and lifting of the plaster, due to air evaporation.*

05b_*Example of gradual destruction tufa wall because salts in solution by lifts.*

06_*Consumption of stone material greater than that of the mortar.*

07_*Formation of visible and invisible efflorescence crystals, due to evaporation.*

08_*Solutions for the infiltration.*

09_*Water infiltration.*

A_INSTABILITY CAUSES | PATHOLOGY ANALYSIS

When water infiltrates a wall it always contains mineral salts; such soluble salt is found everywhere, any land is full of it and it transfers just is passing through water, even the building materials (mortar, bricks, paving stones and building etc.) contain salts, often human activity itself generates salt presence trough humidity production.

There are several ways in which water and salts, penetrates the materials of wall or plaster, by infiltrations, damp capillar rise, water and salts condensation, salts from human activities, from building materials.

Water infiltration

Such penetration of water can occur through leaks from underground pipes or embedded in the walls: these losses contain salts that spread in the masonry work.

Even rainwater, if not properly removed from gutters, channels, descendants, is a great source of indirect contribution of salts in the walls. Also storms carries marine saltiness.

Rain that wets a wall locally can lead to moisture inside a building, but also dissolves and leaves in the wall salts actually "that belongs" elsewhere.

The problem deriving from rainwater diffusion inside the wall is a consequenceof an underestimated dimensioning of the draining system, a poor maintenance and / or clogging of the pipe systems for the water flow from the roof and for the water's movement from the building by horizontal pipes. This water movement damps the wall surfaces until it rains and consequentially infiltrates any fissure; in some cases water stagnates at the base of the wall and infiltrates into the ground below, in the absence of a barrier, becomes a reservoir for the damp ascent, the sidewalks - if well implemented - can be a good prevention, otherwise it can't discharge a lot of water underground.

From the roof the waterproof coatings can link from the overlapping of the sealing sheets (for ineffectiveness of flashings, converse) or ruptures in the sheeting, the water penetrates and permeates the walls and below during its path down can dissolve soluble salts present in the mortar or inside the wall.

On a wall of facing masonry, water could spill out (through an open joint between stone portions or from a stone with major porosity) evaporating and consequentially forms salt crystals. On a plastered wall at the point that it there has been a link in the wall in correspondence below there shall be stains of moisture.

The salt that forms foam brought by storms can be present on building also very distant from the sea; the salt is deposited on the surface of walls of brick, stone or plaster and penetrates inside depending on the permeability of the wall itself. The subsequent drying of the wall (the evaporation of

salt from the surface) will leave crystals of sodium chloride and other salts present in sea water. The rain will wash away some of these salts but not all, those that remains in the substrate will increase or decrease in time. vv the time the entire thickness of a brick wall can be traversed by salt with the formation of crystals inside.

09.

Water by capillary rise

The capillary rise of water is a common cause of salt presence in the walls, it is a particular case of the capillary diffusion.

The building materials are never totally compact and homogeneous, they always contain voids (said pores) distributed in its interiors. The pores may be closed and not communicating as bubbles or be more or less interconnected so as to create a continuous system of capillaries. The percentage of pores of a material is referred to as porosity.

The capillary system makes the material able to absorb and hold water in its interior: the property to allow the passage of water or water vapor is called permeability to water or steam and influences the durability of buildings.

A material with a porous structure is permeable to water when the pores in its interiors are connected to form a "network" of internal channels communicating. If the pores are closed in bubbles even if the material is not very porous permeable to water.

For walls of buildings standing outground damp rising occurs only if the foundations are based directly on the ground without being separated from it by an impermeable layer (as it is typical of the historic buildings).

When water that enters the wall carries with it dissolved salts: the evaporation of saline is also done within and on its surface of the wall. The height of moisture rising in the wall will be higher inside than outside because evaporation in the wall is much less than on the surface.

10.

10_ *Water by capillary rise.*

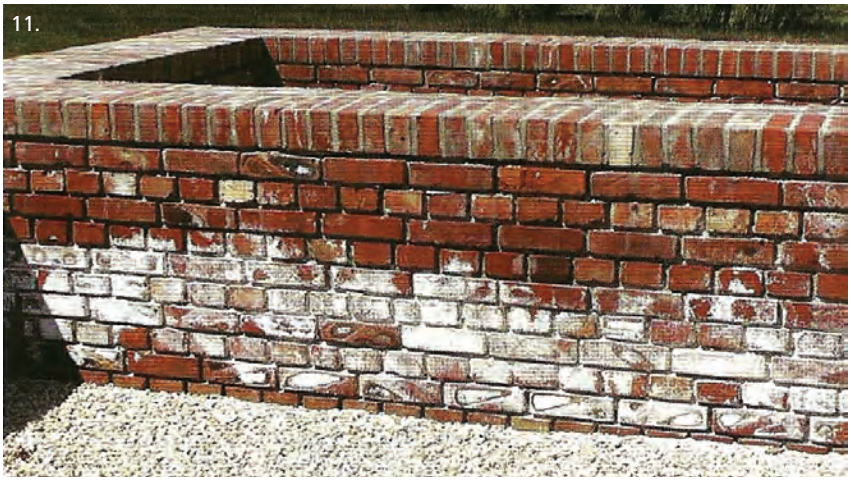
11_ *Efflorescence of sulphates present in the clay with which they were made the bricks.*

Water and salt from condensation

Condensation causes a real damage risk, penetrating into the material of the wall it can extract (leach) salts already present in the mortar or the stones of the walls; these may manifest on the outside surface (efflorescence) or remain invisible (sub-efflorescence). Wet and salt stains can be present on the top instead of the bottom because that is where the warm, moist air cools, forming condensation.

Salts from human activities

As already said water present in the soil, in floors or walls isn't pure and many human activities are the cause of the presence of soluble salts.
For example, the loss of water from the pipes of the water system or heating or by descendants of gutters do not result in serious losses in terms of salts (unless the water can't find in the wall or plaster salts dissolve and goes in circulation); the damage is immediately alerted by appearance of moisture and stains.
Loss of sewage piping fluids is frequent and happens ceiled in the ground or inside a wall; the slurry contains nitrate salts of organic origin and therefore the loss contaminates the wall; when the damage is detected it could be immediately repaired.
More harmful are the effects if the loss is of an underground urban sewer that runs adjacent to the building, in this case you can't notice the damage until you see its effects. The leakage of the slurry wets the ground and if it leans against an outside wall or a wall of a basement, it creates moisture rising from the wet wall side with the consequential presence of white patches of salts and rotting plaster. The solution is to dig next to the wall, repairing sewer and treat the wall with a contaminated or convert chemical salt (if recent and / or mild) or extraction of salts (if old and / or heavy).


11.

Salt release from building materials

The building materials are an endless source of harmful soluble salts:

- Salts release from water mixture of mortar and concrete: the majority of salts such as carbonates, which contaminates water used in small - medium yards, is less harmful, not so the sulfates whose quantity is limited by a set of rules.
- Salts from the bricks: clay that constitutes bricks contain many impurities that after the grinding and cooking are transformed into sulfates salts present in the brick. For this reason, for the construction of the masonry walls it would be preferable to damp them before putting in the blockwork, also the mortar used for cementing contains water that soaks the bricks and dissolves the salts sulphates dispersed within them, when the masonry dries (by evaporation of water) the solution migrates to the surface, where evaporation takes place. The salts in the solution are concentrated and precipitate forming showy white spots. The method to remedy the manifestation of blooms of white spots is to wash the wall with acids (diluted muriatic type) that are effective with carbonates and mortar residue but not with sulfates. Also, if the acid residue applied is not washed away or neutralized with soda, it attacks the mortar forming silicates blackish on the bricks.
- Salts deriving from inherts: aggregates present in the mixture of mortar may contain salts although in theory the aggregates should be cleaned to avoid contain traces of mud, silt or salts (UNI by precise indications on the chemical and physical characteristics that must have the aggregates to be used for the different aggregates).

B_METHODOLOGICAL PREMISE

The problem is complex because the dehumidification procedures not only is necessary to lower the humidity of the ambient air and in damp walls but also to stop the deterioration of salts in the masonry.
One category of solutions proposed to achieve this only by preventing the entry of new water in the walls through barriers to the rise effect. But this doesn't change the existing situation in the wall or plaster infested for more or less long periods from the crystals of the salts, nor the only interruption of damp rising can prevent the crystals of the salts already present to continue to keep it moist and do damage.
Another category of solutions proposed to achieve the same result of the global reorganization only through the use of interior restorative.
Particular "restorative" plasters which are macro porous shall dry the wall but, without barriers to the rising damp it shall, transfer to the ambient air; in reference to such plasters it has to be stated that the salts shall be ceiled in the macro pores and if a barrier against damp rises shall not be installed the problem will recur within an expectable average of two years.
The dehumidifying plasters called "lock-salts" keep the salts in the wall but if not associated with a barrier to lift the problem will reoccur predictably within 4-5 years.

Except in the case of condensation, the problems are two and two must be the proposed interventions:

- stop the deterioration and damage by treating the salts already present in the wall;
- prevent the entry of new water and salts, blocking the wall damp rises acting and the repetition of the original situation of contamination to avoid an entry of new salts.

The manifestation of the presence of salts is **efflorescence** and **sub-efflorescence.**

The white efflorescence are often regarded as "annoying aesthetic inconveniences " and then are treated with simple surface cleaning; this is not completely wrong as visible efflorescence is not in itself cause of damage, but can be a symptom of the presence of harmful sub-efflorescence, in which it may be transformed. Cleaning is useful when the efflorescence salts are due to carbonates emerged from new brick or mortar residue, as they can be dissolved or neutralized with acid. If the stains are due to accumulated salts (chlorides, nitrates, sulfates) that have emerged on the face view due to the wetting of the implementation acids do not serve.
The sub-efflorescence (salt crystals generated by the evaporation of the first 15 mm inside the wall) are the causes of all damages to the wall materials, including plaster, unless the natural phenomenon as frost.

There are two methods of restoration:

- methods that treat the salts keeping them inside the wall by means of chemical or physical methods
- methods that extract them and remove them from the wall.

Chemical - physical methods for salt sealing

One method is to neutralize the salts with a chemical "anti-salt" (called chemical salt converter) to make them harmless.

These reacts chemically with salts transforming them from soluble and insoluble and creating a new permanent material inside the wall; salts thus transformed can no longer melt and crystallize or re-crystallize again periodically.

The treatment often does not work for two reasons:

- there are different categories of salts (sulfates, chlorides, nitrates) inside the masonry, and in different quantities, since there is a reagent effective for all types it would serve one for each type with increased costs. Given that almost never there are performed prior an analysis on the wall to know the salts present, it shall be prepared a mixture of products or a single product for the type of salt that is believed more present.
- reagents fail to arrive to salts in depth (is diluted losing effectiveness; just applied the reagent comes into contact with the first salt that is, the reaction of the two leads to the formation of a new material that becomes an obstacle to its own penetration).

The method that converts chemical salts works only if contamination is superficial and accessible from brushwork or all classes of salts were neutralized by their specific reagent. Except to visible brickwork, liquids convert chemical salts are rarely used alone and are often associated with special plasters.

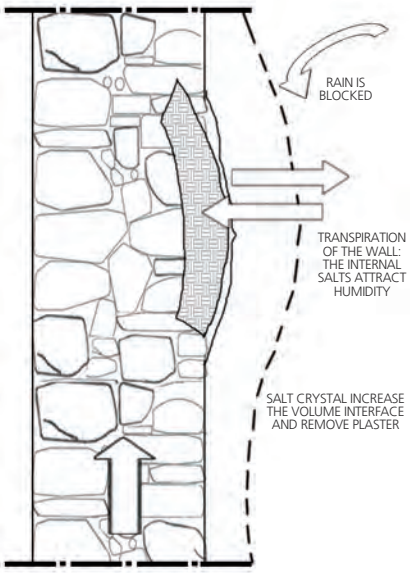
This method salt-convertion doesn't complies with the 4 modern criteria of restoration (minimum intervention - non-invasive - reversibility - compatibility).

Following the principle according to which the salts are not harmful as long as they are in solution, some methods keep the salts inside the wall in saline state to prevent the crystallization resulting of an evaporation. The saline solution can be maintained within the wall as a total waterproofing (ex .: bituminous and bentonite welded in the wall; continuous film of epoxy or polyurethane dates brush or roller, said liquid membrane; plasters containing additives waterproofing) or with a waterproofing - said hydrophobic - that blocks the passage of liquid water, but permits the passage of water vapor

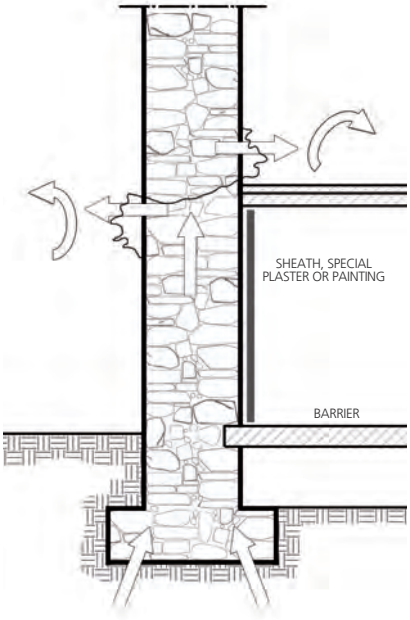
12_ *Effect of paint laid on hydrophobic macroporous plaster.*
13_ *Ascent of water to the upper floors after waterproofing.*

from the substrate (it is used a water-repellent product that penetrates all 'interior of the material and reacts with it, the product blocks the entrance or the exit of saline solution from the capillaries and at the same time the escape of water vapor of the interior of the wall. The hydrophobic resins - potassium silicate, resins resulting from the silicate ethyl, methyl, or by the families of silanes, siloxanes or fluorinated polymers modified - can be provided in aqueous solution, in a solvent, in the form of micro emulsions, mono or bi-component catalysts: the hydrophobic liquid can be brushed or sprayed as a protective finish or painting on plaster, to brick or concrete beams as the first layer prior to a plaster of any type; directly embedded in a plaster finishing, as a rendering salt-blocker of a system of interior restorative single-layer or multilayer. As all the solutions of the problem to keep the salts inside the wall, the hydrophobic method has side effects that emerge over time, determined by the crystallization of salts in the material stuck behind the treated layer.

12.

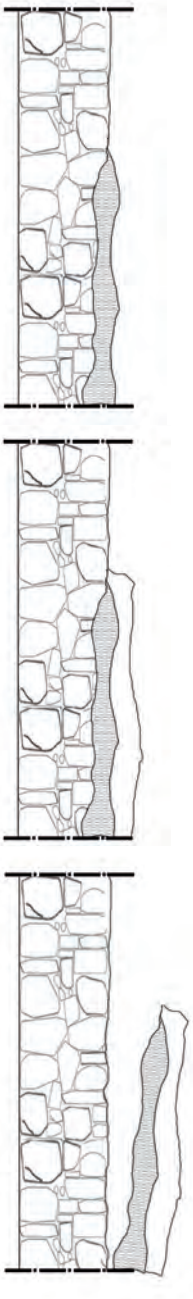


13.



Hydrophobic method for the salt-control slightly complies with the 4 modern criteria of restoration (minimum intervention - non-invasive - reversibility - compatibility).

14.



14_ *Method of the wrapping to extract and remove the salts in the first 3-4 centimetres of the wall.*

Methods to extract the salts and remove them from the wall

A method to extract and remove salts through wrap applications is a purely physical treatment and it works for water evaporation which contains and is the only extraction of salts which allows a quantitative verification of remediation made [the amount of salts in the wall can be measured before and after treatment extractive]. The only limitation is that it does not work on impermeable surfaces or waterproofed (ex .: surfaces covered with acrylic paints or paints and plasters containing potassium silicate or terracotta floors waxed or fireclay).

Common type of wraps are:
Type A: PULP - GARZA - ABSORBENT PAPER (used in restorations Archive of statues and frescoes)

- Type B: CLAY [CAOLINO - BENTONITE - SEPIOLITE - montmorillonite]: limitations related to their nature (requiring water to be mixed and adhere to the substrate, such water limits the capacity to extract and to store extra water - dry quickly becoming dust and are subject shrinkage breaking away from the substrate and then the pack must be replaced - are composed of small particles that can penetrate into the substrate and contaminate);
- Type C: MIXTURES OF CLAY AND SAND OR PULP (to overcome limitations of the clays are mixed with pulp - dust - cellulose or sands, this pack must be renewed approximately every 3-5 days);
- Type D: MIXTURES OF FIBRE PULP AND LANDS diatomaceous: single pack valid for the construction of large-scale restoration in that it contains clay, tested in Australia is a material composed of 86% pure silicon and a small amount of carbonate.

Wrapping method complies with the 4 modern criteria of restoration (minimum intervention - non-invasive - reversibility - compatibility).

Methods based on storing the crystals inside special plasters: the definition of "healing" plaster and / or dehumidifying plaster are commercial terms without any technical value exact as any plaster from which water evaporates is dehumidifying and any rotted plaster to be full of salts will have played healing function. A good plaster must be transpire-able , have a good thermal insulation and little absorbance of water from rain and resistant to deterioration due to temperature and humidity, the additional characteristic that must have a plaster to be used on a damp wall and / or full salt is the ability to prevent the deterioration confronting crystals of salts that accumulate in the wall with time.
This characteristic (excluding special cement plaster) can be satisfied with the interior restorative macro porous absorbent salt-carrying (allow evaporation of saline solution from the wall below the plaster inside, the

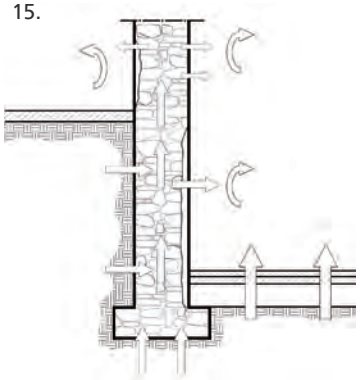
crystals that are formed are absorbed and hidden in large pores of the body of the plaster, eg .: sacrificial plasters: temporarily applied to extract the salts from the walls contaminated before being taken away, have a different formulation from a plaster that has to last) and the interior restorative salts blockers (prevent the formation of crystals avoiding the release and evaporation of the salt solution from the wall below with capillaries hydrophobic resins)
Other types of plaster "dehumidifying" and "RESTORING" are: plaster of earthenware, plaster and pozzolanic ground.

Methods based on the washing of the salts from the wall are treatments that involves water (de-ionized) by exploiting the solubility of the salts, but this is true only for those in the surface as the deeper ones are not achieved.

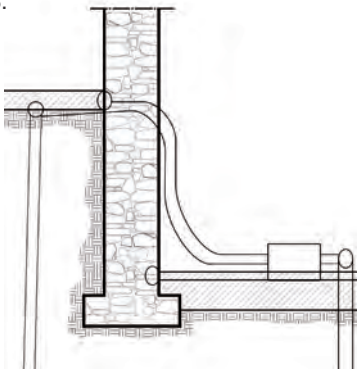
This method is fine for small articles, but not to remove salts from a wall or large pieces, also disadvantages make an it useless operation in the medium term. The wall contaminated is washed with de-ionized water (expensive) that eliminates the salt crystals visible on the surface or just below, but impregnates (especially if done by jet) the wall also dissolving the crystals of the sub-efflorescence (deeper) with result of increasing the concentration and allow the salts external entering deeper.

Another method uses dry under vacuum or depression that is by increasing the washing efficiency by forcing the passage of the de-ionized water through the material. The part to rinse is wrapped and enclosed in a kind of tarp pond through which passes the water jet. This system is suitable for small parts or small - medium and large-scale, cost aside, has a number of difficulties of application and contraindications: the wall soaked with water will take months / years to dry (even with electro - osmosis technique) and the finer part of the mortar is rinsed away causing a weakening of the 30% of the bearing capacity of the wall.

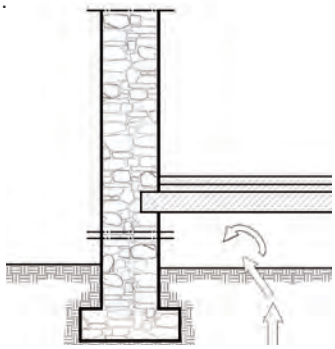
15.



16.



17.



15_ *The three modes of infiltration of water and moisture in a basement*

16_ *Total internal reorganization by electro osmosis active*

17_ *Sectional diagram of aeration with straw*

C_DESCRIPTION OF THE INTERVENTIONS

Methods to prevent entry of new water and salt in new walls

In the construction of a new building it will be necessary in order to preserve it, to prevent the entry of water and salts, while in the restoration of an old building it will be necessary, to extract the present salts and to prevent the entry of new water that would bring new salts.
So interventions apply to both new and old buildings is away rainwater running from the base of the wall using appropriate collection, intubation and downspouts and prevent water seepage from the top with waterproofing and flashings of adequate size.

C.1_Solutions to clean up the basements and retaining walls

The underground rooms have three input sources of water and salts contained in the soil: vertically from the floor in contact with the ground, vertically from the base of the sidewalls, horizontally from the wet ground. The solutions for a permanent restoration depend on whether or not to access the outside of the walls. It shll be necessary to achieve four separate effects:

- Stop infiltration from horizontal wall against the ground by sealing;
- Countering the vertical ascent into the wall against the ground by a barrier;
- Prevent rising vertically from the floor by means of waterproofing;
- Treat or remove from the walls and floor salts exist.

C.2_ Interventions to prevent vertical lifts

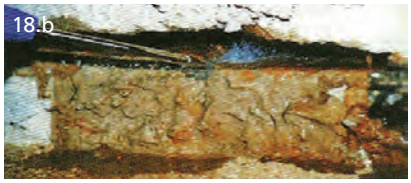
Well the new design and / or heal properly the old blocking the vertical lift at the base of the wall, preventing the wet earth to adhere directly to foundations or to a retaining wall recessed below the ground level, avoiding the accumulation of water through wells and installation of pumps.

Methods to prevent rising damp are based on two principles with its variants:

- The principle airing priory (to evaporate the water that rises from the ground and disperse it into the air before it goes up too high in the wall)
- The principle of creating a barrier to the rise of water at the base of the wall

The method of aeration prior

The aeration prior *with specific holes*, a method is introduced at the beginning of the '900 and consisted in practice about 30 cm from the ground and for almost the entire thickness of the wall and for the entire length to dry a row of through holes (8x8cm) at a distance of 50-60 cm from each other, inside of each hole was a walled tube of triangular section terracotta vacuum inside. In the long run, however, the crystals formed were deposited in the inner walls forming a waterproof layer that clog the pores and prevent further evaporation.



18_*Sequence execution of the cutting of a wall:*
a_ *Cut with saw.*
b_ *Cleaning of the cut.*
c_ *Injection.*
d_ *Blade insertion.*
19_ *Inserting the blade cutting the wall.*
20_ *Injection of the barrier to lift by injecting liquid into the wall.*

The modern version, the ventilation with cartridges, but maintains the principle simplifies the realization, instead of earthenware pipes are performed with drill holes of 16mm in diameter, inclined upwards (angle 15 °) for three quarters of the thickness of the wall, within which is inserted a tube of plastic. The method works only in specific environmental atmospheric condition.

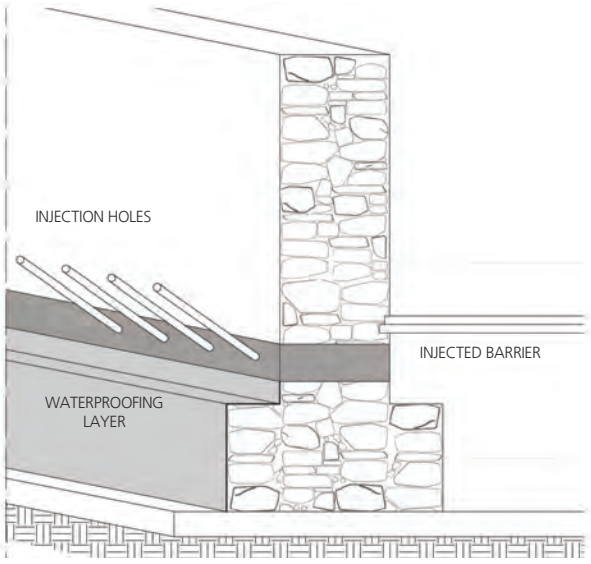
Aeration preventive crawl spaces with air-entraining is not recommended in the case of the renovation of houses of old building as it is culturally right place curbs concrete (too different from traditional materials), useless (there are better solutions), as well as technically incorrect.

The physical cut

The physical cut is a drastic intervention, definitely resolving (to be verified by the earthquake standards) and is to perform a horizontal cut at the base of the wall (just above where it is thought to reach the water) throughout the thickness and filling the tear created with waterproof material capable of withstanding the static load original.
Drawbacks: problems of a static nature, creating overlaps the waterproof layer that determine discontinuity in waterproofing, invasiveness compared to the modern theory of restoration.

The barriers injection: the liquids which are injected to stop the ascent of water are different and work on two principles: clogging the capillaries or creating water repellency inside the capillaries. Depending on the type of walls, the injection is done in different ways (it is necessary to know the texture of the wall and its porosity.

20.



The chemical barrier or chemical cutting is not an actual cutting of the wall, but it creates a chemical barrier that repels the ascent of water by capillarity, chemically forming a layer of water repellent. The resins most commonly used to form such hydrophobic layer are: Alkaline silicate or potassium, siloxanes and silicones, stearates, micro emulsions.

The filling can be done by gravity (the band is realized by practicing with the drill a series of holes with a diameter of 15-22mm, through which liquid is introduced by gravity - the limit is that you can not fill more of the apparent porosity and have difficulty filling large pores already full of water) - or pressure (the band is realized by practicing with the drill a series of holes, 10mm in diameter, through which the liquid is introduced: advantages: the amount absorbed is always verifiable and being a solvent-based liquid can be re-injected into the same holes several times).

21_ *Examples of injections to gravity:*
a) Preparation of the holes.
b) Detail of the bags with liquid.
22_ *Examples of injections for pressure.*

To restore the walls and against rising damp the system peter cox offers as solution to create a continuous chemical barrier in the wall that stops the capillary moisture.
For this purpose are used based products formulated silicone that are placed in the wall thanks to special transfusion that allow the slow diffusion in the entire area in which it intervenes, thereby intercepting the entire wall section concerned. These products bind chemically inside of the capillaries providing a hydrophobic treatment stable in time. The surgery is performed on plastered walls. After surgery, the plaster is removed to a height of 50 cm above the area where it is degraded. When the wall is dry, apply breathable macro porous plaster.

The performance of the barrier is performed according to establish patterns and consistent in their application type:

- STEP 1 Before you determine the level at which to perform the operation taking into account the height of the floors inside and outside (usually 20 cm above the floor level more high). After checking the thickness of the wall starts the drilling phase with a spating of 15 cm (normally the holes are made for the whole thickness of the wall less than 5-8 cm);
- STEP 2 It comprises the length of the diffuser tube depending on the depth of the hole and you place it in the wall, then putty each bottle to prevent any leakage during transfusion;
- STEP 3 Before moving transfusion expects the grout to dry;
- STEP 4 Transfusion of the liquid and, depending on the thickness of the wall, is calculated by the amount 'of product for each bottle;
- STEP 5 The wall is up to a height of 40-50 cm above the stain more high. If after this operation the wall is very uneven is stabilized with a rough coat of cement sand;
- STEP 6 Finally, we proceed to restore the plaster.

STEP 1

STEP 2

STEP 3

STEP 4

STEP 5

STEP 6

The active electrosmosis, or electrostatic cutting, is a phenomenon known from the mid-nineteenth century and part of the concept that at the molecular level the surface of any material is silicic charge of a negative electrostatic potential; the water adhering to a means siliceous moves, on the basis of known scientific principles, towards the negative pole. The potential is supplied by a central power supply / transformer connected to the network, making the positive and negative wall the ground water moves downwards and the wall dries.

The course has no active electrosmosis effect on non-siliceous (limestone). Rising damp is caused by the phenomenon of rising damp in the walls in contact with moist soil or groundwater. The consistency of the phenomenon depends on several factors: the porosity of the materials forming the wall, amount of water present in the soil, the presence of a waterproofing in the masonry and the ability of evaporation of the outer surface of the masonry. Unfortunately in this case the physical play against us, the walls of our homes by their nature possess a negative charge, which attracts water dispersed into the ground and goes back through the macro and micro pores are in the masonry. When one is in the presence of capillary rise, it is possible to measure a potential difference of the order of hundreds of millivolts; if we measure the voltage generated by the water during the ascent, you would notice that it is higher, the greater the height of ascension.
In fact, if the water was in his classic form of H_2O would not capillary rise since it is a neutral molecule and is not affected by the attraction produced the negative charges of the walls. The water never occurs in the form of neutral molecule, and dissociating binding to dissolved salts in the soil is affected by the electrostatic forces present in masonry, then goes back.

Among the systems based on active electrosmosis, an example is given by the "System Dehumy" which is a system that uses the principle electro osmosis generates a movement of water through a capillary or a porous due to the application of a potential difference electric.
When there is moisture in a masonry capillary rise, it is possible to measure a potential difference variable from point to point and proportional to the level of the slope, but never more than a few hundred millivolts.
The simplest solution to the problem is precisely that impose a greater potential to masonry and opposite, through the installation of appropriate facility.

This type of problem has to be solved by acting on the cause and the effects; using procedures such as plaster breathable, "cartridges anti humidity", cutting the wall and chemical barriers does not mean solving

the problem, but covers it. This system can be applied on all types of masonry and intervenes directly on the causes using electrostatic fields at low voltage, is a natural, safe, effective and easy to install, which in addition to dehumidify the walls creates an electrostatic barrier against rising damp and it prevents the return.

The solution of the problem starts on an accurate diagnosis: before the installation it is necessary to perform a precise detection of the levels of damp rising, this is possible thanks to special instruments capable of measuring the potential difference in the masonry, the temperatures of the same, the resistivity of the wall to the passage of current and the presence of any water leakage from pipes and downpipes.

The installation is very quick and definitely not very invasive.

- It realizes a small trace along the wall to be treated, usually for the execution of the groove using small ribbed double blade or in the case of stone walls shall hand. Inside the grooves can be inserted and fixed the wire electrode; immediately after the track must be closed in order to ensure a continuity between masonry and electrode. At the cable must then be applied a suitable potential difference high enough to reverse the motion of water migration.
- At the base of the wall or at least at the floor level it must be drilled a sequence of holes for the bedding of the electrodes; these are usually performed by a drill or hammer-drill and have a diameter of about 28 mm. Within the holes are fixted by beating hollow rods of aluminum inside which is conveyed the electrode. These rods must be driven into the ground and have a depth that preferably is not less than one meter. The head of each electrode should remain inspectable, and then covered by a PVC box of minimum diameter of 10 cm. Each electrode is connected by an electric cable copper to the control panel.
- At the end of installation, the system is connected to a control unit able to supply the system with the necessary voltage to reverse the motion of lift. The last step is the restoration of masonry.

Effects and consequences of the installation of the damp rising barrier

The first consequence of any cutting is that the evaporation of the saline solution now takes place in the area of exposed wall, placed under the level of the cut, and therefore at that point and for the whole length of the wall, cut there will be a high concentration of salts and resulting in damage to the wall. Intervention necessary in each barrier is therefore to keep the salts in solution waterproofing outside this band to prevent evaporation and the formation of crystals.

23_ *Diagram of an effective barrier lifts into a wall with the presence of old salts drying, the result is that the wall is degraded and the hygroscopic salts keeps it wet on the surface .*

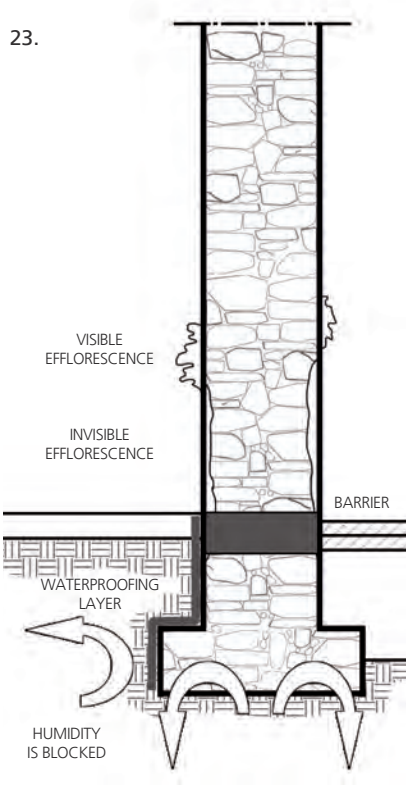
24a_24b_24c_24d_24e_24d_*Naseef house terrace.*

After the interruption of the humidity rising (via one of the listed methods) starts the drying phase and consequenially the percentage of internal humidity decreases progressively; the drying time of a wall is variable and depends on the material and its texture (t = P x s2 with time t in days, P empirical coefficient and s wall thickness in cm). The moisture moves toward the outer layers of the wall with a speed that depends on the path that takes, by the compactness of the material and the possibility of evaporation, at this stage we can observe an actual drainage of the wall. The soluble salts arrived at the surface re-crystallizes, while keeping the wall wet, though apparently dry, and the damage to the entire height of the humidity rise. The ideal solution would be to extract the salts through compresses of cellulose before performing the barrier and then continuing the application for a few weeks, after the realization of the barrier, while the wall dries.
The drying of an old plastered wall, after insertion of a barrier lift, has the same risks with the difference that in this case there is the collapse of the plaster for saturation by one level (the threshold is exceeded by 100% saturation).

C3_ Waterproofing terrace roofing

The roofs of Al Balad actually are a network of terraces. These various terraces are actually ceilings of the rooms below. Each level is therefore different, according to the height of each building and each top floor.

23.



The terraces are delimited from one another by low walls. The structure of these terraces is identical to that of the floors below.
The terraces are flat and sloped downwards, towards the lowest edge:

- Outwards, away from the walls through hollow wooden waterspouts;
- Towards the inside of the building, for water to go down glazed terracotta pipes into cisterns.

The terraces sometimes have round or octagonal chimneys, and wooden kiosks. The mortars, laid tight with metal trowels and tools, waterproof the roofing in successive slopes. The outside rim of the walls is often a little higher, surmounted with decorative crenellation work (built with masonry work or moulded), or with wooden palisades.

A very common pathology of the roofs of Al Balad is the loss or weakening of the waterproofing capacity, that could be due to several causes:

- Structural movements reverse the slopes of the roof (settlement of the ground or the masonry) leading to stagnant water and infiltration;
- Sagging floor beams lead to stagnant water and infiltration;
- Cracking and deterioration of the coating or layers of the slab, likewise: leaking or infiltration.

A thorough survey or diagnosis of the building is necessary before any works of restoration: treating waterproofing issues will be useless if the causes for the damage are not dealt with beforehand.
The minimal maintenance of a terrace requires maintaining the tight coating or rendering, since stagnating water and subsequent infiltrations are most common. The key maintenance on Al Balad terraces consists in restoring the slopes and waterproofing. Repairing can consist in fixing the slab, which must remain identical to the original, made of earth or other materials, as well as the waterproofing material.

Heavier works can be more advantageous, in terms of means and cost, when structural works are also necessary, such as implementing new wall ties, upgrading floor resistance, laying waterproofing materials that can be warranted by manufacturers and contractors.

The principles of a full scale building repair include the following stages:

- Implementing a connected floor. The slab must have an appropriate enough slope to drain water through the sheer force of gravity. Using light aggregates is best, both for loads and heat insulation;
- Laying a flexible, easily extensible, tight membrane on top of the reinforced concrete covering. There are several types of waterproofing materials: traditional layers of tarred roofing, double-layered bitumen elastomer, single layer PVC;
- Laying heavy protection on the membrane. It is important to protect the watertight facing against impact and UV. Several solutions can be carried out : aggregates, blocks on supports or studs… the simplest, most adapted in Al Balad remains a tightened slab.

The slab must be properly sloped and follow the various levels and thresholds: follow the height of the steps in the staircases between floors and between terraces. The mortar must be reinforced with steel mesh or fibers and can be improved with additives, resins, water retentive agents, damp-proof or surfacing products.


24a.


24b.


24c.


24d.


24e.

5 | Earth consolidation procedures

01_ *Kingdom of Saudi Arabia and the middle east.*

The Governorate of Jeddah is located within the Makkah region, on the central western coast of Saudi Arabia; It occupies 5,460 sq km on the Red Sea coast.
The land is mainly formed by deposits of superficial calcarenite and sand and gravel in depth.
Since the affected area consists of a formation of incoherent soils has a high permeability, the aquifer layer has probably a coincident depth with the sea level and, in any case, higher than the zone of influence of the foundations of the buildings.

A_INSTABILITY CAUSES | PATHOLOGY ANALYSIS

It is necessary to consolidate the ground to confer the land the proper physical-mechanical and chemical requirements in presence of:

- Land with poor load resistance capacity;
- Seasonal variations of the water content in the soil;
- Dehydration of the soil;
- Structural and functional transformation of existing buildings;
- Changes of the underground's hydraulic status and its repercussions on the stability of the foundations of buildings;
- Construction of buildings in the vicinity of existing buildings;
- Exploitation of residual areas of the urban system;

The presence of water in the soil is one of the main causes of failure. In cohesive soils the water binds to the soil in the rainy seasons, only to suffer the changes in abundance and distribution in times of drought.

This effect leads to a cyclic change in volume of the foundation soils that in rainy periods tend to 'swell' increasing their volume, and then 'shrink' favoring a lowering of the building above, urging land mechanically according to a logic that is not compatible with the structural possibilities of the buildings. For this reason the structures initially deforms plastically and then collapse unveiling damages which are more or less significant according to the magnitude of the phenomenon in place.

Similarly, when a land is of granular type the presence of water inside is once again crucial for the stability of the building. In fact, the phenomenon of strong washing involves the removal of the fine part of the foundation soils which in turn freeing spaces allow a lowering of the foundation structure to a new static equilibrium.

Not only rain and natural phenomenon with the presence of water are causes to these phenomena but also loss of sewer and water collection facilities adjacent to the house, often overlooked in their routine maintenance.
The progressive deformation of a soil always involves a decrease in volume and is manifested in different ways depending on the type of the same. If in the pores of the soil is present only air (granular soils such as gravel and pebbles) the volume change occurs quickly because the air, which is compressible, can flow out quickly. If the soil is saturated (silts and clays), since water is incompressible, the volume change is generated as a result of its expulsion (phenomenon of filtration); this requires a long time in relation to the permeability of the soil. In partially saturated soils initially happens the expulsion of the air and only then will establish a

phenomenon of filtration with expulsion of water from the pores.
It could happen that the soil has dehydration problems. Obvious sign of dehydration are cracklings that are visible in the fields during the summer; these have a three-dimensional development and create discontinuities, which under the weight of a building tends to close and to 'lower' the terrain and structures that is upon it.

Dehydration can be affected by several factors:

1) Exposure to South/South-West in relation to a major solar radiation that increase evaporation.
2) During dry periods an adult tree can absorb up to 300 liters of water per day from the ground, consequently in situations characterized by strong sunlight trees roots moves in portions of soil where evaporation is less effective, such as under the foundations of a building.
3) Buildings generally exerts pressure on the surface where they insists deforming the structures.

B_METHODOLOGICAL PREMISE

The planning of a restoration or structural consolidation of a building must take into account the stability of the construction, this does not only depend on the characteristics of the structures in elevation, but is closely related to the reactivity of the land where it insists and the mechanisms of interaction between the soil and the structure.

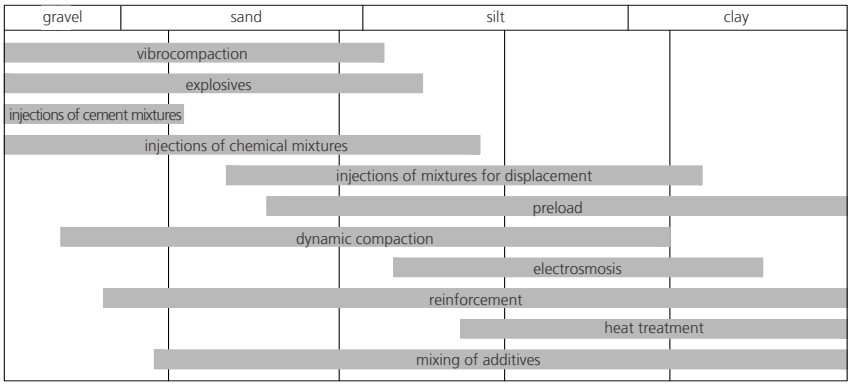
The methods and the reasons of an conservative intervention are aimed to modify the soil properties such as mechanical resistance, deformability and permeability, or to modify a volume of soil by introducing in it elements formed from other materials with mechanical and physical characteristics such as to obtain a proper resistance or reactivity. The techniques of soil improvement can roughly be divided into four groups:

Mechanical changes: the soil density is increased by the application of external mechanical actions in the short term, such as the compaction of the layers of the surface by rolling or vibrating plates, and the deep compaction by dynamic hammering on surface or in depth vibration.

Hydraulic changes: forces water to exit from the soil. In coarse-grained soils with good permeability this is achieved by lowering the level of the water and also using drains systems of various types, while in the fine-grained soils with the application of an external load (preload) or electrical forces (electro kinetic stabilization).

Physical and chemical changes: improves the characteristics of soil consistency by the usage of various additives in the surface layers or more deeply with columns of soil. The additives include natural soils, industrial products or waste materials, and cementitious products and chemicals that react with each other and/or with the ground. The heating and freezing of the ground are both considered methods of thermal change. The heating evaporates the water and cause permanent changes in the structure of the mineral soil, freezing, however, solidifies in part or entirely water and binds together the individual particles.

The various methods also differ in their applicability to certain types of land rather than to others, as you can see in the figure below:



This classification of the techniques of intervention in the soil has, however, a certain degree of arbitrariness since quite often has a mechanical, hydraulic, physical, chemical factors combination. The feasibility of a particular intervention is highly dependent on the type of problem at hand: a foundation, an embankment on soft ground, an unstable slope, an excavation, a structure considered in land, a dam with water, or a reservoir, etc.

The purposes of the improvement of the ground or the earth as a building material are as follows:

- Increase the resistance and decrease erosion
- Decrease the deformation under stress (increase the effort form deformation)
- Reduce the compressibility
- Control the shrinkage and swelling
- Modify the permeability, reduce pore pressure
- Prevent any physical or chemical changes caused by environmental conditions
- Reduce the susceptibility to liquefaction
- Decrease the natural variability of quarry materials and land

In order to decide how to intervene in the restoration of a land subsidence should always first perform geotechnical survey, the level of detail of the survey will be from time to time depending on the type of work and the complexity of the situation.

The geotechnical investigation shall provide data on:

- Succession of soils present in the subsurface around the significant volume;
- Physical and mechanical properties of soils;
- Hydraulic characteristics of underground.

In order to:

- Rebuild the soil stratigraphic and define its physical and mechanical properties;
- Ascertain the depth and the state of motion of the water may be present in the subsurface.

For the determination of physical and mechanical properties of soil it must be collected samples that preserves the structure, water content and texture of the soil in its own location. The evidence obtained by survey investigations (constitution of the soil, groundwater regime, physical and mechanical properties of soil, etc.) must be designed to outline the complex natural situation in order to rebuild a ‘model’ of the subsurface.

C_DESCRIPTION OF THE INTERVENTIONS

C.1_Mechanical modifications

By the terms 'mechanical modification of soil' refers to densification of the interested ground by the application of external forces.

The **compaction** (or *compression*) indicates the susceptibility of the terrain to vary the volume only to effect the expulsion of the air in the voids and has as a direct consequence a decrease of void volume of the same and an increase in the density of the soil. It's an irreversible phenomenon just in granular soils that runs out quickly and can also be caused mechanically. This procedure implies that the soil particles are compacted by the application of high loads and sudden or dynamic forces; this densification shall be accompanied by crushing of grains of soil or rock particles.

Superficial compactation

The development of compaction equipment surface has led to a wide variety of instruments, with different shapes, sizes and methods of use. The compaction in the pipeline can be performed with equipment that act on the lands with actions:

- Static;
- Compression and cutting;
- Dynamic, impact or vibration.

The work done by the external forces applied on the surface of the soil with machines leads to compaction. The total energy supplied by the machines can be divided into wasted energy (heat, friction, etc.) and in useful energy to obtain elastic and plastic displacements of the soil. With the repeating of this action of mechanic plastic deformations, including internal ruptures, the mass tends to shrink while the elasticity increases with a proper densification. For cohesive land action it is effective only statically, while with predominantly granular soils and inconsistent compounds the effective action has to be dynamic too. Influence on the reactivity, in addition to factors related to the action of the machine, are related to the situation of in the ground (such as shear strength, compressibility, capillary tension, conditions of air and water in the pores, etc.).
The compaction equipment, depending on the choice of one of the both types of action, can be divided into two classes and may consist in predominantly static or mainly dynamic:

first class: smooth rollers, roller or wheel, roller tips and rollers grids;
second class: vibrant plates, vibrating rollers and impactful rollers.

Deep compactation

If it is to consider a passage from a surface compaction to a deep compaction the soil involved may be saturated and be affected by injections of water or by partial replacement of the original soil. The in depth soil densification is achieved with the following techniques:

- *Pre-compression:* an area is pre-loaded by a load or of lowering of the level of water, and this causes soil consolidation. This technique is usually reserved for cohesive soils; their consolidation is a long term process, unless the longer drainage paths are not reduced through the installation of pillars of sand, wicks of paper or geo-composite draining. Since the success of pre-stressing depends essentially on the hydraulic parameters of the soil, this intervention is considered a method of hydraulic changing. Pre-stressing is one of the few viable techniques for clay soils and permeable soils this technique is less economical than other methods.

- *Explosion:* consists into detonating explosives, on the surface, or more frequently inside a series of holes, which causes the collapse of the soil's structure and consequentially results in a more compact structure of particles. The final density can't be achieved immediately since the dissipation of interstitial overpressure employs a bit 'of time to occur. The dynamic load transmitted with the explosion is more appropriate for less permeable sands, but can also be applied in silts and clayey sands.

- *Heavy tamping (hammering dynamic)*: a heavy mass is dropped from several meters in height on the surface of the deposit, sometimes causing compaction and consolidation of the soil in the long term, therefore, this technique also takes the name of 'dynamic consolidation'. The dynamic load transmitted with heavy tamping is more appropriate for slim sands as less permeable types, but can also be applied in silts and clayey sands.
- *Vibration.* The densification is achieved through the vibration of a probe or a post, possibly facilitated by jets of water or air under pressure, and the addition of granular material with sometimes cementing agents. The vibration is suitable for loose soils free to drain.

- *Compaction grouting (injections compacting):* a grout is injected at high pressure into the ground, causing the displacement and the densification of the surrounding terrain.

Vibro - substitution

Gravel columns are realized in cohesive soils, with typical dimensions: diameter between 0.7 and 1.2 m, length of 5 to 14 m (although sometimes also coming to 20 m) and have a distance between 1.5 and 3.5 m.

Propose to:

- decrease the total and differential subsidence;
- reduce the time of drainage and then increase the speed of failure;
- decrease the potential for liquefaction;
- improve the stability of embankments and natural slopes;
- increase the bearing capacity of shallow foundations (footings, beams and slabs).

The granular material is inserted through three techniques:

- *Vibro flotation* (from which the name of vibro-substitution): the vibrator in the ground creates a cylindrical cavity which is filled with coarse-grained material, such as gravel and crushed aggregates, which in turn is compacted by vibration. Sometimes, instead of a probe in full section, vibration of a hollow tube, also with the help of water or air under pressure; while the instrument is withdrawn are lowered inside crushed rocks or pebbles, which are then compacted. This method 'to lower feed' is increasingly preferred to other techniques of vibro replacement.

- *Japanese technique* with helical auger more suitable soils susceptible to liquefaction. The tube-shaped (hollow steel cylinder) has a protruding wing that is wound helically along the shaft and facilitates the insertion into the ground. The material is placed and compacted inside the tube shape when the latter is extracted.

- *Tubular Poles:* steel pipes are vibro poles or beaten and then filled with gravel during the extraction tube shape. The inserted material is compacted by a compactor, which moves vertically inside the tube. With this technique are also realized columns in cement mortar (Vibro Cement Columns).

C.2_ Hydraulic modifications

Soil consolidation process through electro osmotic (technique used in Jeddah)

To solve the problem of dehydration solutions it has to be considered to adopt expanding resins and foundation structures consolidation.

The resins have a fundamental limit: to revive the walls are centered on a plot itself already stressed that still tends to dehydrate. This means that every time that the hydration of the soil decreases, the land and the resins cease to move integrally with them. An intervention as structural overhaul, micropiles and piles is very invasive and highly destructive; often they haven't the space to operate in a appropriate manner and then we had to settle for a partial intervention.

The proposed product is called '**hydrater**' and uses electrostatic fields at low voltage; it is a natural, safe, effective and easy installation which, in addition to rehydrate foundation soils, is able to maintain a constant level of humidity throughout the year, even during the drier seasons.
This prevents the occurrence of that movement to 'accordion' caused by shrinkage and swelling of the soil leading to the opening of cracks during the driest periods and to close them during the wetter seasons.

The **electrosmotic process,** discovered and studied since the mid-800, consists in obtaining the migration of water and salts dissolved in a porous medium by activating the flow with the application of a continuous electrical field. The passage of electric power in the cohesive soil consists essentially in the migration of the ions present in the fluid, in particular the cautions coordinate water molecules and migrate towards the cathode.
The diffusion of salts acts mainly on the electrolyte fluid in the pores and then scaffold particles of clay, while the electro osmosis generates transformations in the interlayer of clay minerals 'open', blocking its reactivity.
In nature, the process occurs spontaneously when cohesive materials of different nature and humidity are in contact: in this case, it generates a potential difference which tends to migrate to the water from the material to the higher potential to the one with the lowest potential.
The hydrater system, through the electrostatic field that it generates, conditions the natural motion of the water and convey it so that rehydrate the soil underlying the foundation plan of the buildings.
This allows the dehydrated clay that has lost much of its original thickness, to recover part of its natural water content and keeping it constant throughout the year, irrespective of seasonal variations.

02_ *The images show the implementation of the system:*
a) track in the ground for housing electrodes;
b) the installation of the timer for the water supply;
c) the control unit for the supply of current to the system;
d) Complete Works.

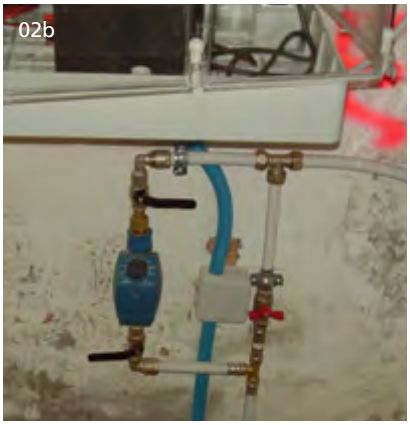
The methodology of the intervention is non-invasive and allows the protection and respect of the environments present, especially in urban areas. The system acts directly on the causes of dehydration.

Before beginning work, it is necessary to have a precise geological picture of the area: the solution of the problem starts from an accurate diagnosis.

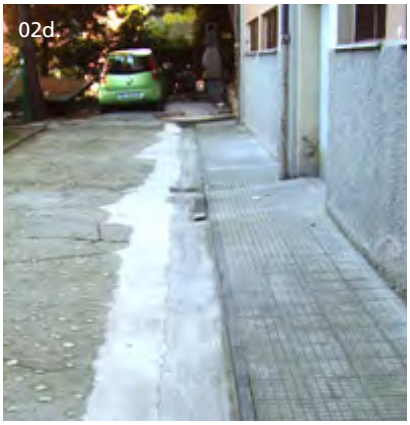
The installation and commissioning of the system has working steps very similar to those required for exposure of an irrigation system and the disturbance is minimal:

1) you run a trace in the ground around the perimeter of the building on which it must act in which you create the space for the laying of the electrodes.
2) after the installation of the cables we proceed with the installation of the timer for the water supply and the control unit for the supply of current to the system.
3) the final product is a plant safe, effective, environmentally friendly and above all completely disappeared.


02a.


02b


02c.


02d.

C.3_ Physical and chemical modifications

Consolidation of land by the usage of expanding resins (technique used in Jeddah)

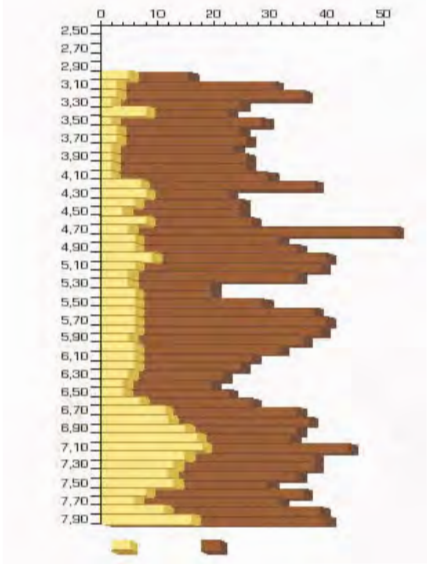
Land's consolidation is the improvement of the characteristics of the soil in situ. Depending on the objective to be achieved with the consolidation of the land (improved permeability, increased resistance, etc.) are used a number of techniques: drains, injections, mechanical mixing and dynamic compaction.

In recent years the consolidation of land with resins was matched to traditional technologies: the detailed implementing rules are relatively simple and do not require excavation invasive or problematic connection systems for the solidarity existing and new foundation works.

Conducted a careful review of the possible presence of buried lines (gas, water etc.) Are performed holes of about 25 mm in diameter at the foundation to a depth considered significant in relation to land and work seabed; is inserted into the hole in a copper tube connected to a gun in turn is connected with the compressor general; the application involves the injection into the ground, at low pressures, resin deemed appropriate high pressure expansion. At the time of injection, the mixture develops an exothermic chemical reaction that causes the change of state from liquid to solid with a consequent increase in volume related to the development of an expansion force.

This phase is particularly delicate, is monitored with laser instruments and the fissuring that allows to control the process of consolidation of the ground at all times; after a few hours the resin reaches the final expansion and the ground immediately assumes new geotechnical characteristics with compressive strength well above the pre-injection.

03.



The method provides that the resins are expanded by that much needed to fill the pores of the ground by giving the same a very high compressive strength, without causing additional damage to the walls and floors. The effectiveness of the resin is maximum in granular soils decreasing gradually in the range of fine particles (clay).

The resins used are of the type one-component polyurethane and/or two-component, are specifically designed and formulated to solve all the possible situations that may be encountered in the consolidation of the land of all kinds; are lighter soil and therefore do not weigh down, also have an elastic modulus similar to that of the land, varying from 15 to 85 MPa depending on the density. The two-component resins and resins single component are designed and made in respect of the ecosystem and safety of the environment; once hardened resins assume characteristics of simple

inert without creating pollution effects to the surrounding environment and do not change their behavior even when used in the presence of water.

Notice the number of strokes of the dynamic penetrometer clearly superior to the right (in green, trial post injection) which indicates a better densification of the soil obtained thanks to the action of the resin.

Before and after the intervention it should be performed by dynamic penetration tests adjacent to the foundation and/or geophysical surveys (GPR) that allow you to view in section geometry of bodies injected determine the lateral extent and depth. During the expansion of the resin laser pointers precision control in continuous lifting of the structures.

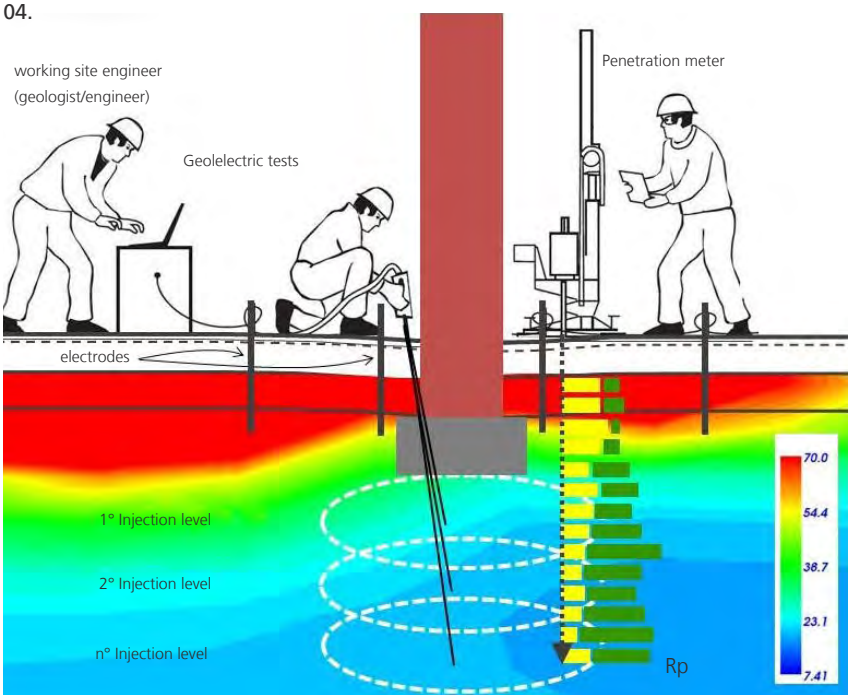
Jet grouting

Among the methods for improvement in physical and chemical changes includes the jet-grouting (or blasting injections) with which are modified in the site characteristics of the ground using the effect of fluid jets at very high speed obtained with high pressures to break up the soil and mix or even replace it partially with a stabilizing fluid formed by a mixture of water-cement.

This system originated in Japan around 1965, has established itself within a few years in all European countries and American technology.

The reasons for the rapid development of this technique are to be found

04.



03_*Penetrometer.*

04_ *Schematic of the operational phases.*

in its versatility; if it is necessary to deal with fine-grained soils or otherwise closed, in fact, the traditional systems of consolidation or waterproofing for impregnation, compacting, have significant limitations for technical or economic, and can also lead to serious pollution problems. These techniques, mixing the soil directly on site with cement, can treat these formations so homogenous, continuous and non-polluting.

The technology of 'blow grouting' involves injecting, through perforations of small diameter (from 7 to 10 cm) controlled volumes of cement mixture in controlled volumes of soil. The treatment can be performed with three different methods, the first two perfected in Italy, the third of Japanese origin:

1) *Injection of mixture only* (system mono fluid): the disintegration of the ground takes place through the action of the cement mixture which also has the function of stabilization;
2) *injection of air, the mixture* (system double fluid): the disruptive action is still entrusted to the jet of the mixture at very high pressure, but this is driven by a compressed air to about 8-12 bar, which limits the dispersion increasing consequently, the penetrating power;
3) *injection of air, water and mixture* (system tri fluid): the function disintegrate is instead assigned to the action of a jet of water (about 400 bar) to guide air (ca 5 bar) that realizes a breakdown process and de - caving soil completely independent of that injection. The subsequent layer of the mixture, which occurs with pressures of the order of 50 bar, replaces the excavated soil with the stabilizing mixture.

The operations necessary for the execution of blow grouting mono and double fluid, which are the most used system, are divided in two main phases:

1) *Step forward or perforation*: where you put in the ground the battery auction, bears the valve gate nozzles, to a depth of treatment required by the project.
2) *Return phase or presentatio*n: the battery auction is extracted in ascent and angular programmed while making the injection of the mixture through the nozzles.

Blow grouting can be used in all granular and cohesive soils in those presenting shear strength such that once they reacts to the blow pressure. This offers the considerable advantage of being able to treat heterogeneous soils, ensuring consolidation and waterproofing uniform regardless of the nature of the soils encountered. The presence of water under hydrostatic not in any way compromise the results of treatment, in the hydrodynamic

regime, however, the use of special measures such as the use of accelerators has allowed to obtain good results even in the with 0.1 cm/sec velocity.

The planning of an intervention of consolidation of the soil by jet grouting must be developed through the following stages:

- execution of the preliminary investigation on the ground and test fields;
- choosing the type of mixture and operating parameters;
- choice of the geometry and dimensions of the treatments;
- identification of the mathematical model best suited for the study of evolution of stress and deformation;
- choice of control systems.

After the treatment you perform load tests and tests of coring sonic to verify the improvement of the mechanical characteristics, the continuity and the possible penetration of columns.

Thermic treatments

To this category belongs the methods of freezing and heating the soil, but while the former are necessarily temporary, in the ground causing an effect that lasts for the time of application of cooling, those that realize the cooking of loose soil can be regarded as definitive, making the ground a structural change almost permanent.

The heating of a soil causes a considerable energy consumption. At a time like this where the cost of energy and air pollution are ever increasing, interventions cooking of the land on a large scale are not very common, except in very special circumstances: a special situation can occur when the soil already contains the fuel, either by nature or in the form of waste products.

Heating

The thermic consolidation of the soil is a practice applicable to clay soils (of which causes a real cooking) forming in them columns of heated material which final mechanical characteristics greatly changes.

The first experiments of this technique for land's improvement has been done back to the thirties in Australia, where it was attempted to improve the mechanical properties of road foundations heatening the masses. Heat is generated by burning liquid fuel, gaseous, or solid; can be distinguished treatments with heat transfer from the contact surface and treatments with heat transfer through the holes and wells (which can be forced circulation - closed type - or to draw free - open type).

By heating it changes moving in the structure of clay minerals, such as to make irreversible the phenomenon of expulsion of water, reaching an upper limit of the heating temperature in which they occur the first characteristic traits of the merger of the clays.

The temperature ranges which occurs modifications of the structure of the clay soil can be considered comprised between 350 and 1000 ° C, a temperature at which they begin to manifest the first liquefaction phenomenon with consequent reduction of the permeability to cracking which occurred at lower temperatures. With the temperature increases the compressive strength of the clayey soil Treaty which can reach considerable values.

Freezing

The technique of freezing of soils for geotechnical purposes has grown from about 40 years; Was done in a very rudimentary way in a mining to block pulverization of granular materials which were waterlogged. Freezing ground is used when you need to perform an excavation in difficult terrain and in static conditions of danger. Lowering the temperature of the soil up to its freezing point is attributed to it a high degree of cohesion, which greatly enhances its resistance to compression.

The effect of freezing is unfortunately reduced in time and it is thus necessary continuously for the duration of the work to the repeated cooling of the soil to be treated. These operations involve a substantial cost and their programming must be done with the utmost precision to avoid any possible waste.

The freezing of the soil can produce side effects, often unintended and which should be followed. The first is that of a general swelling of the treated soil, which can become dangerous for the integrity of the structures involved in the treatment.

The second effect comes from the fact that the land subject to freezing show a significant deterioration of their geo-mechanical once thawed.

Freezing, to effectively control these effects, match then interventions consolidating injections, which make it more stabilized the composition of the soil to be treated.

The land that are more influenced by freezing procedures are sands and generally granular soils; clay soils can't endure freezing, will fail to show improvement in their geo-mechanical properties of the same order of magnitude of sandy soils.

During the freezing of the ground not all the water contained in it is transformed into ice, but a significant part of it is kept in the liquid state; Also for this reason, clay soils present greater volumes of free water, compared to sandy soils treated with the same temperatures and which have the same degree of initial water saturation.

The mechanical behavior of the frozen soil is comparable to that of a body with elastic-plastic with plasticity viscous type.

The current techniques for freezing can be linked to three different types:

- *Direct method* is also known as open-loop method and is adopting the lower temperatures (-194 ° C). Is accomplished by pumping liquid nitrogen within appropriate probes inserted into the ground to be frozen by means of normal perforations. The liquid nitrogen is brought to the site with insulated tanks and transferred to tanks with the same characteristics of the insulation, in which is maintained with pressures not exceeding 1 MPa;

- *Indirect method:* this system will adopt real refrigeration systems that allow to produce a circulation of coolant in the soil. Temperatures reached by this technique are significantly lower than those characteristics of the direct method, they are around -25/-30 ° C;

- *Mixed method:* it is achieved with the combination of the two previous methods, thereby taking advantage of the high capacity cryogenic liquid nitrogen (direct method) that enables the quick creation of the freezing of the soil and the maintenance of low temperatures with the indirect method at acceptable costs. The two methods are then conjugated using always the same freezing pipes and binding appropriately lines adduction of coolants.

The types of intervention, as already mentioned, can be many, but we must keep in mind the two very negative aspects of the process: the high cost of implementation which adjoins the use in geotechnical problems really can't receive the most economical and consistent induced structural changes in soils in which this method is applied (at the end of the freezing relaxations with loss of cohesion and increases the volume of the frozen materials that occur during treatment).

6 | Preservation and restoration interventions on structures and constructive elements

Foundations consolidation

The foundations of buildings, when they exist, are usually laid on limy and sandy ground, containing a large amount of silt and coral fragments.
On the level of the foundations, the ground has a bearing capacity of 1,5 kg/cm²; the constraint under the very foundation can be slightly higher, due to a compaction and consolidation of the ground during the construction phase.

The foundation do not constitute a particularly special element, they are identical to the wall they support (stone masonry laid with earth mortar) but they go down into the ground, at an average depth of 0.70 to 0.80 cm.

01a_01b_ *Bab al Bunt foundations*

A_INSTABILITY CAUSES | PATHOLOGY ANALYSIS

The foundation's instability of a building hardly is referenced to a technical error in the designing or construction phase, in these cases the building would crumble in short time. Damages that formed immediately after the construction may have been originated by foundation settlement that now has stabilized, instead if the cracking phenomena are recent, or worse, in progression, you need to take urgent precautions.

The cause of foundation damages could generally be :

- In the changes that may have altered the terrain characteristics (settlements, changes in elevation of water tables, new loads surrounding etc.)
- In the same elevated structure of the building, which changes (elevations, construction of new interior walls etc.) may have changed, even during a long period of time, not only the entity of the load borne by the foundations, but also its distribution.
- In the deterioration of the foundations structure, meaning materials (stone, bricks, concrete), or more often of binders, rendered incoherent, for example, infiltration of chemically polluted water.

B_METHODOLOGICAL PREMISE

Prior to any intervention it is necessary to check the consistency of the foundation structures and the nature of the terrain; to ensure this information it shall be necessary to perform assays in adherence to the perimeter walls which dimensions shall allow a hand excavation and an easy extraction of the resulting material (at least 100-150 cm). The excavation work shall be related by temporary works related to the nature and composition of the soil and the depth to be reached.

Structures that are not efficient shall be pre-consolidated by partial reconstruction of the masonry and foundation structures or with cement injections.

Once completed the excavation it shall be possible to make a detailed analysis of the structures that shall be provided with geotechnical and geophysical information of the terrain's nature. The depth of investigation shall be related to the load and the width of the foundations in order to verify if the nature of the failure is attributable to the compressive strength of the surface layer, the consistency of the underlying layers, the presence of groundwater or other causes yet.

Only after the execution of assays, both in the soil (geological surveys) as of the foundation itself (conservative status, control of horizontality, deformations measurements, etc.), and after a careful analysis of the results it shall be necessary to define on which part to proceed with a methodology of intervention:

- Located on the ground where the foundation works;
- On the foundation structure;
- On the ground and foundations, simultaneously and in a coordinated manner.

The operating procedures of consolidation must not alter the stability of the wall system to be consolidated or of the neighboring buildings, it shall be necessary to take care to this as to take any measure and precaution useful to ensure the safety of the construction.

C_DESCRIPTION OF THE INTERVENTIONS

C.1_ Ground consolidation

This solution is certainly the most desirable because, aiming to solve the problems at the source, rules out any direct intervention on the structures, ensuring maximum possibility of conservation. This choice is only possible when the failure is caused exclusively by seabed subsidence of the land on which the structure insists.

The consolidation of land produces an overall improvement of the land base. To traditional technologies (micro, underpinning) was joined in recent years with the consolidation resins under the least expensive of the times much shorter construction, the possibility of working inside the building even without producing any damage. But it can't control how and where the resin expands and obtain a homogeneous compaction.

For in-depth description of the different techniques, see the chapter dedicated "earth consolidation procedures"

C.2_ Consolidation by extension of base

If, after the treatment of soil and groundwater, it still is necessary a direct intervention on the structure, and if the usual works of unstitching and sewing (see section "historic masonry restoration") and compensation of the fissures with traditional materials and methods are not sufficient to ensure an adequate stability, it can be the case to build a new foundation alongside the existing one.

With an even ground, the load-bearing capacity of the foundation is greater the larger the surface area is and the deeper it is. To increase the bearing capacity of a building's wall foundation remaining adherent to the traditional technology and to its "logic", you can broaden the base of the foundation and deepen it.

The purpose of the intervention:

- Distribution of the load over a larger surface;
- Reduction of the contact pressure of the soil-structure.

It is a complex intervention but still feasible that should be performed by subsequent site steps of excavations on the sides of the building and, if it is necessary and there is the opportunity, even in the masonry underpinning. It proceeds by successive sections, waiting for the setting and curing of

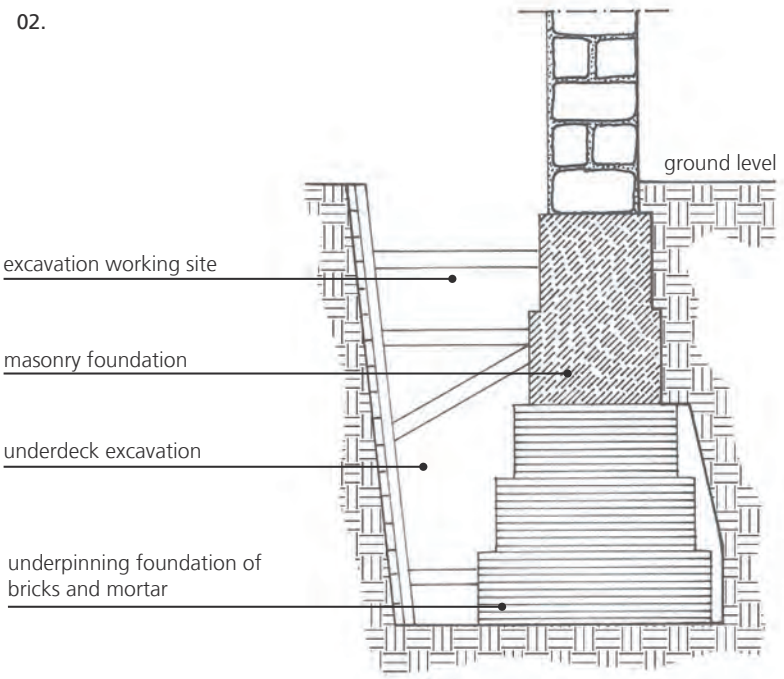
the mortar of a section before proceeding with the next scheduled service, replacing the soil to support the foundation of the new wall that shall reach deeper and wider as to increase the support area. The new masonry shall be compact and present with minimal mortar joints so as to reduce the effect of the withdrawal of the mortar itself. Just implemented it is obviously not operational, it shall be set in operation by steps with small subsidence of the loads as to avoid significant damages to the wall above.

The enlargement of the base can also be achieved by inserting two concrete edge beams, jointing together to the sides of the original structure.
To start it shall be necessary to perform an excavation on the side of the original foundation to create two abutments on the foundation flanks in reinforced concrete, which are then connected in sequence by steel beam profiles or joists of reinforced concrete, the ends of which are then drowned in two lateral edge beams also made of concrete. The steel cross connectors must be stainless because it is protected from moisture in the wall by capillary rise.

This solution is the most adopted for reasons of practicality and resistance, the beams of reinforced concrete, however, require large installation areas, then excavations along the perimeter of the foundation, and consequently the execution of works consisting of shoring also in the parts of the building elevation.

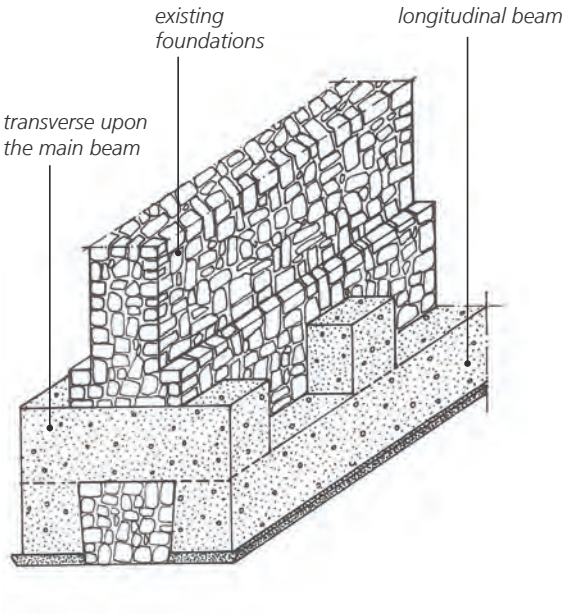
02_ *Bored cast in place piles on.*
03_ *Armored concrete built on the flank of the existing foundation connected by overlaid beams.*
04_ *Armored concrete beams connected by transverse elements and pre-compression of the ground.*
05_*Consolidation phases realized with thick armored concrete piles.*
06_*Underpinning foundation with concrete micropiles driven and cast in place with steel armor*

02.

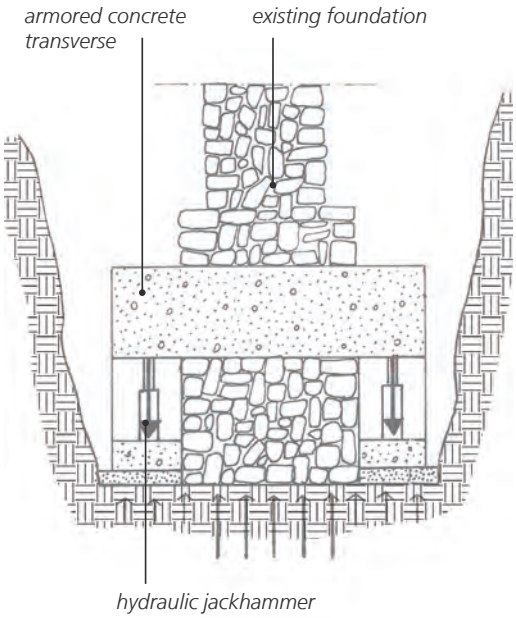


It is a rather invasive intervention since it involves numerous perforations and provides a technology far removed from the original. The parts added, then just run are exhausted and rest on land not yet compacted by the load, thus begin to "work" the first failure of the original foundation. It can "pre compressed" in the initial phase of subsidence the load controlled by hydraulic jacks which are incorporated in a concrete casting shrinkage.

03.



04.



C.3_ Consolidation of foundations with piles or micropiles

This type of intervention falls within the underpinning type of operations, in this type of support system placed under the lower floor of the foundation wall which allow the transfer of loads to the soil layers of greater strength which, because of their depth, are not attainable with normal foundations.

Once done with wooden poles, often pointed by metal cones fixed in depth and clinched up till the pile refuse ulterior hammering, today are made with reinforced concrete piles, which can be:

- of large diameter (40-80 cm)
- small diameter (8-20 cm)
- made by series of prefabricated portions of piles, to be inserted in succession below the foundations with the aid of hydraulic jacks (static piles).

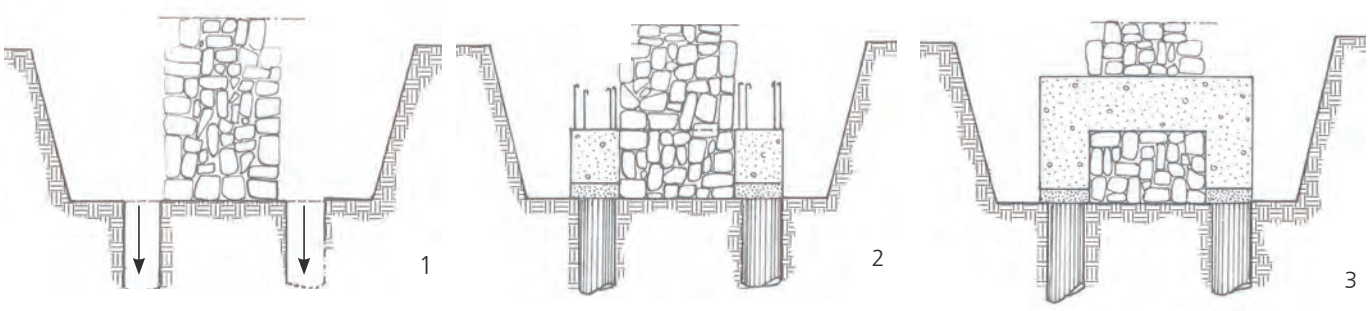
The technique generally used involves the implementation of piles of small diameter, but should be evaluated from situation to situation depending on the type of existing foundations and soil present. Micropiles are inserted without performing any excavation, perforating the rock bottom by the two facing walls in two directions symmetrically inclined respect to the vertical and drilling in the ground to the depth required to reach the soil layers that exhibit a sufficient mechanical resistance.

A common arrangement provides two rows of inclined piles, arranged alternately with respect to the section of the wall in the plant. Inside the holes it is positioned the steel reinforcement and then cast the cement so as to have armored piles that reach in depth the resistant soil layer or works by friction which by the contact of the pile sides and the soil. It is then the step to set the "reinforced earth". The heads of the upper piles has to be interconnected by a horizontal beam which shall be well connected to the masonry.
A solution sometimes adopted is to realize two horizontal edge beams, on each side of the wall and connect them with rods by transverse perforations.
The details of this techniques are complex structural nodes, that must avoid the support of the masonry wall transfers on punctual supports in correspondence the cross connections, where it would have very high concentration of loads, with consequential risk of collapse. At the first subsidence in fact the loads shall concentrate in the most rigid zones and therefore less deformable, which are the piles.

Contraindications

- operation practice far from the original constructive, functional and philological logic of the historic walls of the building
- creates support areas limited to particular zones which are excessively rigid, where the loads would concentrate
- irreversible and destructive, involves the drilling of the original foundations and hopelessly perturbs the soil

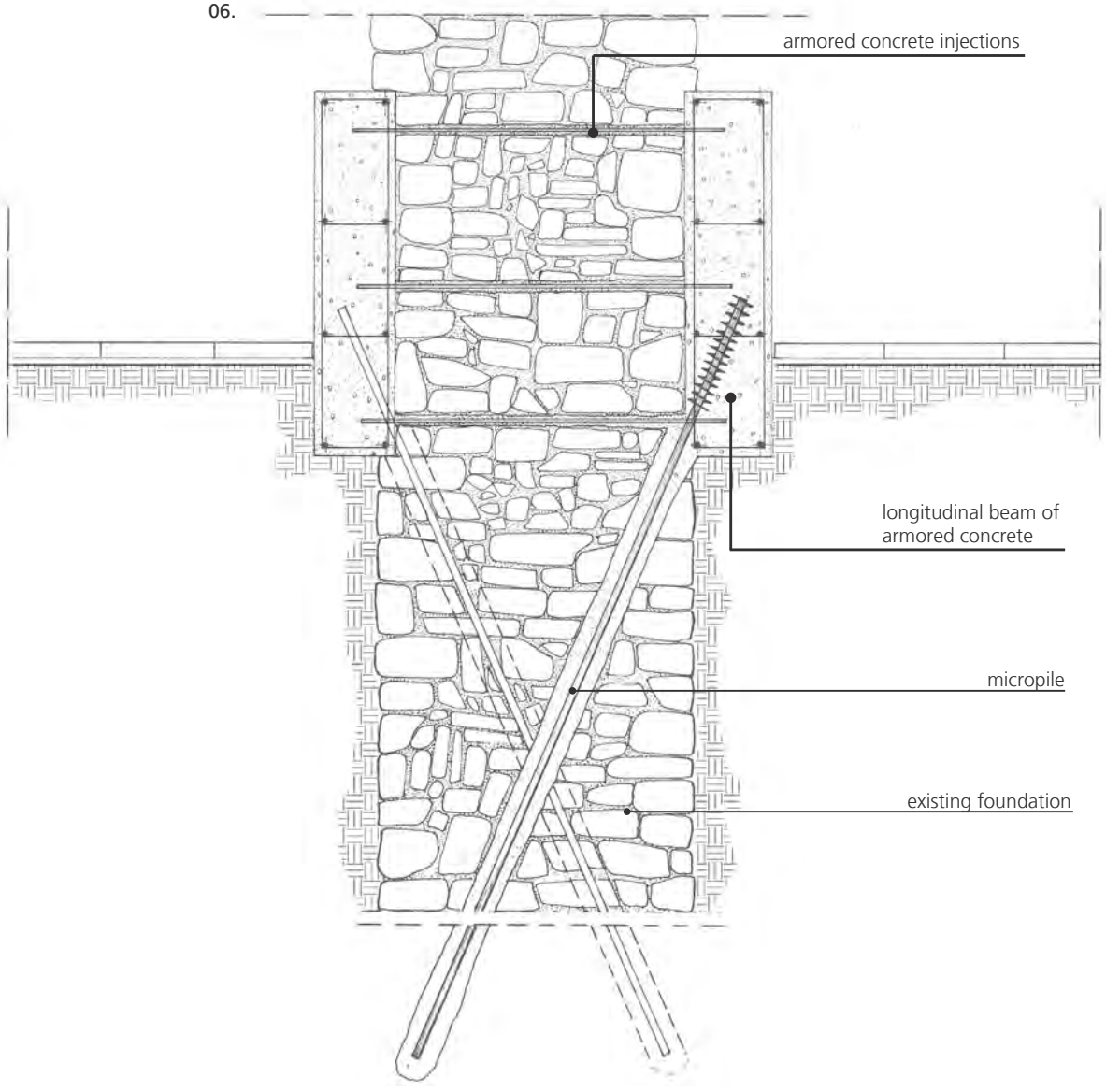
05.



Benefits

- minimally invasive than traditional systems: demolition is minimized; machinery for the implementation are very small, it can also work with internal manual equipment; no need for extraction of sludge.
- connection-pole structure effectively guaranteed.
- fast construction: not installation of any site; interventions are 50% shorter than the normal timing.
- preload and lifting of the structure with recovery of subsidence.
- testing with loads during construction of each pole.
- cost reduction.

06.



Historic masonry restoration

Traditionally, builders have always used materials and resources locally available. Thus, in Jeddah, masons used Mangabi stone, a very porous coral limestone with low resistance. To overcome its disadvantages, masons used to insert wooden wall lies, (lengthwise and as header-binders) to consolidate the walls. They also rendered the wall facings to protect the soft stone from erosion.

As the stone blocks were rather small, double facing walls were preferred, laid with lime and earth mortar, filled with earth and smaller modules. The stones were rough-hewed: only the visible face was really dressed.
Equipments and tools stayed simple and basic on the construction site. Everything was conceived for resources and means to remain affordable. The construction of the walls was quite methodological, using the cubit as the measuring units; the 'height of the masonry between two ties' was of four cubits.
The first masonry unit was the height of the wall, from the ground to the supports of the windows and roshans. The second unit reached the level of the lintels of the doors and the third was the lintels of the roshans. At this stage, the floor was laid on the first level. Then, the fourth unit went up to the supports of the roshans of the first level. Every unit was linked


01a.


01b.


01c.
1a.

to a particular element. All the units were crowned with wooden ties, to ensure wall stability.
Walls were built on foundations that were dug in the ground, roughly the same width as the walls. On the ground floor, the thickness of the walls reached 70-80 cm. This thickness thinned down floor by floor (10 to 15 cm), as the top floors were less load bearing than the first levels.
This proves that builders had an extensive knowledge of the performances of their materials and the reactions of their masonry; they developed elaborate practices through centuries of experience and craftsmanship, combining simplicity and economical intelligence, in an architecture that successfully adapted to stringent climatic conditions.
Nothing was left to chance.

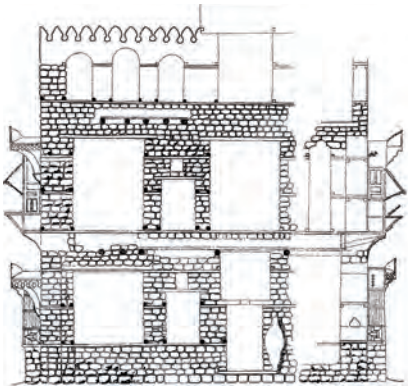
01a_01b_01c_01d_ *Buildings in the historic center of Jeddah with the masonry pattern visible for the plaster detachment.*

Roshans could be connected to the masonry, thanks to wooden ties, distributed regularly along the openings (at the base, in the middle and at the top). As the teak structures were heavy, the overhang on the street was limited, whereas they developed all along the façades. The floor, whose thickness was also a cubit, was laid on the roshans that overhung onto public spaces. The size of structures (or rooms) was limited by the available length of the beams.

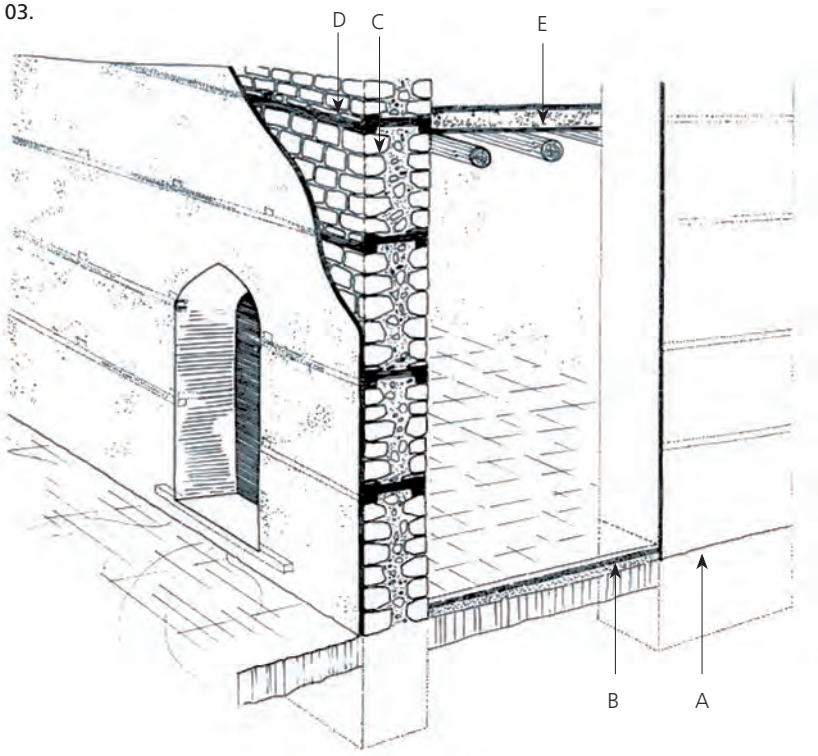
Jeddah suffered from a great lack of wood. As the wood had to be transported, it was very expensive. So, to save on the material, builders developed small wooden sections. Mashrabiyas are generally a trait of the Muslim world and plenty of admirable examples can be found in Jeddah; moreover, in this instance, the craftsmen of the city adopted its techniques as they were particularly adapted to the environment, elevating it to a remarkable level.

Today, although the practices carried out in the old city no longer display the full array of this art and know-how, the architectural heritage still testifies to the true mastery in building arts of its masons.

02.



03.



02_ *House without rendering reported by D.H. Matthews.*

03_ **A** *Foundations dug in the coral layers.*

B *Inside floor, made with compacted sand and terra-cotta tiles.*

C *Mangabi stone modules laid in lime and earth mortar, filled with earth and rubble.*

D *Every six rows, the walls are reinforced with horizontal, longitudinal and transverse wooden ties that act as header-binders, linking the two faces and strengthening the walls.*

E *The floor is made with wooden beams on which the builders lay planks or mats which are covered with earth and a finishing layer.*

04a_04b_04c_*Fissures presence on the walls of building in the historic center of Jeddah.*

05_ *Model scheme of iso-dome masonry.*

A_INSTABILITY CAUSES | PATHOLOGY ANALYSIS

A building can be considered as an organism that is subject to traumas, receives modifications in the time passing, and more than all missing maintenance of the materials and different functions from the original intents are major factors that compromise the structure efficiency and preservation.

If in a part of the building's structure there has been any sort of alteration there will be a different tensional status from the original state, this causes an onset of instability and a different positioning of equilibrium of the structure, generally less solid than the original one. The damage is manifestation of such transformation, of the instability that generated it. It is always possible to produce the survey drawings and to analyze them, and the process that has produce them can never be switched spontaneously. The curve which the fissures develops is called the 'fissure directress'. The way it develops from the source to the surface, the geometrical form it assumes varies in relation to the type of cause of the deformation or the phase of original breaking

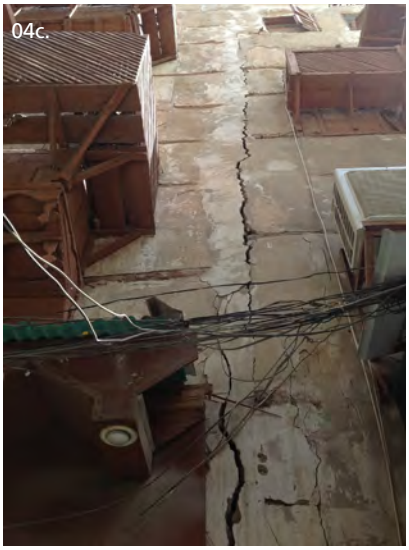
Consequentially the damage (effect) and the instability (cause) are always related:

- An instability causes always a damage;
- A certain type of instability usually is the reason of a certain type of damage, and a certain type of damage is characteristic of one only type of instability cause.

The total ensemble of visible and invisible fissures that derives from a status of instability and deterioration, represent the so called 'reprehensive fissure picture' of the building.


04a.

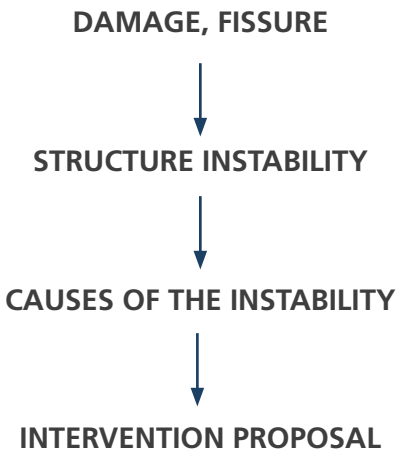

04b.


04c.

The strategic choices can't be started if the diagnostic phase isn't finished, the sequence is:

- Observation of the damage characteristics finalized to recognize the instabilities;
- Identification of the causes of the instabilities recognized;

In order to:
- Removal instability causes;
- Rebuild the static efficiency lost in certain parts of the construction.



The instability in masonry constructions can involve the materials, the structural elements, and the construction itself. The instabilities related to the materials depends on the type of masonry construction: masonry work done with squared stone blocks or brick work well placed, with appropriate mortar generally doesn't present problems, meanwhile the masonry of loose stonework or built with irregular stone portions or with low resistant mortar courses can suffer deterioration, instability and crushing phenomena.

The structural efficiency of a masonry work:
- Stone or brick pattern;
- Mortar consistence;
- Quality of the base material.

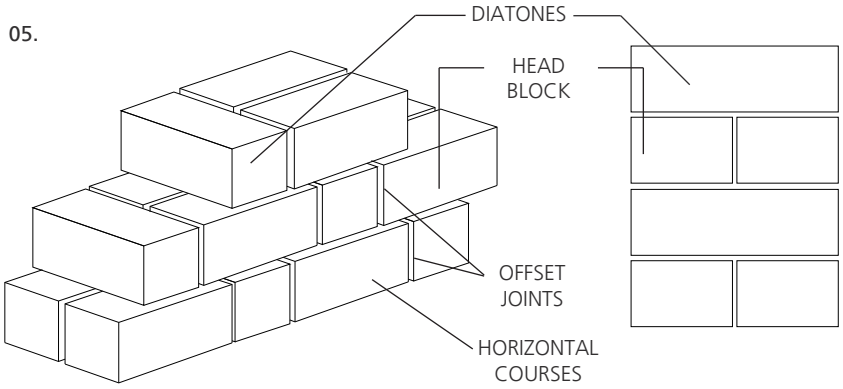
Masonry work built in a traditional:

- Presence of connections of the layers (presence of diatones) in such a manner to be equivalent to a monolithic wall;
- The mortar doesn't determines a weakening appreciable of the masonry pattern;

Masonry rules to foresee:

- Regular horizontal courses
- Regular square cut stone elements
- Straightness of the masonry work
- Not alignment of the vertical joints
- Quality of the blocks
- Quality of the mortar
- Mortise of the block

05.



When the masonry is well settled, namely formed by the overlapping of regular blocks positioned alternately, the mortar has only the function to regularize the blocks which never should touches the subsequent, otherwise the tension state can in this case cause shifting inside the wall. The mortar shall be very thin to avoid pulverizations.

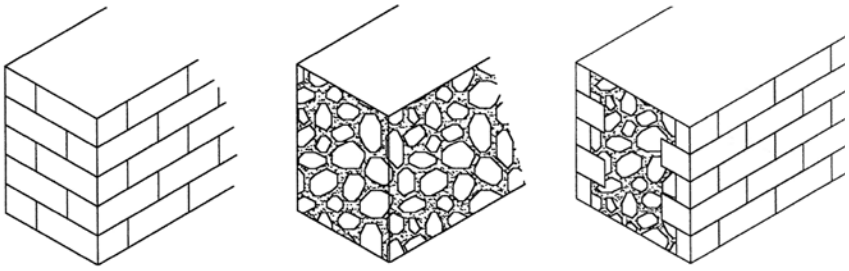
To comprehend the reaction of masonry work it is necessary analyze separately three types of masonry:

- Squared stone or brick walls with regular mortar joints properly built has for his geometric composition has a high resistance to compression and normally doesn't needs of any sort of reinforcement.
- Masonry work constituted of stone blocks irregularly disposed with a lot of mortar to compensate this geometric incoherence, this type of pattern can suffer of micro fissures because of this disposition of

the stonework, in certain parts it is possible to have a direct contact between the stone elements and usually at this points it corresponds the cracking effect.

- Rubble stonwork is the most instable of the masonries patterns. The weakness derives from the difference of rigidity, deformability, cohesion and resistance between the core section of the wall and the external surface of the stonework. The deterioration of the mortar contributes in a considerable way in the weakness of the wall system. The ageing of the mortar joints bring to an loss of cohesion, letting loose the stone elements for its pulverization. Last note is the relation between the mortar joint thickness and the total resistance of the wall which is inversely proportional.

06.



a) Squared stone masonry *b) Irregular stone masonry* *c) Dry posed stone masonry*

The instability relative to the structural elements is related to the function of the single element, a pilaster or a section of a wall axially compressed will manifest small damages horizontally similar to micro fissures or micro shifts of the material, sign of the crushing action inside the stricture, consequentially it shall be visible expulsion of loose parts or of entire portions of plaster dethatching, and in the last phase the collapsing.

The distribution of the loads occurs with the contact of the blocks, the original pattern chosen determines the characteristics of the load transmission and how much it is even and uniform till the foundations.

Once the resistance of the materials is surpassed the comprehension stress leads to a breaking for crush status. In first place the mortar splits and then the stone start moving out of their original position to crush soon after. The fissures that compares for a crushing state of the masonry are parallel and usually after the fissuring compares a swelling state with a detaching of the plaster or cladding part of the wall.

06_*Scheme of three types of masonry.*

07_*In the figure it is represented the situation of an localized overload.*
The fissures are vertical or inclined by 45° in the zone under the load position, the fracture will be on a plane orthogonal to the fissuring, generally the building stability should not be compromised by a single episode like this.

08_*Immagine of crushing by the masonry's own weight. The fissures are parallel and strait as the direction of the load and are visible at the lowest part of the wall.*

09_*The figure shows the distribution of the lesions on a masonry building in the event that a subsidence happens in the central part (a) or the sides (b); in the first case the lesions typically assume a characteristic distribution by the shear behavior, while in the second case they are often more related to a behavior of the flexural type; This difference depends on the different resistance that the masonry has at the top and in the foundation (when sections are larger), and by contrast that provides the ground with respect to the horizontal moving of the foundations.*

There are various causes that could lead to this state of deterioration:

- Stores adding on the upper floors of the building;
- Ground instability;
- Fluidization of part of the ground;
- Design mistakes.

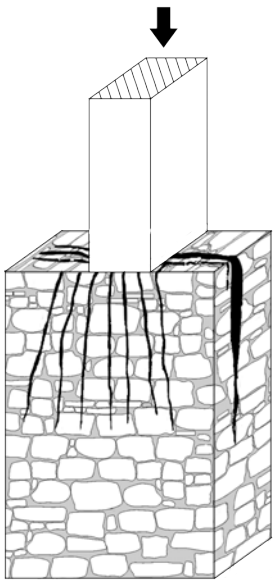
Masonry walls are particularly vulnerable to ground movements, as the masonry work is a rigid structural system, consequentially also a small movement can generate a quite high status of tension, since this technology is completely thought to resist to compression loads and never to traction forces. The consequence of fissuring is on the other hand a changing status of the original rigidity, in this new state the structural system is 'less' hyperstatic and for this reason less rigid and transfers less energy, in a measure that doesn't compromise a proper distribution of loads weight the appearance of fissures can be considered belonging to the masonry life.

The reason of a changed status of the ground consistency can be related to different causes, changing of the quantity of water in the soil for example.

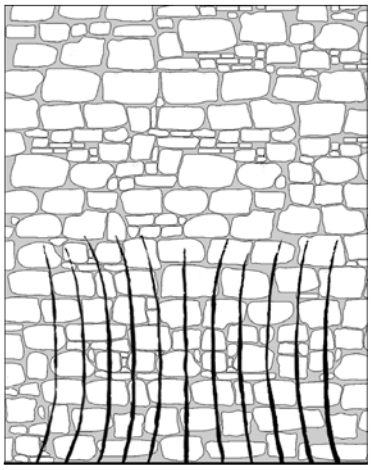
It is possible to understand what type of instability in in action from the observation of the fissures and damages on building:

- Uniform damages: the effect derives from a global movement that keeps the masonry work in a rigid state, usually a major movement that shouldn't weaken the wall as it is but for the entity it is problematic for the scale.
- Differential damages: derives from the movement of a part of the ground it is visible because the wall is interested not uniformly to the damages.

07.

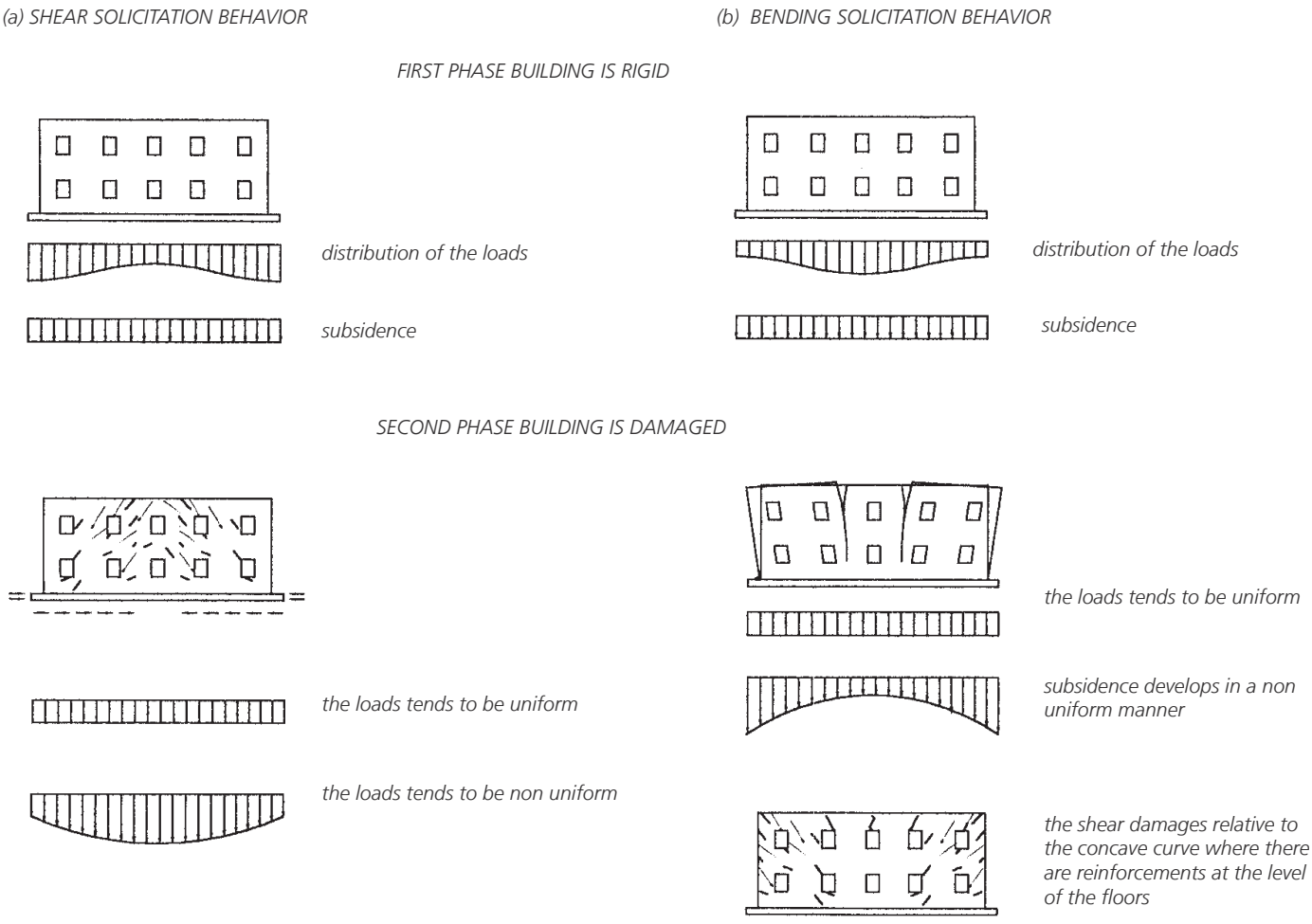


08.



Water is a factor very important, as an aquifer varies position, if it moves down there shall be an increase of the grains pressure, the volume between the pores shall diminish and consequentially there will be instability and lowering of the ground (subsidence); if the aquifer line rises it is possible that the sliding of the grains shall be to 'fluid' and a loss of compactness shall occur, this is called 're-fluidisation'.
Any sort of gallery, conduct, large pipeline, shoring can change the pressure of the ground around the foundations

09.



B_METHODOLOGICAL PREMISE

The choice of which method to apply shall be subordinate to the preventive investigation to reveal the full knowledge of the structure. Further information shall be in a historical perspective, indispensable to understand the constructive techniques, as to report all the events that has occurred as floor additions, window/door openings, earthquake events and so along.
The survey of the 'fissure picture' is the base for the consolidation operation scheduling; the survey and the control of the damages has to be executed with proper tools to verify if the damage is in a accelerated, uniform or retarded progress, or if the instability is stopped, in a new state of balance. In case of advancing progress of the instability it shall be necessary a intervention in urgency, using proper shoring and scaffolding, meanwhile if the damaging progress is arrested a calculation of the new equilibrium has to be done, as to permit a legitimized usage of the building.

The structural intervention on the masonry has to use the original type of materials which has the same characteristics of the traditional design, as to ensure a continuity with the original part of the building.

The consolidation has to respect the original distribution of forces, it shall not be accepted the sort of modification or reinforcement that doesn't contemplate mainly the usage of the walls for structural distribution of the forces to the foundations, as it could happen with the insertion of armored concrete structures. The introduction of extraneous elements in the masonry system would generate an hybrid structure that unlikely could keep the same reactivity of the original structure status to stress forces.
The described procedures has the scope to improve the resistance characteristics of the wall system and to reduce eventual tesnsion inside the materials by external loads.

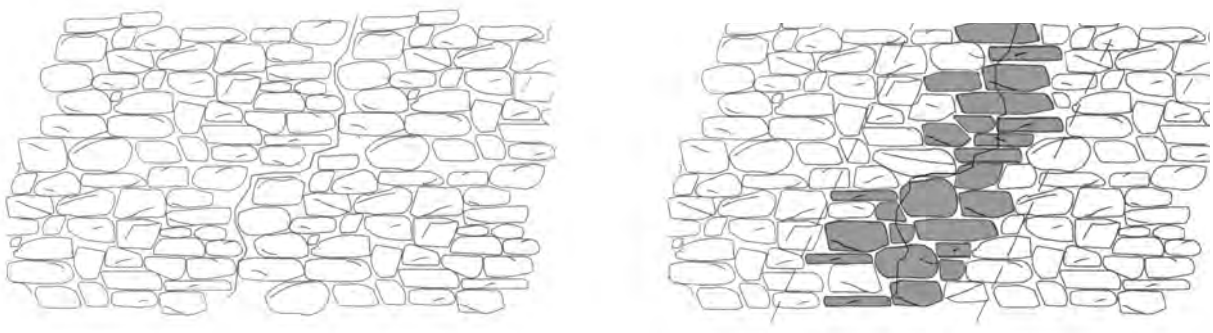
C_DESCRIPTION OF THE INTERVENTIONS

C.1_Unstitch and sew technique

On masonry particularly deteriorated, ineffective to distribute the loads in a proper manner shall need a traditionally respectfull process which contemplates the usage of original materials that has to be reinserted in the locations where they are missing or too damaged.
The operation of unstitching and sewing consists in a sequence of operations that starts with the removal of the masonry parts from the damaged area and the reconstruction with a same material if not the same material, and then to the next part with the same progress sequencing, as to reach the same compactness originally present.

The reconstitution of a damage area has to allow the functional recovering of the original structure system, reactivating the resistance mechanics of the wall constituted of the cohesion and the internal friction.

10.



This intervention shall interest the external part of the masonry or if necessary the whole thickness. The choice of the material to use for the stitching has to be done with extreme cure:

- The new elements has to satisfy various needs: historical (if the building is a monument) esthetical and technical;
- The new elements has to be compatible with the pre existing also for dimensional aspects, as to avoid detachments or not uniform load transmissions;
- The new material has to be of the same kind of the original; a different kind of material can absorb the load pressure in a different way;

10_ *Filling of a damaged zone with the unstitch and sew intervention on the masonry*

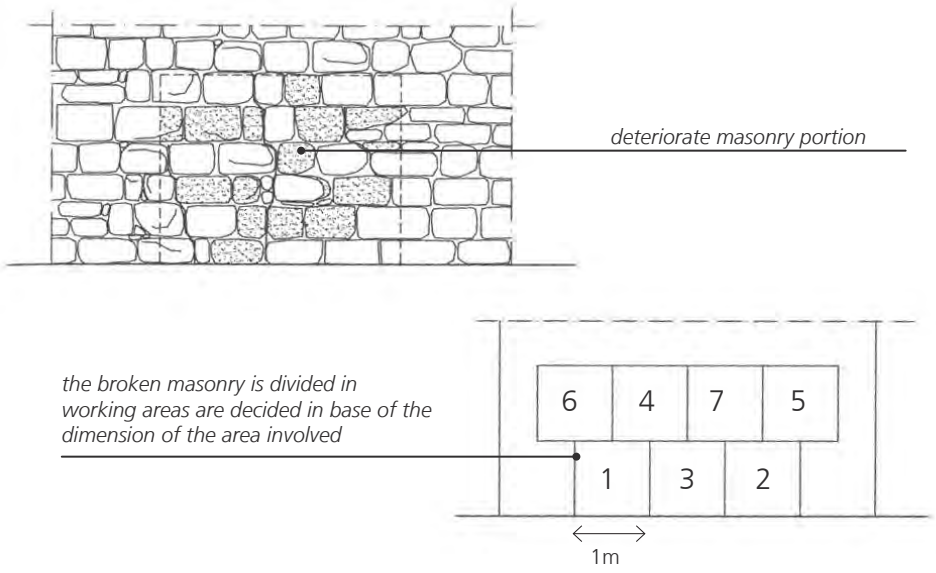
11_ *Unstitch and sew: working site phase*

When possible it is suggested to reuse material from the building, derived from the detached parts, it is necessary to sift accurately the parts extracted from the demolishing or the crumbled portions, to ensure the parts to reuse are capable to resist as the original ones.

It is necessary to realize accurate survey drawings of the portions of masonry damaged as to isolate if possible the area to reconstitute and consequentially to shore up the wall considered to avoid further crumbles or deformations.

It is suggested to subdivide the portion to be treated, usually the operation shall start from the higher part to move sequentially below alternating the demolitions with the reconstructions avoiding to damage the lateral masonry. The demolition can be done using manual tools (hammers, awls

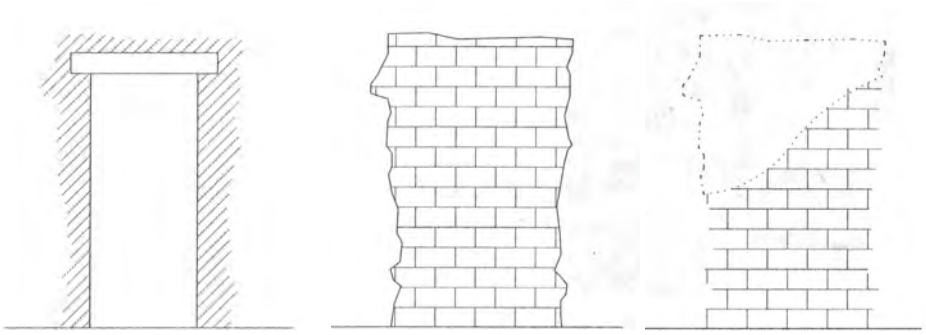
11.



and levers) taking care to not stress to much the structure avoiding to cause further damages; once the extrapolation has been done the cavity has to be cleaned with the help of brushes, trowels and aspirators, as to remove debris pulverized as rumble.
The operation of unstitching and sewing can be a technique that allows to reveal the fact that there has been a intervention in that particular spot, usually the method to leave visible a restoration of a masonry pattern shall be to leave the new bricks slightly retrocede from the front line of the wall. It could be necessary to avoid the visibility of the restoration minimizing the sewing in addition to this a brickwork that isn't coplanar with the wall plane certainly will accumulate dust in the time passing.

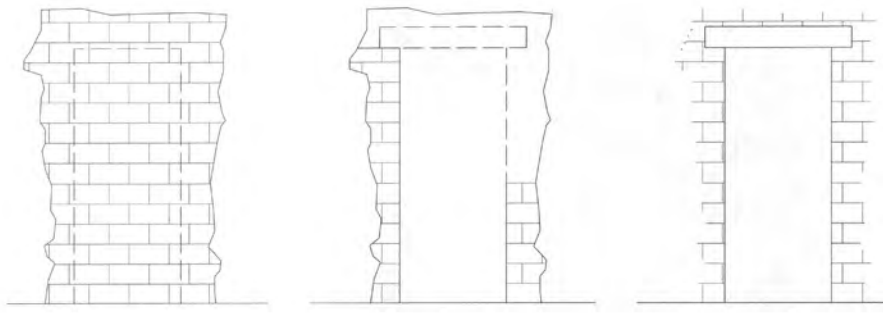
The unstitching and sewing type of intervention is suggested when the masonry work present is in quite good shape, and the damage fissures develops in single branch.
If the masonry presents many branches of damage this traditional technique isn't applicable because it can require to change so many elements that it becomes impossible to reweave the original pattern of the wall, this is the reason why it is necessary before to proceed to any sort of operation to analyze the 'fissure picture' of the single wall. It is not appropriate to use also on incoherent masonry constitute of elements very big and heavy to dismantle.
The closing of openings is instead a good occasion to use this operation because guarantees the continuous of the wall system, it has to be taken care a few aspect though, in first place the positioning of the new elements has to be integrated by dismantling the angles of the openings in such a manner to permit the new elements to crimp the old masonry.
The demolishing phase has to contemplate the lintel as well, but before substituting this element it is necessary that the new filled wall shall be

12.



1° PHASE 2° PHASE 3° PHASE

13.



1° PHASE 2° PHASE 3° PHASE

12_*Enclosure of the opening by whole thickness*

1° phase - demolition of the jamb walls and lintel removal

2° phase - enclosure of the opening with structural blocks and insertion with the pre existing wall

3° phase - plastering application

13_*Opening of new passages in a load bearing wall*

1° phase - cut through the wall

2° phase - building new jamb walls and lintel pose

3° phase - enclosing overhead and plastering

14_*Intervention of jointing of the brick courses*

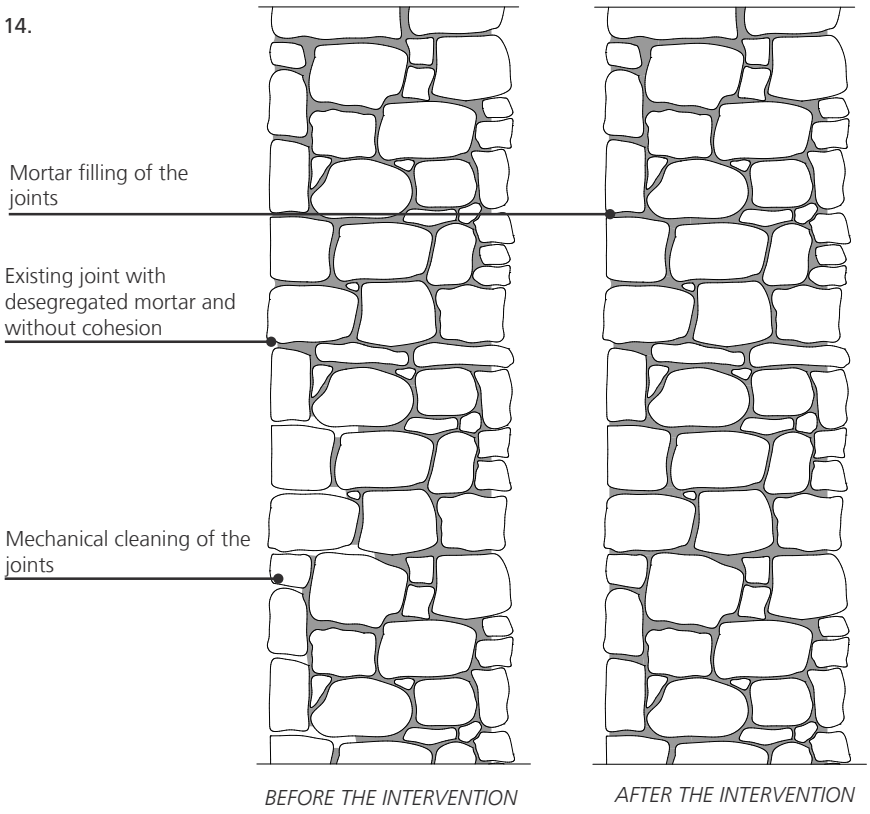
operational, this means that the mortar has to be dry and only then it shall be the moment to remove the lintel and substitute it with another line of masonry blocks. The usage of jacks to contrast the old with the new wall consents to put in compression the new wall masses that otherwise would work only as a infill. In the same way when it is necessary to build new openings inside structural walls it is required to proceed with the unstitch and sew technique, positioning on the new angles jamb elements that ensures a proper resistance.

C.2_Joint grouting

This technique is required when the masonry is in a good state of preservation, and the mortar joint is missing.

This operation if applied on both sides shall be a consistent reinforcement, in particular on thin walls. If executed on masonry of medium or thick dimensions with a not well attached plastering this operation can't be enough to ensure a consistent increase of resistance of the wall and it shall be necessary to combine it with other techniques.

14.



Execution:

- In depth chiseling of the mortar joints avoiding mechanical equipment usage;
- Washing with water possibly sprayed by compression;
- Grouting of the joints with mortar;

This type of operation consents to follow step by step the reinforcement status, this is a superficial operation shall not reveal unexpected situations.

C.3_ Binder injections mixture

Consolidation of the walling by injections drilled holes without any sort of steel reinforcement positioning, consists in a regular array planning of drilled holes to infill at various pressure state a hydraulic grout substance as to fill fissures and substitute the missing mortar layers in the masonry pattern, this technique is optimal also for rubble walling with irregular stone disposition or with very low quantity of mortar;

The injections of binder mixtures in located areas that are damaged and missing entire internal portions with consequential empty hollows to be filled is a specific technique that can be combined with the unstitching and sewing procedure as to fix a damage of this sort in a small intervention portion of the wall.

The injections of binder mixtures in located areas that are damaged and missing entire internal portions with consequential empty hollows to be filled is a specific technique that can be combined with the unstitching and sewing procedure as to fix a damage of this sort in a small intervention portion of the wall.

The procedure can be described in the following manner:

- Plaster removal;
- Removal of the mortar lines of the masonry work;
- Drilling in planned locations with small holes diameters;
- Water injection for a first cleaning phase;
- Mixtures injections;

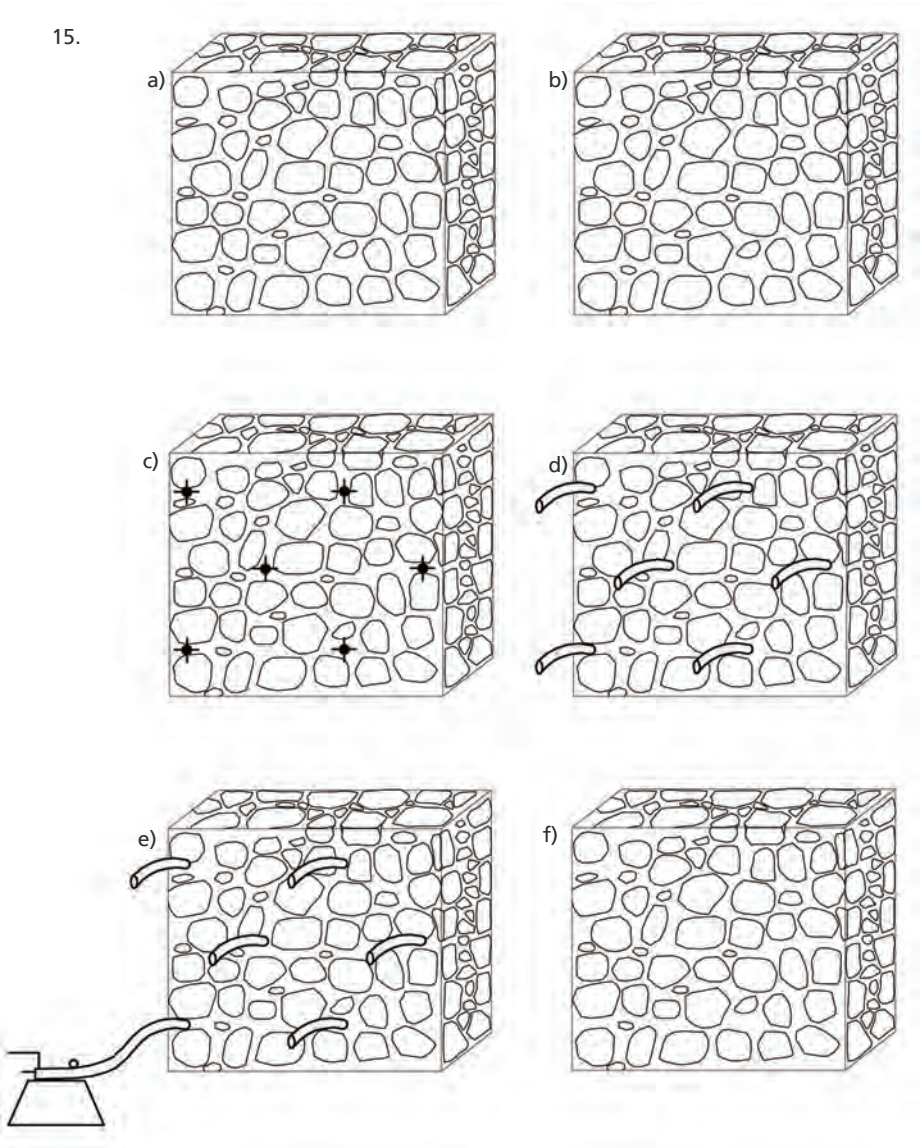
Before the injection it is necessary to tap the holes in a way that consists in sealing the web of drilled perforations to contain the injection liquids. It is possible to operate a plaster layer if necessary also if momentary.

The holes which diameter has to comply with the entity of the work (medially between 16 and 24 mm) has to be planned of a certain depth usually of 2/3 of the walls thickness, as a regular array (between 2 and 4

15_*Injections of mortar during execution steps:*
a) preparation of the surfaces
b) bonds filling
c) perforation of the walls (the holes must have a center to center distance equal to the wall's thickness)
d) posistioning the nozzles
e) pumping the mortar
f) removal of the nozzles and filling the holes

perforations each square meter). The perforations has to be done with an angle of 10% to the perpendicular of the wall surface as to facilitate the injection filling. It is suggested o do a major number of holes of a smaller dimension than a few perforations of wider dimension, as to reach more uniformly all the wall interiors.
Once tapped the web it is possible to place the nozzles for the injection. By these it shall be injected clean water in the web. When the wall thickness is inferior of 60-70 cm the injections shall be done by one side of the wall, beyond the dimension of 70 cm there shall be injections on both sides; in the case the thickness of the wall is very wide or that there is no possibility

15.



to inject on both sides it shall be necessary to drill deeper holes, between 2/3 and 3/4 of the wall thickness, and in no case there shall be holes less deep than 10 cm.

The injections has to be done from the lowest part of the wall surface rising to the top, interrupting the infill if there be over spilling from any hole. It is usually required a low pressure, less than 2 atm, to consent a uniform diffusion of the mixture without damaging any part of the masonry, only once the first row of perforations has been filled and the mixture has started to harden then it is possible to start the row above with the same timing. Once the mixture has hardened after 2-3 day the nozzles and eventually the caps can be removed. The valuation of the results isn't simple and could require a partial coring of the wall to ensure the integrity of the injection diffusion. Ultrasound tests can be used as well, the time of propagation of the sound vibration inside the wall shall report the effectiveness of the injection procedures. Quicker is the sound response better has the filling had been done. It is possible to individuate with this sort of testing the parts of wall the hasn't been filled properly or that has still hollows inside.

16_ *Application of armored perforations for the enhancement of the joint fixing conditions of the restraint wall or reinforce plinths.*

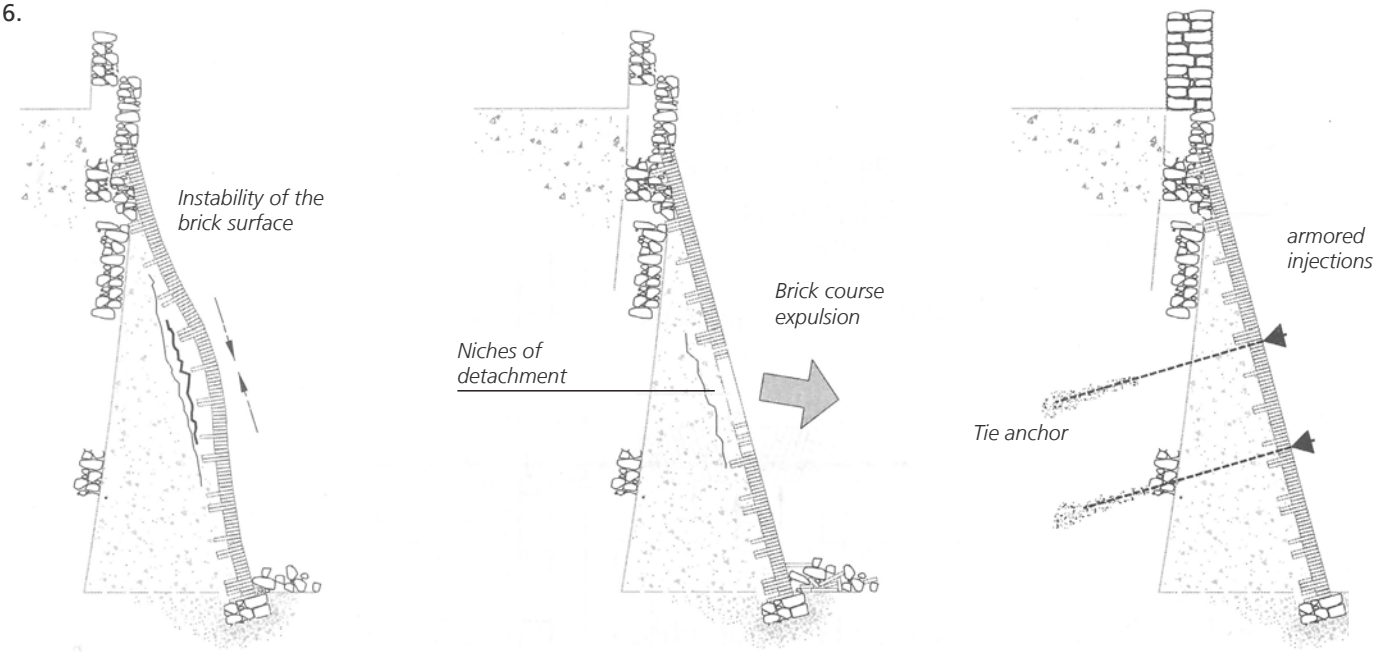
17_ *Armored perforations:*

a) perform perforations orthogonally to the damages

b) armor insertion with steel plate anchor

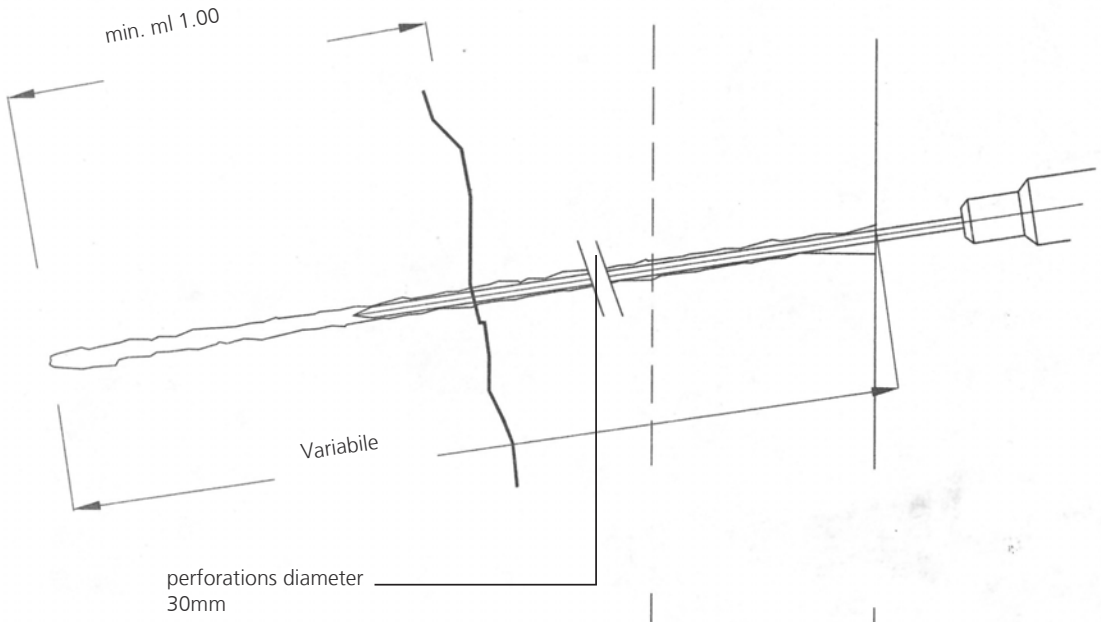
c) mortar injection with hole enclosure installing a nut of anchoring

16.

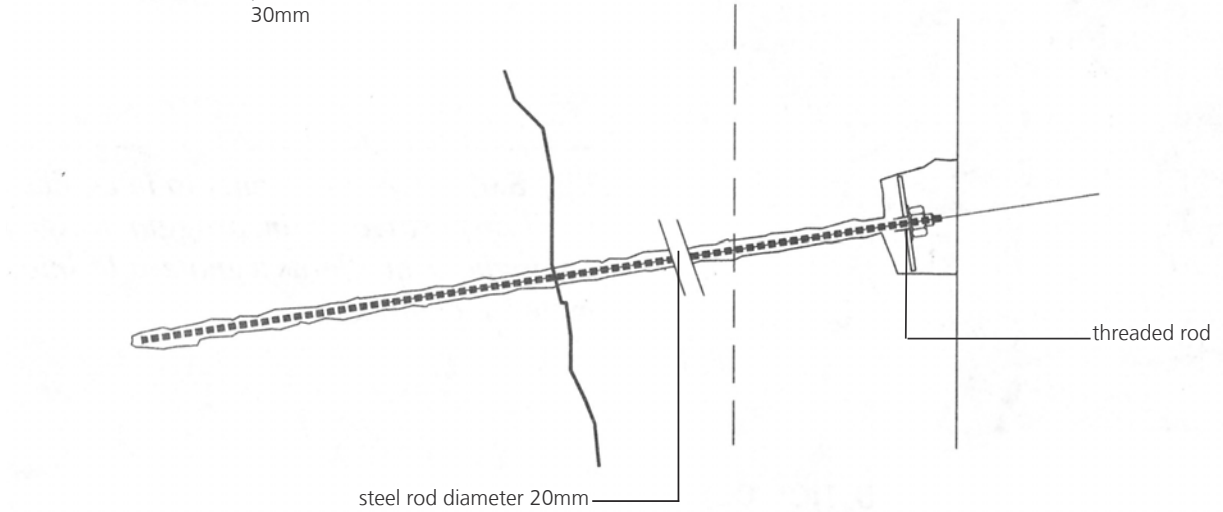


17.

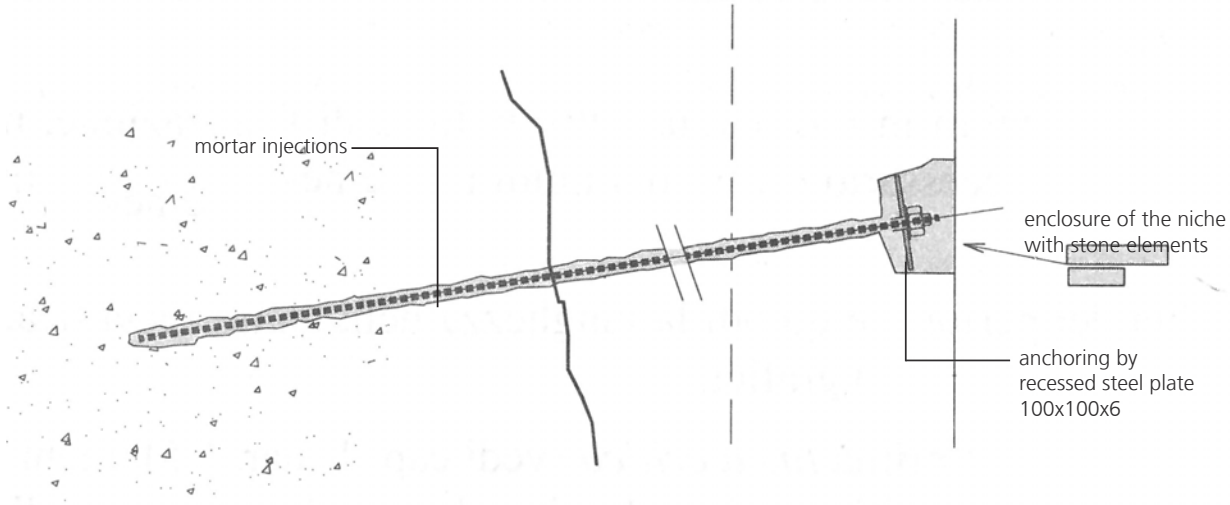
a)


min. ml 1.00
Variabile
perforations diameter
30mm

b)


threaded rod
steel rod diameter 20mm

c)


mortar injections
enclosure of the niche
with stone elements
anchoring by
recessed steel plate
100x100x6

The two operations that has to be done preliminary the removal of the plaster coating and the removal of the mortar from the stone connections inside the wall pattern, shall be an valid option if the plaster has no particular importance as in absence of any sort of graffiti or historical sign to be conserved.

C.4_ Armored perforations

Consolidation of the walling by injections located in pre-planned parts of the wall surface, and once drilled the pattern of holes before the injection of the mixture it is placed a steel reinforcement which can have various specifications, as for example nail based type of reinforcement that clamps the whole thickness of the wall, or web electro-welded of steel that ensures a uniform distribution of the tensions on an wider area of the masonry.
The armored perforations are usually used to reinforce an masonry angle or an internal connection of the wall system, this type of intervention tends to 'clamp' the wall in two steel electro welded webs jointed transversally to ensure the restraint effect. Inside the drilled holes it shall be inserted stainless steel rods with enhanced adherence (dimension varies between 12 to 20 mm) also threaded rods with particular spacers to keep them separated from the stone and allow the mixture injected to infill uniformly the cavity. Inclination, deepness, section dimension of the rod and dimension of the holes are in relation with the wall that has to be restored.

Executive phases of a steel reinforced perforation array:
- Drilling of the hole;
- Steel insertion;
- Mixture injection;
- Tie connection on the extremity of the single rod;

Holes has to be performed perpendicularly to the walls surface as to ensure the most resistant direction to slipping tensions
Once injected the mixture cement based it is necessary to consider if a steel plate has to be placed at the extremities of the rods ties, usually such a plate of metal can be concealed under the new plaster layer.
The last stent of the steel rods has to be under the final plaster surface by at least 5 cm and has to be protected by any sort of aggression that time can deliver as chemical or corrosions or mechanical.

Technically this operation has a heavy intervention schedule and can be planned only when the wall is seriously damaged and no other procedure can be viable.

C.5_Consolidation by steel clamping (grout reinforcement)

Surface wall clamping by cement based armored plaster - Operation the consists in placing on both sides of a wall that has to be treated a welded web of steel cemented directly on the masonry, the pins shall be shooted in the wall to clamp al together. This procedure permits to improve the resistance of the wall as it is a very invasive treatment it is to be an ultimate option to be chosen.

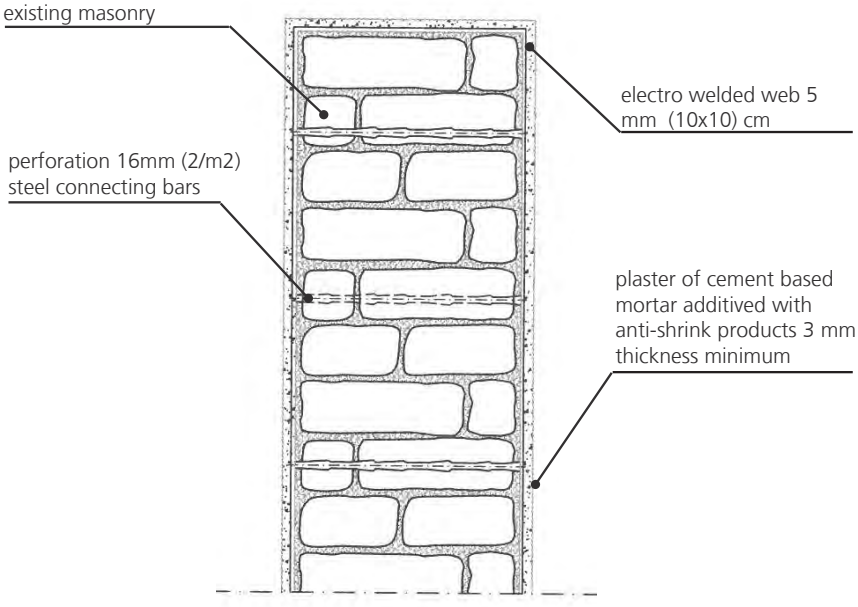
The operative procedure has three steps:

- Preparation of the masonry surface;
- Electro welded web positioning;
- Cement mixture plastering;

The first step consists in the removal of the old layer of plaster from the wall, it has to be removed any loosen part of stone that is fissured or broke and could move in the cementation phase, the final result of this phase it the bare masonry discovered and a removal of at least 2-3 cm of plaster from the wall. The step after consist in using a blow machine to dust away the micro particles that the demolishing phase hasn't removed, the there shall be a first layer of fast hardening mortar to be set on the masonry to fixate the stonework, then there shall be a water cleaning;

The perforations shall be executed with a rotator drill without demolishing operations, and shall be done in a oblique direction if the intervention involves both sides of the wall, and if only one side shall be treated the perforations shall be done to a 3/4 of the thickness depth, the number of

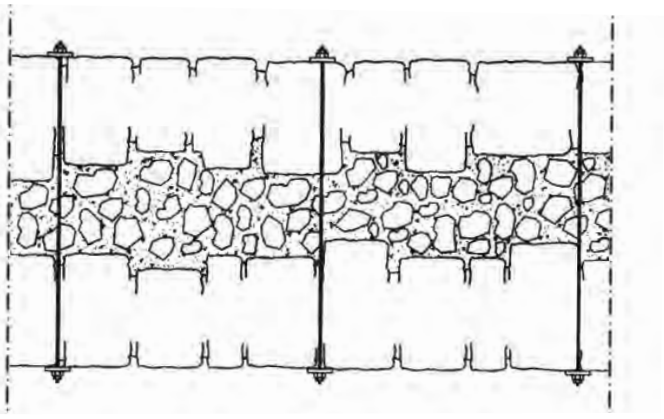
18.



steel rods placed varies in reference to the designs but it shall never be less than 2 per each square meter. In the drilled holes there shall be inserted the steel rods that will stand out for about 10 cm at least by each side, once this phase is done and all the perforations has been occupied then a electro welded steel web shall be placed on the masonry surface, the steel if possible shall be stainless type, and shall be set on both sides ready for the clamping. The electro welded web steel sheets shall overlap each other by 20 cm or by 2 meshes at least. Once the steel meshes has been collocated the outstanding steel rods shall be bent to hook the mesh as to confer an unique steel cage system that clamps the wall thickness.

The mortar surface place before the electro welded web shall be damped of water as to avoid any sort of water subtraction from the final cement plastering. This phase has to be of 48 hours to ensure that the mortar is well wet and without fissures or dryness, to avoid this the surface has to be protected from sun or wind actions. If the damage that has occurred on the wall system is passer by type or isolated, and the wall is thick then it is possible to intervene on the single part overlapping the damaged area with the steel web (about 60-80 cm offset around the area). It is necessary to remind that this sort of operation is to be intended as a last sort and has to applied only if there is no other operation viable.
The wall changes with this type of application his nature and basic elasticity, actually it is impossible once the treatment is done that there could ever be fissuring or partial movements and the portion involved by the treatment shall be very rigid in comparison with the original resistance of the wall, this involves a different type of reaction f the system in seismic situations as the rigidity will transfer the energy and not dissipate it by cracking or fissuring. This technique has to be considered an optimal resolution on portions of walls that are very thick and had originally a very rigid reactivity for their geometrical position inside the building like the base floors. The other option shall be the complete substitution of the wall portion and the rebuilding of the part. When it is possible there are other type of

19.



18_ *Section of wall consolidated by armored plaster.*

19_*Sewing with tie rods anti- expulsive. Tie rods, formed by bolts equipped with two sealing washers to extremes, should be introduced through holes formed transversely to the masonry and distributed on the surface of parietal.*

20_*Insertion in a direction transverse to the plane of the masonry wall of artificial diatones for the realization of a bond between internal and external facing.*

21_*Visible fissuring phenomenon on a historic building's façade in the center of Jeddah.*

operations that can be considered to avoid such a massive intervention. It can be the case to compact the existing plastering of the wall with in depth grouting, unstitching and sewing technique in local areas, shimming the single damaged fissures, or creating single transversal steel pinning or connections.

C.6_Consolidation by anti expulsive steel rods

When the wall has the exterior parts as the plastering detached or not more connected on the interior masonry pattern (masonry done usually by rubble technique or with poor mortar applied), there could be another solution that involves the insertion of steel rods the are anti expulsive type. This technique recovers the structural continuity of the wall more than all working on the transversal connectivity by inserting pins, steel rods tied externally by small plate plaques that can be reversible.
This technique do not involve mixtures or cement based binders to be injected or plastered, in some cases it impossible to insert inside the wall the plaques as to avoid any visibility but this confers a less performing system at the end.

The working phases:

- The perforation phase (enough one hole per square meter) with a only rotator drill without any sort of percussion to avoid damages to the wall. The hole shall be of 20-26 mm and requires a planning to ensure the optimal locations of the micro clamping (in any case the surface of the plate shall be chosen the most planar as to avoid deform movements when it is going to be righted together);
- Cleaning of the hole and insertion of the stainless steel rod, (16-20mm) with the last stent threaded to ensure and facilitate the bolting phase;
- Plate plaque insertion (these circular elements has to be dimensioned in relation of the wall resistance at the tightening phase and usually is between 80-100mm) and consequent bolting as to ensure the rod is in tension for the bolting and conferring it a sort of pre solicitation status.

C.7_ Consolidation by transversal connections (diatones)

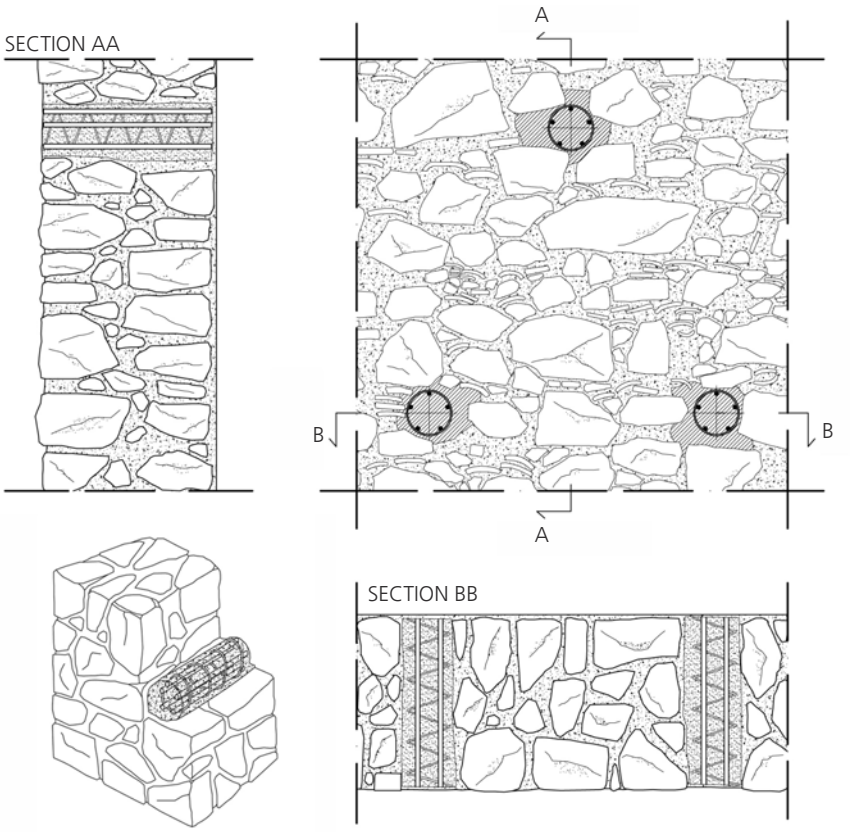
This technique consists in inserting inside the wall hollow bars the has to be placed after a coring procedure. Inside the tube there shall be inserted the diatones.

Diatones insertion phasing:

- Confers the wall a monolithic reactivity to orthogonal tensions on the walls plane of force distribution;
- Connects the external plastering/cladding;
- Avoids the instability by compression;.

As this technique doesn't creates any sort of pre solicitation it can be applied on weaken walls or very poor type of masonry.The procedure consists in creating perforations of 16 mm, the reinforcement is done by a bar called diatone that is a spiral stainless steel element truncated at the wall thickness and connected to a specific cap that has a hole$_A$that permits the insertion of cement based mixtures in the hole. The steel spiral has longitudinal steel rods long 10 cm.The peripheral area has to be sealed by a specific grouting as to avoid the mixture to spill out, it has to be considered a hole for the air to deflate during the injection phase which consists in a low pressure procedure.This technique is adapt to seismic consolidation because it confers a monolithic connection between the two sides of the wall.

20.



21.

Wooden beam floors consolidation

Horizontal structures are characterized of wooden beam floors which consists in small dimensions trusses spaced very closely (between 25 to 50 cm). The wood was usually imported by sea, the trusses where made of Javas wood meanwhile the decks where boards of a wood called Gandal with palms fibers of India which were less resistant.
The horizontal structures in the upper floors of the buildings of Al Balad are made of main beam frameworks supporting a joist frame. This framework is usually covered with planks or jointed boards, with or without battens or strips; or plant mats with earth and lime flooring on top, smoothened with a tool.
The light gray surface was traditionally covered with carpets or khilims.
A few richly ornate under-faces can be found, consisting of a suspended board ceiling, fixed against the lathing. These ceilings can be decorated and painted (geometrical or floral patterns).
The undergoing rehabilitation program would be an opportunity to uncover ancient ornamentation, where possible, as most have probably been covered by more recent layers of rendering or painted layers.
The roofings of Al Balad actually make up a network of terraces. These various terraces are actually the ceilings of the rooms below.

The terraces are delimited from one another by low walls. The structure of these terraces is identical to that of the floors below.

- The terraces are flat and sloped downwards, towards the lowest edge:
- Outwards, away from the walls through hollow wooden waterspouts;
- Towards the inside of the building, for water to go down glazed terracotta pipes into cisterns.

The terraces sometimes have round or octagonal chimneys, and wooden kiosks. The mortars, laid tight with metal trowels and tools, waterproof the roofing in successive slopes.
The outside rim of the walls is often a little higher, surmounted with decorative crenellation work (built with masonry work or moulded), or with wooden palisade


01a.


01b.

A_INSTABILITY CAUSES | PATHOLOGY ANALYSIS

The quality and the life of a wooden floor beam deck depends:

- By the characteristics of the wood essence and it's preservation state;
- By the structure configuration.

Wood pathologies, recovering procedures and it's preservation is detailed in the wood restoration section, in this chapter it shall be analyzed the structural side and the maintenance.
The main problem derives from the dimension of the structure trusses and the distance between the single beams and the missing of connections that should consolidate the structure.
The wooden floor decks can have longitudinal damages or fissures on the flanks of the wood beams. The longitudinal fissures are inevitable as the wood is a living material that changes in presence of temperature gradients of water in the environment and consequentially can suffer of slitting and fissures as it expands, this type of damages aren't problematic because also if broken it shall keep the same load bearing capacity.
If there are instead cracks that doesn't moves on in longitudinal direction but transversally there could be problems that could produce an inefficiency of the structural system that could bring to a sudden collapse. Viscous deformations of the wood fibers membering (this type of deformations occurs during long time lapses it is characterized by small movements and sliding that is related with the time factor by an asymptotic trend)

02.

01a_01b_*Naseef house: views of the terrace.*
02_*Architettura traditional Jeddah: masonry building with wooden floors.*

also if not properly considered a damage, this type of deformation can during the life of the wood elements generate instabilities because once deformed their geometry the element could deliver different type of loads on the supports, with a unexpected new tensional state.
The horizontal structures are destined to support loads permanent and accidental transferring the tensions on the masonry vertical system; the changing of the functions, the new living requirements, of the use destination, the demolitions and re-buildings the transformations during the years usually can generate a major load bearing on the system.

The manifestations of the instability usually are:

- Depression of in the middle part of the floor deck;
- Paving breaking or fissuring in perpendicular direction to the main wooden beams usually near the wall perimeter;
- Excessive inflection of the wood beam visible from the floor below;

The breaking of a wood beam doesn't involve usually the collapse of the entire structure since the system is not to be considered 'rigid' but quite 'elastic' and the deformation of other components that has occurred in the meanwhile compensates the damaged part supporting it. The secondary trusses and the floor boards that are nailed together acts as a unique system, creating a new load distribution to the walls.

03_*Ceiling home in Jeddah strongly degraded beams under bending, damaged and spotted.*

04_*Static scheme of a beam supported-supported. The floors are two-dimensional structures loaded orthogonally to themselves. They are generally supported by the walls, solicited mainly to bending, do not generate horizontal thrust on but supports deform significantly.*

B_METHODOLOGICAL PREMISE

The criteria to be followed is the basic respect of the original structural distribution, preserving the most possible of the structural elements and materials of the masonry as of the floor system, also if there has been a modified maintenance status in relation to the modified structures and functions, it is important where possible to be applied the restitution of the original structure rules and materials as to **restore the static effective effectiveness.**

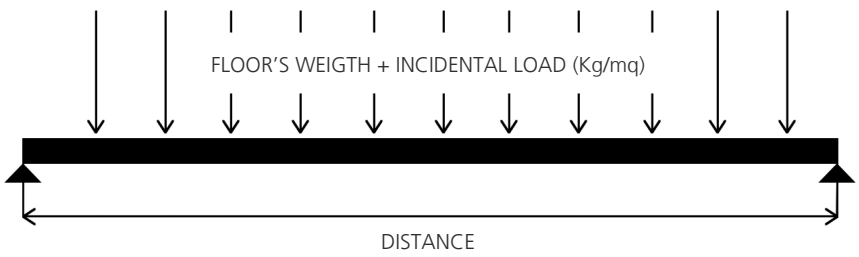
The restoration of a wood deck floor is achieved by repairing the primary and the secondary wood trusses, by conferring these elements the proper rigidity and resistance, improving the connections of the parts with other structural systems present in the building.

The operative procedures has as final goal the consolidation of the structure with precautions of reinforcement that consents the rigidity improvement and contemporary to tie the floor system to the perimetral walls, all by working on site, as to avoid the mutation of the static asset between the varies elements that compose the floor deck. The dismantling of the elements to consolidate the single parts can have as consequence the lost of the structural equilibrium that time had conferred to the structure and its deformations.

Any sort of intervention has to be supported by all a series of verifications done preliminary on the material resistance and it's relative state of preservation.

The safety check of an element that is subject of a bending moment is based on the comparison of the moment acting $\boldsymbol{Ms = \alpha\, p\, L^2}$ that depends by:
p = *acting load*
L = *distance of the supports*
α = *function of the grade fixing restrain*
with the resistant moment that depends by the type of material and the geometry of the section.

04.



The safety can be improved in different ways:

- Reducing the stress moment:
- Diminishing the accidental load
- Diminishing the distance of the supports

Modifying the fixing restrain grade:

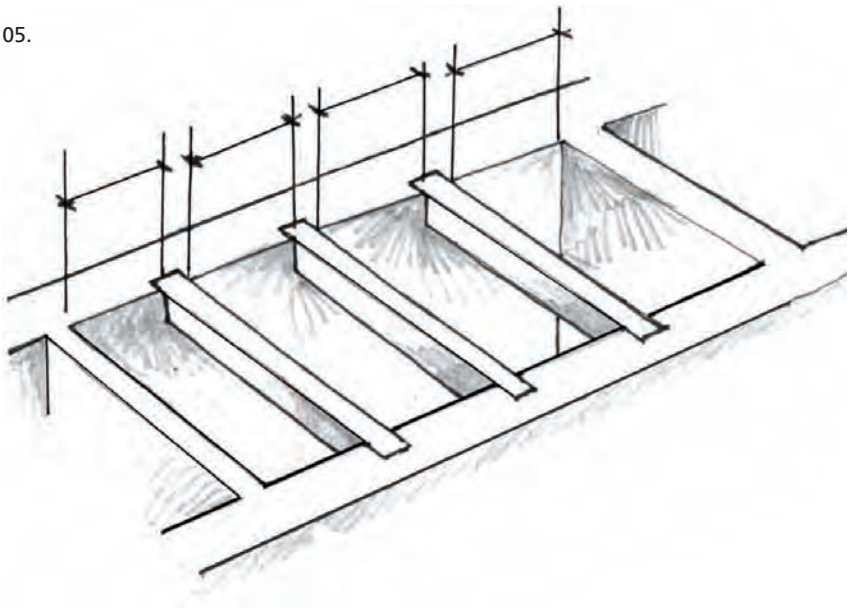
- Improving the resistant moment modifying the section:
- Using different materials
- Improving the geometry of the section;

If the wood trusses are ruined or if the analysis of the wooden fibers membranes aren't any more able to support the load bearing it has to be considered the substitution of the element;

Preliminary operations:

- Shoring and casing of the structure
- Identification of the causes if the instability;
- Verification of the pathologic picture of the wooden manufacts.

05.



05_ *The arrangement of the elements that make up the slab is defined 'warping'. The beam is parallel to the shorter side of the surface to be covered till the beams are subjected to less strain.*

C_DESCRIPTION OF THE INTERVENTIONS

C.1_ Dismantling, reservation or substitution of the wooden elements

The dismantling of the wooden floor deck shall be done in an opposite way of the original building phasing

- Demolishing of the paving surface;
- Removal of the screeds or any sort of pane element between the paving and the wood boards;
- Removal of the wooden boards from the secondary trusses;
- Removal end detaching of the secondary wood elements from the primary;
- Removal of the wood beams from the walls holes/supports;

This last operation needs to be done with attention and care as to avoid any sort of lever movement of the wood axis inside the wall by the positioning of proper shore and scaffoldings (with the usage of appropriate cranes and lifts) or eventually cuts on the walls plane line the entire wood beam leaving the wood element inside to momentary keep transferring the vertical loads of the wall without extrapolating till the moment to rebuild the missing volume.

In the case of dismantling the wood beam floor system that had already received a treatment in the past years it is necessary to avoid the normal procedure as if it was an simple removal, because the wood beam certainly has been anchored with metal elements to ensure the connection with the wall system, in this case the wood element is to be considered not only as a loading bearer but also as a 'chain' inside the macroscopic system of the masonry work of the entire building. The simple removal can cause problems to the wall box of the building.

The dismantling of the primary structures of the floor system when connected with metal parts (nailing, metal plaques, anchors) shall require more cautions and the adoption of instruments to avoid new damages on the wall structure. for example to remove nails from a wood board it could be necessary the cutting of the nails head or the usage of specific pliers to pull them out with a lever movement.

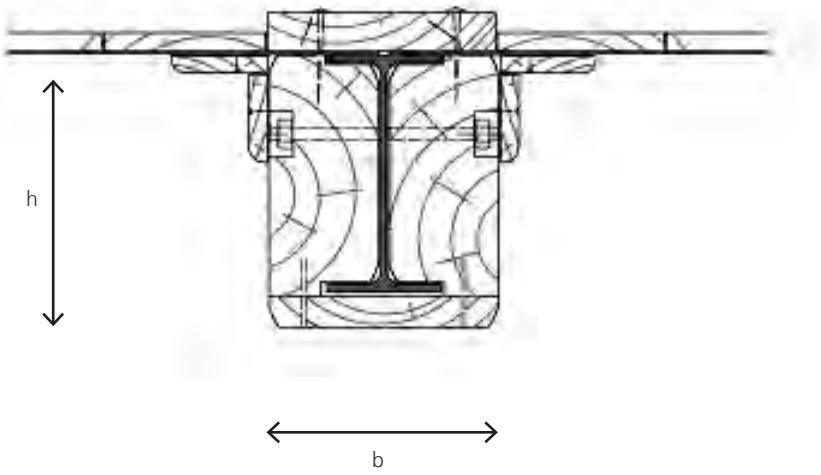
Usually it shall be necessary to remove the upper floors descending down to the lower ones.

The interventions finalized to the preservation of the wooden frame disposition can be divided in two categories:

- Operations that shall leave the wooden beam with the only function to don't change the esthetic semblance of the room;
- Operations that shall leave the structural function of the wood beam but shal contemporarily be supported by parallel elements;

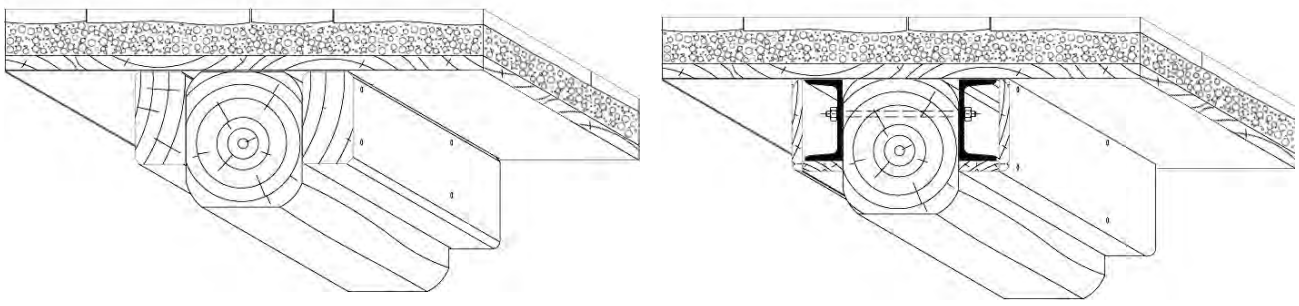
It is possible to substitute the wood trusses with specific beams made of steel/wood structure where the real function of load bearing is done by the steel part and the wood ensures an equivalent esthetic of the original one. This solution has several advantages, doesn't require a different load distribution of the floor system, is very resistant for the major resistance of the steel compared to a wood element, and finally has a optimal resistance in case of fire for the double sheeting of the main structure.

06.

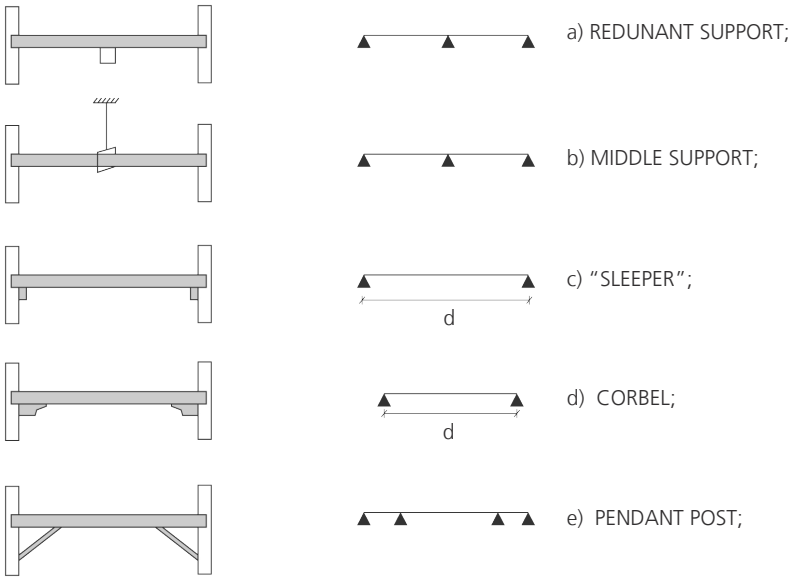


The operation that aims to the maintenance of the static efficiency of the structural system are absolutely to prefer, it is to be remembered that it isn't only a question of esthetics but also a restoration of proper functions of the building.

07.



08.



It is necessary to make a distinction of the type of elements involved in the wooden floor system, and more accurately the quality of the single elements of the construction, for an example it could be necessary to take particular caution to the restoration of very important wood beams that could have particular chisel works on the flanks or be considered of value for the type of wood used or the age, in comparison with less valuable floor decks.
In case of a load problem the reduction can be obtained changing the functions of the building reducing the not structural loads, or set beside the original structure elements that can support the excessive weight. A technique that ensures this is called 'breakpoint' are transversal beams that supports usually in the middle section of a load bearing with structural brackets. This intervention is very efficient but it is to be placed on the under section of the floor and shall be visible from the rooms below, it could be not esthetically appreciated.
An intervention that has a minimum of visibility consists in the disposal of an iron plate in adherence of the inferior side of the wooden beam anchored to the original truss by specific metal strips. It is optimal when it is needed to fix horizontal damages. This type of operation has different under cases such as when it is missing a portion of the original beam that can be integrated with a new wood element of a glass resin insertion.
When the wooden floor that has to be restored is a minor type or a less valuable wood essence it could be the case to substitute the entire floor especially if the original system is structurally ineffective for the load

06_*Steel/wood type of beam in substitution of the original one*

07_*Wooden beams set on the flanks of the original one or steel flanking.*

08_*Diminishing of the distances of the supports or increase of the fixing restrain grade*

bearing. The realization of a whole new floor has to comply the original specifications and materials, the construction techniques has to be traditional but it has to be considered the anti seismic implementations and the new loadings that it has to support.

EVALUTAION OF THE CONSEVATIVE STATE

↓

DAMAGED ELEMENT DAMAGED PRESERVATION AND ELIMINATION OF THE DETERIORED PORTIONS

↓

INTEGRATION WITH NEW JOINTED ELEMENTS

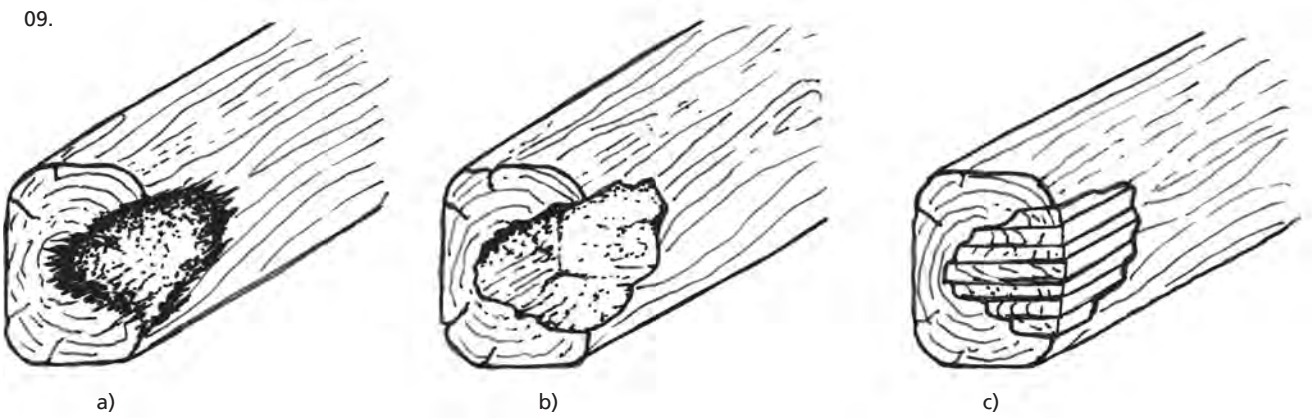
C.2_Rebuilding of missing or damaged portions

A zone that is particularly important to take care is the insertion location inside the masonry system of the new or rebuilt elements; the portion of wood that is inside the wall is unseen and for this reason it could be broken or rotten and not be visible since it collapses.

Before the operation of substitution or consolidation of the single element the wood has to be examined with proper diagnostics of the manufacture as to verify the perseveration status of the material and his resistance as a beam. If the inserted portion results deteriorated and for external reasons it is chosen to keep the original wood element it shall be necessary to regenerate the beam by substituting the deteriorate part with a new prosthesis.

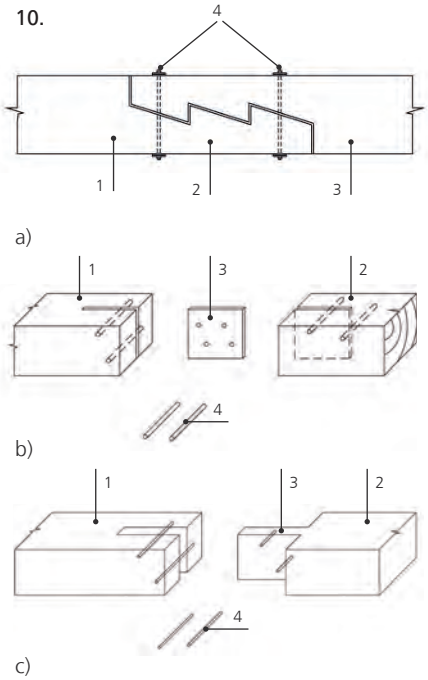
The procedure consists to work on the 'back' portion of the beam (superior side). It shall be discovered by all the length dismantling the paving and the upper deck by removing the wood boards as to uncover the main

09.



a) b) c)

10.



09_ *a) Elimination of degraded parts*
b) Cleaning and Regularization of the cavity
c) substructure with blocks of wood bound together by epoxy resins.
10_*a) Union to dart "giove" (1) and (2) wooden elements to be connected; (3) indentation to dart of Jupiter; (4) clamping bolts union*
b) Union with steel plate inside. (1) and (2) wooden elements to be connected; (3) steel plate (4) metal pins inserted to force c) Union tenon - mortise. (1) and (2) wooden elements to be connected; (3) tenon with any adhesive; (4) pins hardwood

beam ceiled side. Once opened the floor it shall be cleaned as to remove any portion ruined or rotten. The final goal is to reestablish the original functioning of the beam recovering as much as possible the ductility of the connections too.
The wood that has to be used for the integration has to be excellent as quality (better than the original wood if possible), without any sort of defection, with low state of humidity (not more than 6-10%); and shall be if possible of the same essence or if not possible of a species of better mechanical resistances. All the wood inserted has to be treated with biocide products.

The construction and modeling of prosthesis can be done with different techniques. The prosthesis can be connected to the remaining part of the beam with vertical joints done with profiles as 'half wooden squared/ oblique', 'Giove's dart', dovetail, fork etc. As to improve this joint it shall be possible to use appropriate steel 'ties' or bolting of stainless steel with circular section and hexagonal head bolt, jointed on the wood by blind nut and washer.

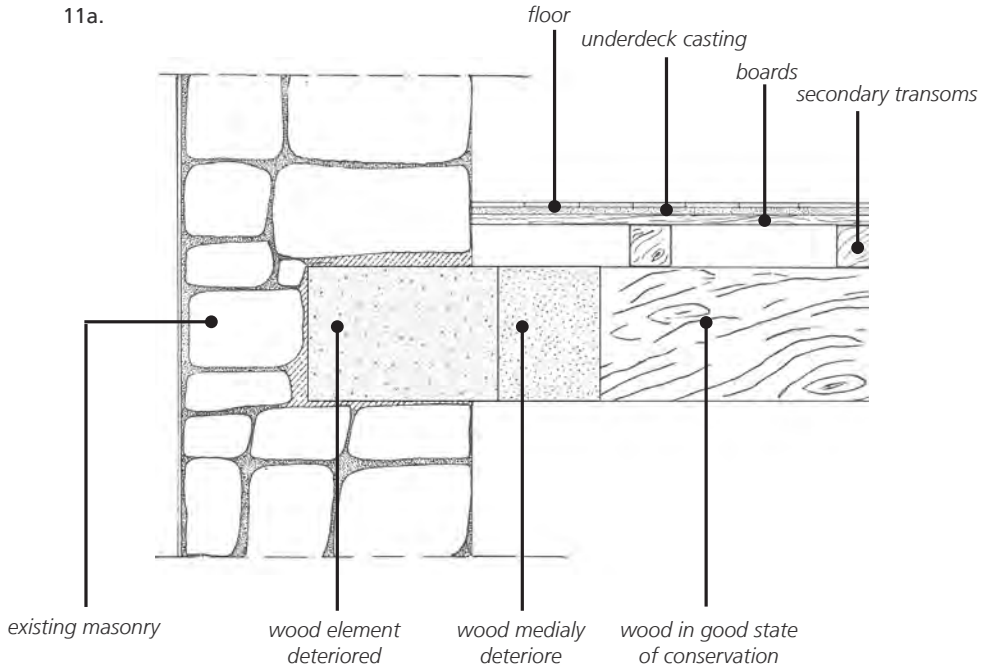
It is possible to cut the wooden beam and the prosthesis by an angle of 45° and ensure a jointing with threaded stainless steel bars positioned inside the holes or hollows created inside the wood beam and in the prosthesis with proper tools as cutters or drills, the connect the structure by the usage of epoxy adhesives. The openings or holes done or this bolting process shall be capped by wood portions.

A more invasive method is the re construction of entire parts by the integration with epoxy concretions. This operation can be done on the superior side of the original beam that has to be treated, once the paving and boards shall be removed the wood beam shall be treated as to receive the casting of the epoxy mixture.

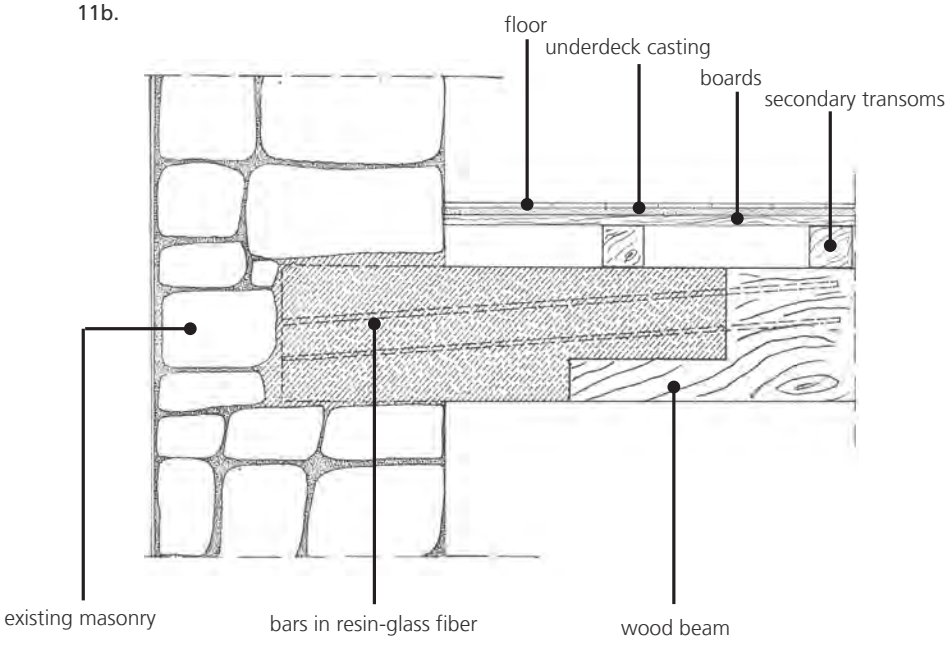
Phasing:
- Realization of the holes on the wood beam sane parts;
- Cleaning of the perforations;
- Insertion of stainless steel rods that has to be threaded highly adherent type for a depth of at least 50 cm;
- Positioning of secondary reinforcement transversally;
- Casting of the epoxy resin as to fill the perforation;

This technique that is the less suggestible is on the other hand very cheap and quick to be applied without alliterating the final image of the wooden system especially if is possible to use part of the original wooden beam as casting form box for the resins.

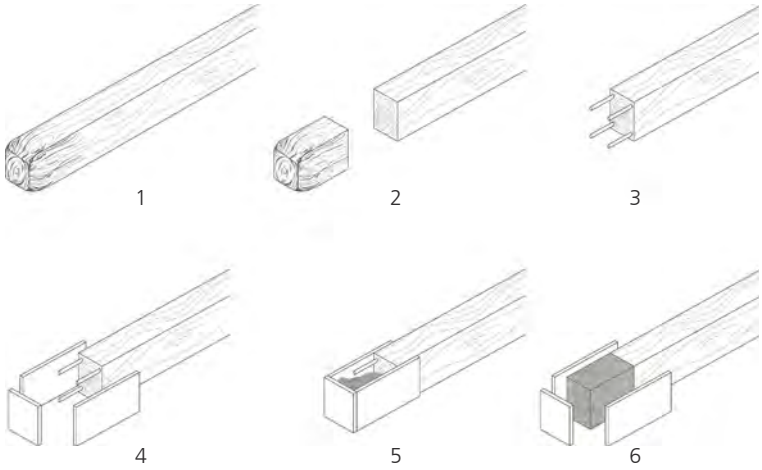
11a.


floor
underdeck casting
boards
secondary transoms
existing masonry
wood element deteriored
wood medialy deteriore
wood in good state of conservation

11b.


floor
underdeck casting
boards
secondary transoms
existing masonry
bars in resin-glass fiber
wood beam

12.



C.3 _Improvement of the supports

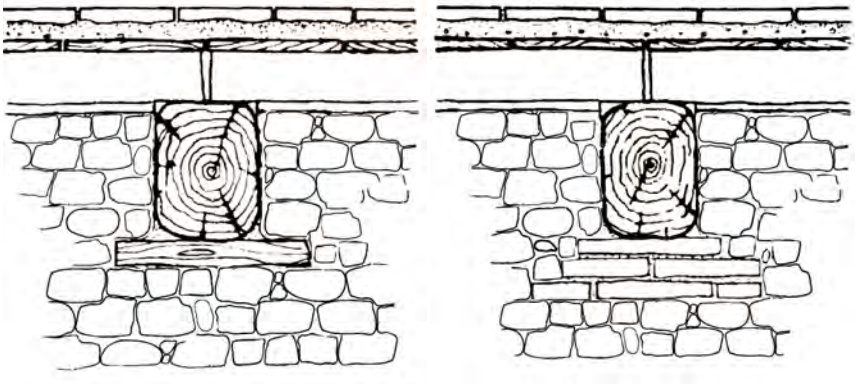
This operation can be obtained by two procedures, inserting a cushion that supports the beam inside the wall or reducing the distance of the beams supports by the construction of specific brackets or the insertion of elements under the beam connection on the wall.

The insertion of an element that extends the support, that is usually called 'sleeper' permits a better distribution of the load that has to be transferred to the wall.

It needs a larger base to be deployed on, and can be done in several techniques:

- Single board overlapping, the board has to be at least of 10 cm thick (minimum wideness = height of the beam, minimum length = height of the beam + 10 cm by side);
- One or more full brick (55mm of thickness) disposed by plane;
- A stainless steel plate Fe 430 of at least 10 mm;

13.



This last solution is usually the most chosen in relation to the modest demolition necessary to place the steel element. It is necessary to lay between the wood and the steel plate a cushion of neoprene.

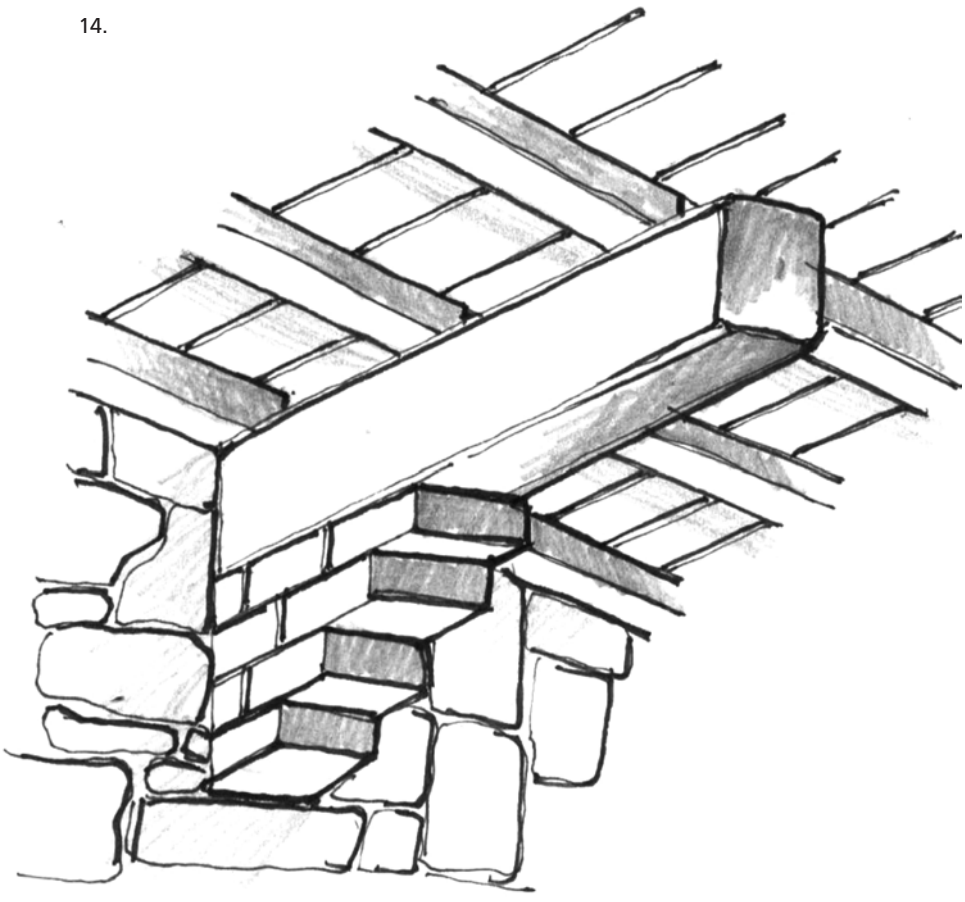
Brackets and 'sleepers' elements are expedients that reduces the distance of the beams supports and at the same time it helps distributing the load on a wider section of wall. The bracket can ensure an improvement of the total resistance of the beam only if it works properly with the wall, it is necessary that the connection shall be a joint, this prerequisite can by

11a_11b_ *Regeneration of a head flaking materials with insertion of fiberglass rods.*
12_ *Schematic stages of realization of a prosthesis with epoxy resin reinforced with fiberglass rods.epossidica armata con barre di vetroresina.*
13_ *"Sleeping" element realized by inserting below the beam a wooden board (a) or solid bricks (b).*

obtain only if the wall is thick enough. When the frame of the primary beams is aligned from room to room it can be possible to build a double bracket that ensures the jointing of both the beams on each side of the wall, the bracket element shall be one and shall pass through the entire section of the wall.

A 'sleeping' beam can be inserted parallel to the wall as to ensure an uniformity of load distribution on the wall, this edge beam shall hold all the primary be as of the floor system, it is usually made of wood or if necessary a smaller section it can be a steel profile.

14.



14_*The presence of shelves reduces the distance of the supports of the beam, and increases the supporting surface by spreading the load over a larger area. However produces bending stresses in the wall 'support.*

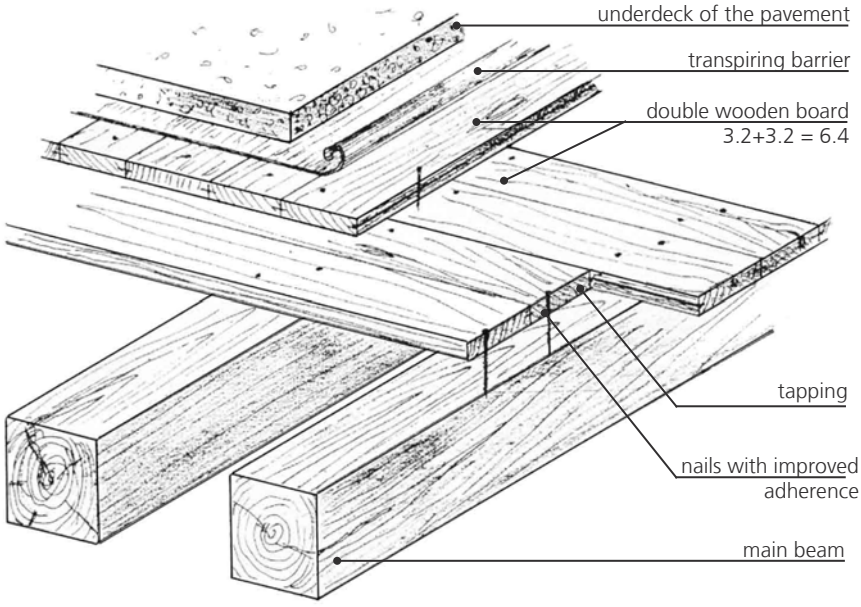
15_*The picture shows the recommended choice to stiffen a floor: Inserting a second plank and nailed perpendicular to the first, on which is placed a breathable barrier before throwing in the mortar.*

C.4_ Floor deck stiffening

This technique shall be used when the wooden beam floor system is considered in a good condition, it is necessary that not only the beam but also the secondary and the wood boards is in a well preserved status and that the geometrical section of the trusses are properly dimensioned too. It is an improvement necessary when the floor if too elastic and it is required an stiffening of the system.

After that there has been a control of the state of preservation of the boards upon the secondary wood beams, there be a positioning of a textile sheet the has insulating properties as contemporary transpiring characteristics. On this pellicle divider there shall be disposed a second layer of wood boards not aligned with the original boards direction, the single board shall be 30-40mm thick and the wood essence type shall be the most rigid possible, less elastic of the original one in any case, it shall be perfectly aged and with low humidity values.

15.



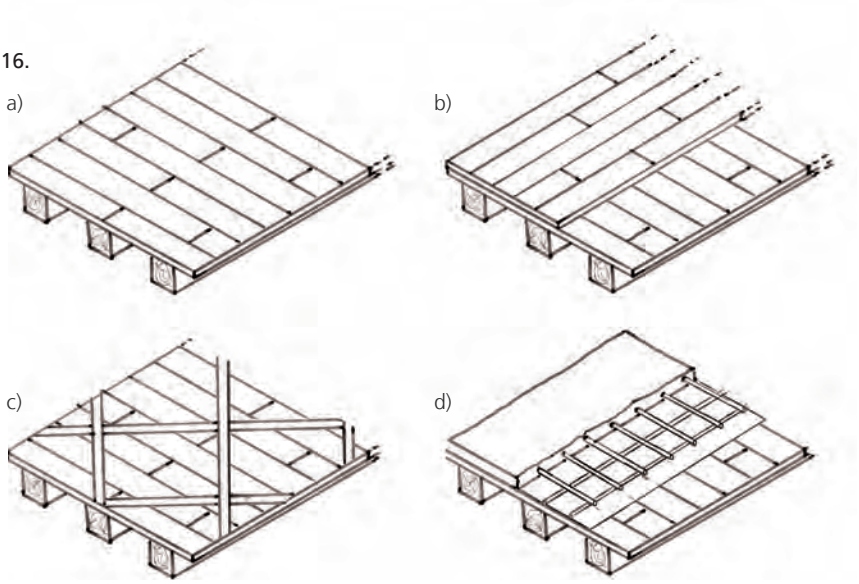
The boards shall be adherent on the preexisting one and positioned orthogonally or diagonally to the old one, once placed and tighten the boards shall be screwed on the original with stainless steel screws or nailed with stainless steel grooved nails (diameter and length are related to the type and the thickness of the boards; in any case the dimension shall vary 150 to 400 mm and the diameter shall not be less than 4mm) and with

specific glues that are humidity resistant. In absence of other specifics the nailing shall be perpendicular to the boards, the nailing shall be complete till the nail's head is flush on the boards plane.

The nails with diameter inferior of 6 mm shall be inserted without pre holing; for diameters that are thicker a perforation shall be done before as to avoid fissuring of the board. The wooden boards shall be clamped at the walls demolishing the plaster and inserting wooden wedges on the line of connection.
Another technique is the casting of a lightened cement based screed that works with the wooden boards and helps to distribute the loads.

The wooden floor system will always preserve an elasticity that will deliver an bent deformation to the beams, the paving shall be placed considering this movement, and the screed shall be casted with a low percent of binder in the mixture as to avoid the transmission to the structure of shear forces. A rigidity effect that exceeds can be harmful as wood is a material that moves and changes dimension with the changing of thermohygrometric conditions damaging and breaking if not allowed to slide. It is important to improve the humidity conditions as the temperature in the surrounding environment, avoiding cyclic variations and sudden brusque changes, it could be enough to keep a distance between the perimeter of the walls and the new boards.
This technique can be used also in seismic zones together with special improvements on the connection between the wall and the wood boards.

16.



16_*Interventions to reduce the deformability of floors:*
a) simple plank;
b) double deck;
c) diagonal bracing (FRP strips or metal sheets)
d) a cooperative slab of armored concrete.

C.5 _ FLOOR DECK STIFFENING THROUGH COMPOSITE MATERIALS (FRP)

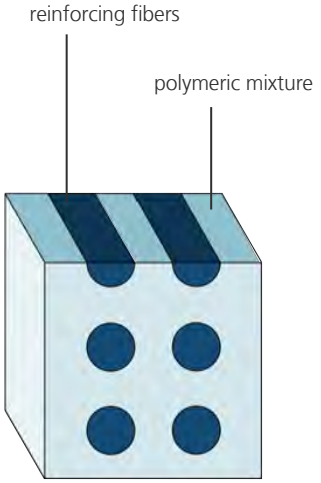
Alternatively to the double board system, or as addition it can be used steel stripping or composite hoops fixed on the original boards in a transverse direction to the original boards position.

The term FRP stands for Fiber Reinforced Polymer and it refers to materials composed by reinforcing fibers immersed into a polymeric mixture. In fiber-reinforced composites, fibers play the role of structural elements both in terms of resistance and stiffness, while the base mixture, as well as protecting the fibers themselves, conducts forces through the fibers and between them and the structural element to which the composite has been applied.
The fibers can be disposed in every direction, according to the project data, in order to optimize the mechanical properties of the composite in the desired directions.

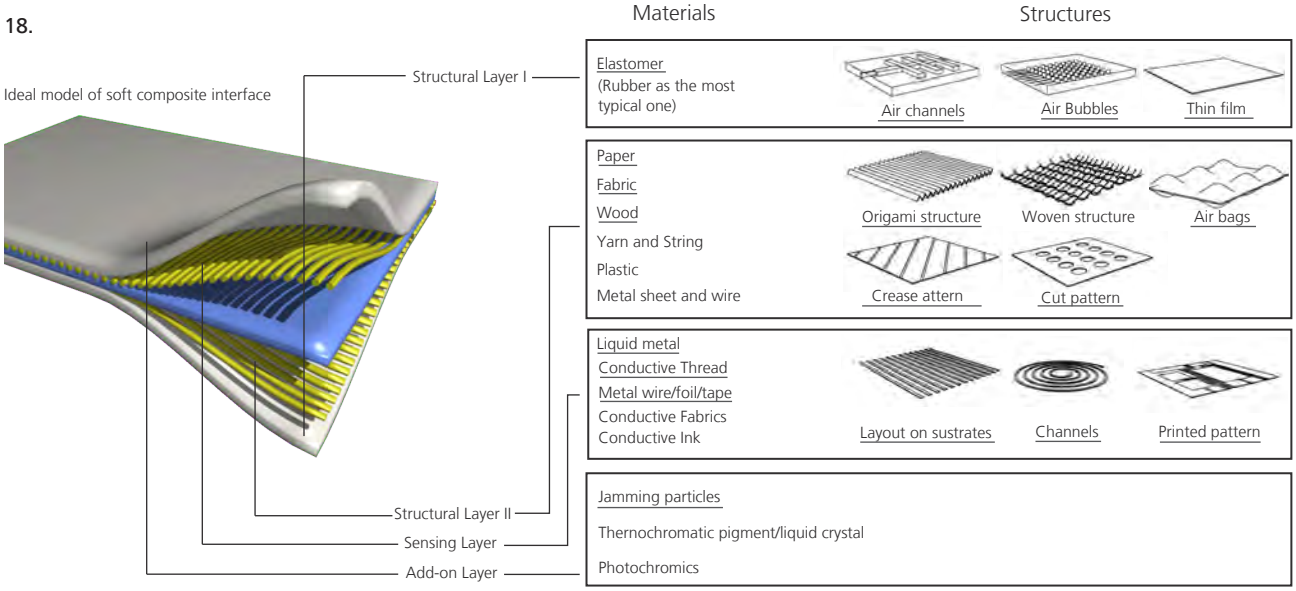
In polymeric composites, the mixture is usually made of epoxys, which become polymeric (they take reticular form) by mixing up with an appropriate reagent, until they evolve into a solid vitreous material.

FRP materials are already in use from several years, mostly in naval, aeronautical and military fields, where they're used for their incomparable specific resistance (meant as mechanical resistance to traction per unity of weight). The considerable reduction of costs, mainly due to carbon fibers' increasing diffusion ad to optimization of productive processes, has led to the introduction of these materials in the constructive field as well.

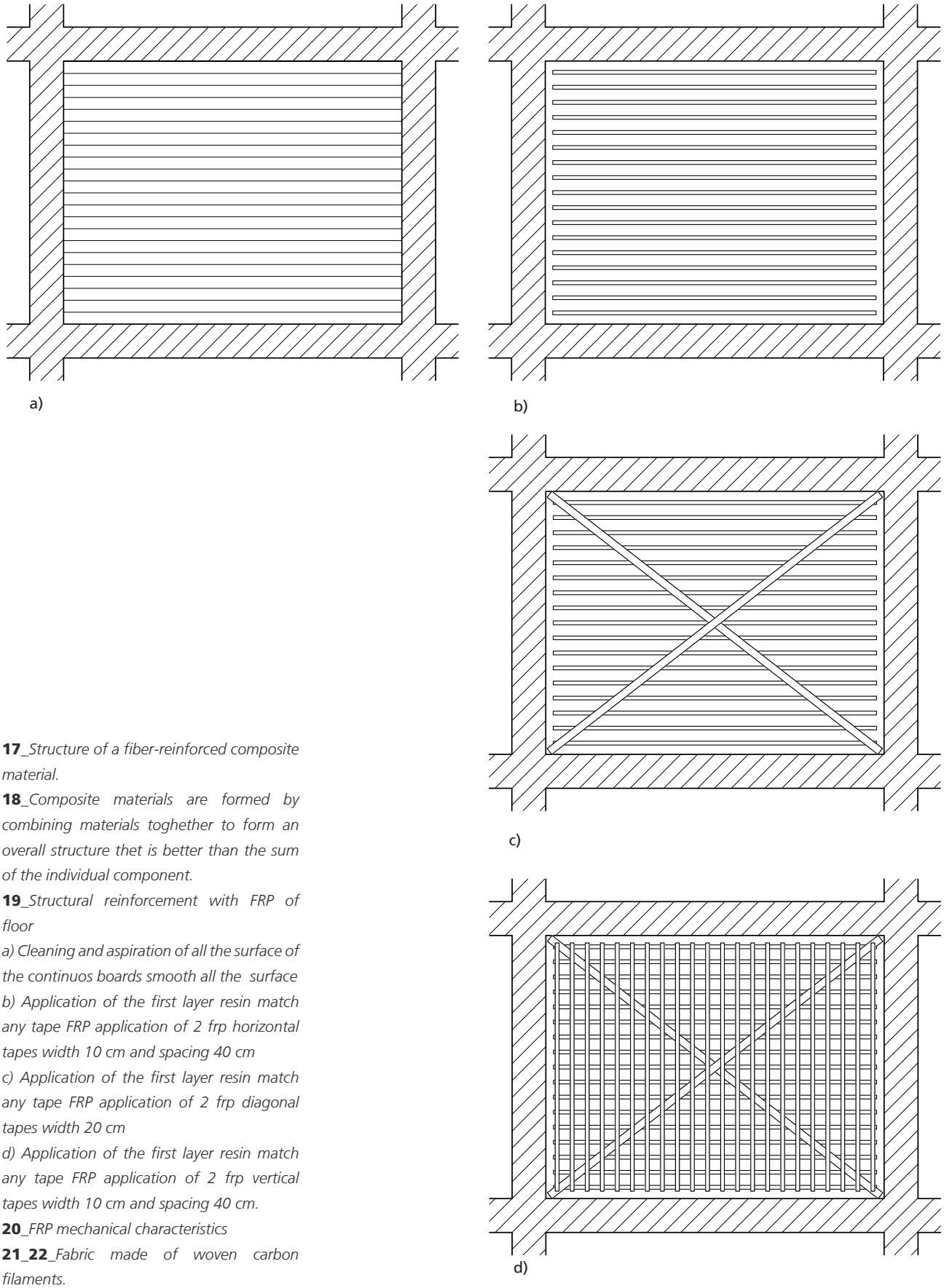
17.



18.



19.



17_*Structure of a fiber-reinforced composite material.*

18_*Composite materials are formed by combining materials toghether to form an overall structure thet is better than the sum of the individual component.*

19_*Structural reinforcement with FRP of floor*

a) Cleaning and aspiration of all the surface of the continuos boards smooth all the surface

b) Application of the first layer resin match any tape FRP application of 2 frp horizontal tapes width 10 cm and spacing 40 cm

c) Application of the first layer resin match any tape FRP application of 2 frp diagonal tapes width 20 cm

d) Application of the first layer resin match any tape FRP application of 2 frp vertical tapes width 10 cm and spacing 40 cm.

20_*FRP mechanical characteristics*

21_22_*Fabric made of woven carbon filaments.*

23_*FRP installation.*

FRP MECHANICAL CHARACTERISTICS					
FIBERS TYPE FRP	MEDIUM VALUES			AFFECTED BY HUMIDITY	VISCOUS SLIDING (CREEP)
	RESISTANCE [MPa]	MODULUS [GPa]	ELONGATION [%]		
CARBONIO	2500-5000	240 - 390 640	0,4 - 2	NO	ABSENT
ARAMID	3000	120	2 - 3	HIGHLY	MEDIUM
E-AR GLASS	3000	70	3 - 4	MODESTLY	HIGH

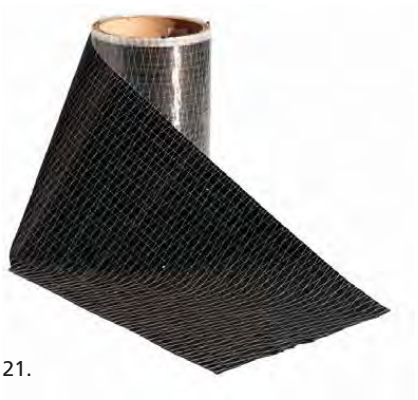
20.

The reinforcements are made of:
Carbon fibers: can be distinguished between high resistance + high elastic modulus fibers and high resistance + extremely high elastic modulus fibers.
Glass fibers: can be of glass type E or glass type A.R. (resistant to alkali).
Basalt fibers: they have half-way characteristics between carbon fibers and glass fibers, since they have both characteristics comparable to the first ones, in terms of mechanical resistance, and an elasticity modulus similar to glass fibers.
Metallic fibers: are steel fibers with extremely high mechanical resistance.

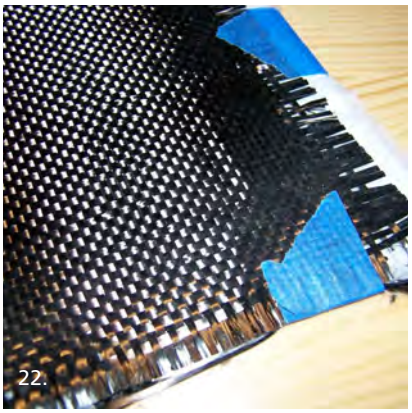
Structural composites are applied as textiles in constructions reinforcement, distinguished in:
- mono-axial: with all the fibers oriented in length direction and held together by a light non-structural texture;
- bi-axial: composed by an orthogonal fabric net, usually balanced (same percentage of the fibers in both directions);
- multi-axial: with fibers oriented in different directions of the plane.

The main parameter that defines the characteristics of a FRP reinforcement is the elastic modulus: higher the modulus is, higher is the resistant contribution of the fibers in terms of rigidity.

A restoration intervention based on the adoption of high performing composites results cheaper than traditional ones, if the economic evaluation, in addiction to time parameter and instrumentation necessary, considers also the costs deriving from possible interruptions of the activity in the building and the life of the structure itself after the intervention.
FRP materials, indeed, thanks to their lightness can be placed without any particular equipment and they can be handled by few workers, in extremely few time and, very often, without interrupting any activity in the building.



21.



22.

Main vantages deriving from FRP application:

- limited invasiveness and good compatibility with historical walls
- high increase of ductility and resistance of the structures
- no new or greater loads on the existing structure
- quick application
- high resistance to chemical attacks
- minimum space occupation in storage and on construction site


23.

C.6 _Rebuilding from new of a wooden floor

The restoration of a wooden floor particularly ruined may be too complicated to put in act or time-consuming and consequentially not acceptable: the intervention that is recommended in this case is a disassembly of the original elements and proceed to a new reconstruction of the wooden deck.

It 's definitely to be intended as a drastic option to proceed and should be avoided in presence of floors with a historical value, in this case it shall be necessary to recover as much as possible of the original material.

Dismantling must be made following the practice shown in chapter 'Dismantling, preservation or replacement of wooden items' on the present manual, with the particular fact to taking care to not mechanically stress the masonry.

The new floor must have a static scheme as the original system, the materials shall be of excellent quality, if possible, a same essence type of wood shall be used. The size and pitch of the beams must take into account the environment characteristics, the functions uses of the building in the future and ensure full compliance of anti-seismic directives. Must be reinforced and well connected to the walls.

24_*Proposal for reconstruction from scratch of a timber floor.*

25_26_*Connection of wooden beams to masonry*

a) Titanium bar inserted in a hole filled of two component resin

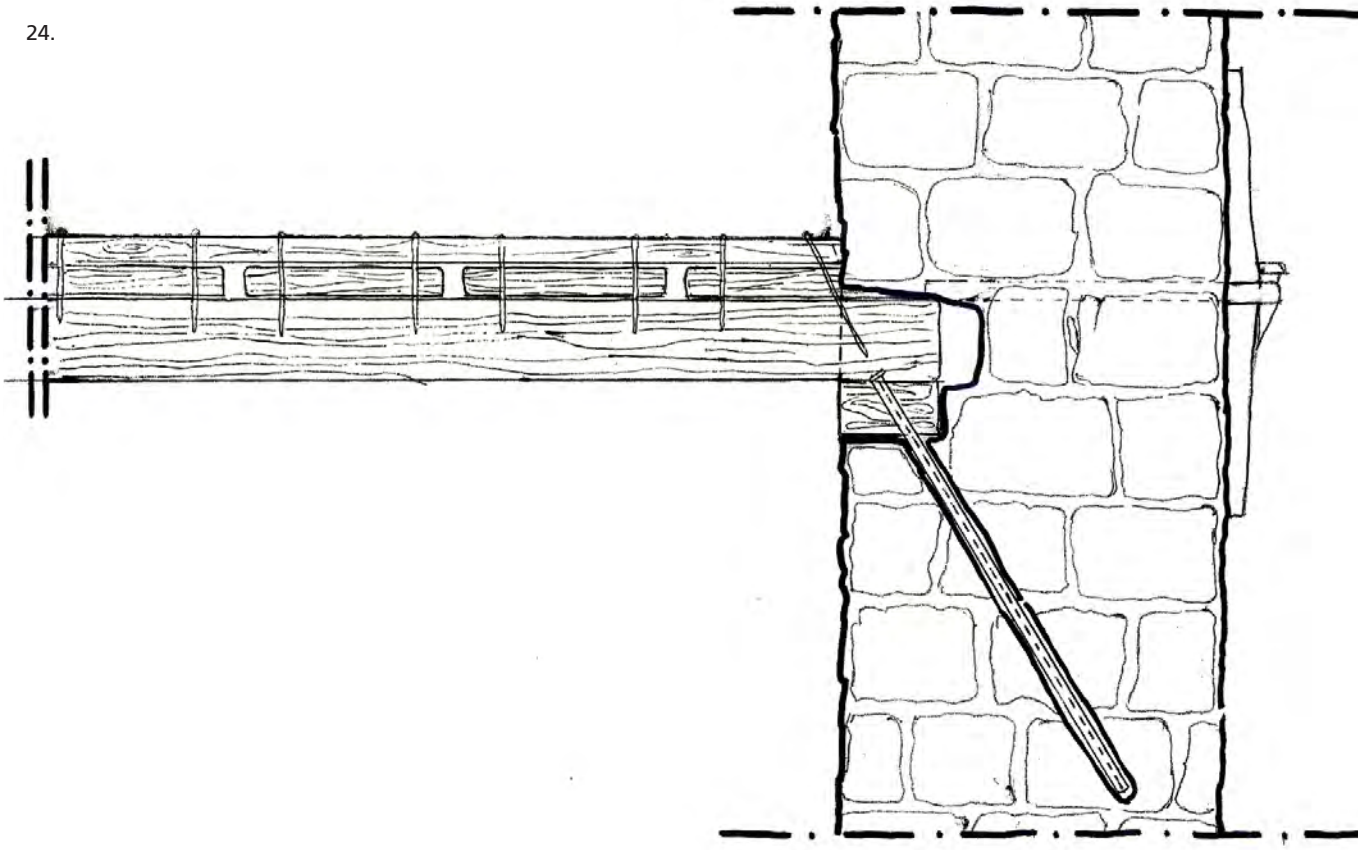
b) Wooden beam

c) Sealing of the groove with expansive mortar

d) Doubling continuous boards

e) Wooden bearing

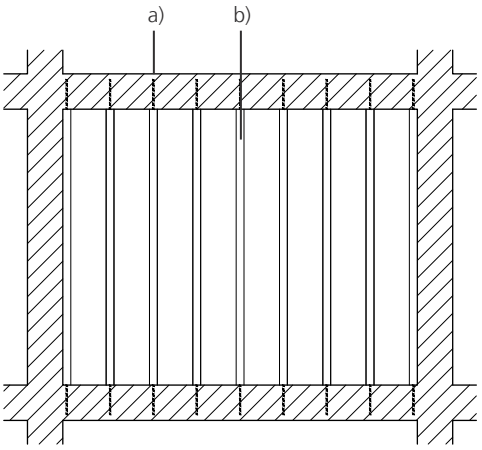
24.



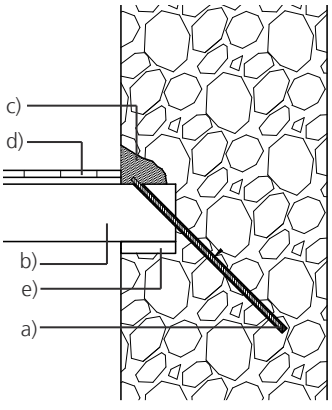
Execution:

- Beams suitably sized embedded in the masonry prior the insertion of an 'sleeping' truss of wood to improve the load distribution.
- Laying of a double cross and nailed plank
- Reinforcement of the floor with metal bracing or crossed hoops (mesh more diagonal) FRP (thickness about 0,20 mm);
- Tightening of masonry with steel rods placed on the perimeter of each room that are displaced over the wood planks and casted in place on the screed floor. For tie nods it shall be recommend the use of particular hooks ('bolzoni') to insert inclined.
- Hoop fastening of wooden beams of the floor with the perimeter wall using inclined nails (30-45 °) grouted with proper two-component resin.
- Laying the setting layer and the flooring.

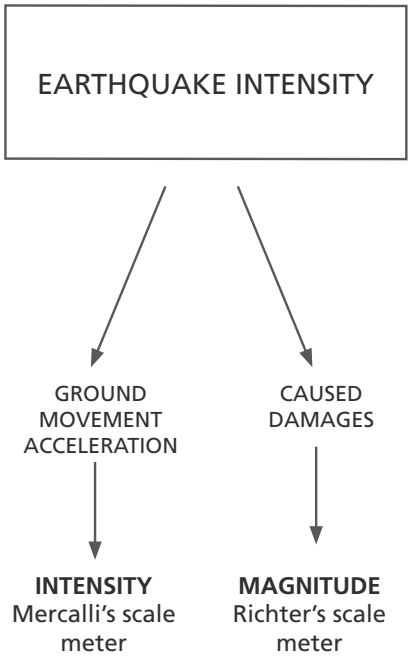
25.



26.



7 | Seismic resistance improvements



01.

In Jeddah seismatic activity is characterized by seismic acceleration peak values comprehensive between 0.10 - 0.15 g and a maximum magnitude recorded of 5.0, which is to consider as a zone of medium seismicity.

The insertion of horizontal wooden beams has been the traditional treatment to reduce the effects of earthquakes on old buildings. Modern buildings in Jeddah are seismic resistant planned but the old buildings aren't built in concrete or steel. An analysis of the most common techniques can be useful to give a general base of knowledge for a specific reinforcement planning. The major part of the building has no seismic - resistance predisposition, since this is a recent approach.

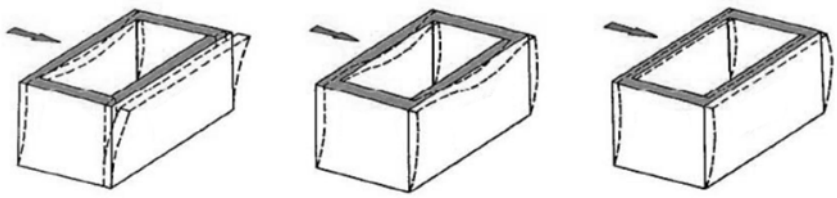
Seismic risk is related to two aspects:
- The frequency of local earthquakes, and their intensity;
- The vulnerability of the traditional structures, and the amount of damage received in the past years.

Every area can be analyzed in a geological and seismologic point of view. This type of data can help us to determine the frequency of the earthquakes and its intensity.
The seismic actions are the most dangerous for a building, and in particular in these buildings types that were not built to resist to such horizontal loads. The reaction of a masonry based structure to an earthquake is related to it's box wall integrity which has to act as a closed box:

- The walls shall be built with a proper thickness, with resistant materials and not wide openings.
- The floor decks systems has to be anelastic and well inserted in the walling.

The distribution of the horizontal forces is characterized by a major intensity on the top floors respectively to the base floors, the law of distribution of the forces depends to the geometrical characteristics of the construction and its rigidity. The damages and the instability produced by a seismic action have a certain relation with the ground subsidence because both produces tangential tensions of the structure.

02.



01_ *Magnitude and intensity are the two parameters that defines an earthquake. Magnitude was defined in 1935 by the seismologist CF Richter as an objective measurement of the amount of elastic energy released during an earthquake. Intensity of an earthquake quantifies and classifies the effects on environment caused by the seism, consequences on things and humans are torefer to the 'Mercalli's scale', conceived by Mercalli in 1902 and modified by Cancani and Sieberg (MCS) in 1923 and then in 1931 and 1956 and scaled to 12 degrees.*

02_*Reactions of wall systems subjected to perpendicular actions: the answer varies widely depending on the condition of constraint fixtures*

A_INSTABILITY CAUSES | PATHOLOGY ANALYSIS

Building instability causes and a general seismic vulnerability investigation identify factors that confers weak areas in the wall structure which can degenerate in a collapsing status. The analysis of the building shall be focusing structural - technological aspects, and their deterioration.

Types of vulnerability to reveal:

1_Vulnerability derived from original constructive errors:

- Poor cohesion of the wall *(absence of the horizontal reinforcements;* low quality of the mortar, stone cladding, jambs, lintels not properly integrated with the masonry);
- *Elements that reduces the wall's thickness* (system pipelines, water gutters, system pipelines, niches, stairways inside very thick walls);
- *Inadequate structural elements* (thin elements, not appropriate section dimensions, trusses which bearing is not well supported or could work better);
- *Not well located hollows in the walling* (windows to close or to near the angles of the building, not properly aligned openings);

2_ Vulnerability derived from tranformations:

- *Missing connections between the original structures and the new intervention, (*new building adherent to the old without any sort of connection, additional floors elevated without reinforcements of the lower decks or not integrated);
- *Removal of structural portions or elements* (opening of new windows, removal of internal walls);
- *Structural modifications not adequate* (new walls or pilasters built directly on wooden floors or in the middle of vaults);
- *Wall infilling of old openings* (the closing of doorways, or windows with infill masonry not well connected to the walling structural);

3_ Vulnerability derived loss of structural connections:

- *Scarce connections or missing integrations* (inadequate connections in specific parts, such as T or L wall connections);
- *Scarce or missing connection between walls and roofing* (not well supported of the wooden beams, missing elements of integration between the high stent of walling and the roof elements);
- *Scarce connection between the masonry and the floor decks* (wooden beam not enough integrated inside the wall, missing any sort of unthread element);

Cinematic mechanisms can bring to a loss of balance inside the wall structural system, with the consequence of new allocation of the force distribution or at the worst in a new danger state of collapsing eventuality.

BUILDING'S DAMAGE MECHANICS ABACUS

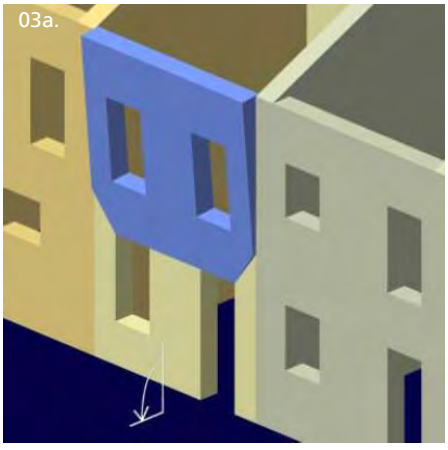
Out plane wall collapsing happens in two manners:

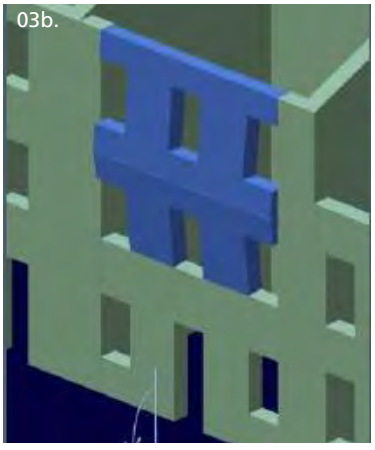
- *Flipping action of masonry walls*
  Occurs when a wall is not sufficiently clamped to the floors or orthogonal walls so in the absence of structural connecting parts such as edge beams or steel chains/ties on wall head.
  In presence of openings (doors and windows) and/or of a pre-existing 'fissure picture' wall flipping action may involve only partial sections of the masonry.
  In the presence of walls consisting of two separate and parallel lines of brickwork (cavity walls) flipping action may only affect the exterior side.
  The tilting can also involve part of the orthogonal walls, this mechanism is influenced by the presence of openings in the wall orthogonal and the quality of the masonry which constitutes it.

- *Bend actions of masonry walls*
  Occurs when a wall is constrained at the extreme parts and free to move at the center as example it can be mentioned the situation when in presence of a upper edge beam, of a metal tie rod or an anchorage of a beam head to a wall section (in the absence of connections to eventual intermediate floors).
  It can also occur in cases when a wall portion between two floors is well bound to it.
  It can affect one or more buildings floors and can also occur for only one of the garments in case of double-walled wall if the outer facing is effectively connected to the intermediate floors.

03a_03b_*In the images it is schematized the damage that may occur to the walls for flipping actions (3a) and for bending actions (3b)*

04_ *The collapse of full built masonry by shear movement typically occurs in cases of low store buildings and characterized by the presence of interstories with high rigidity.*
In case of buildings of greater height and/or with bands of lesser stiffness interstorey the appearance of diagonal cracks occurs in correspondence of the horizontal on plane brickwork.



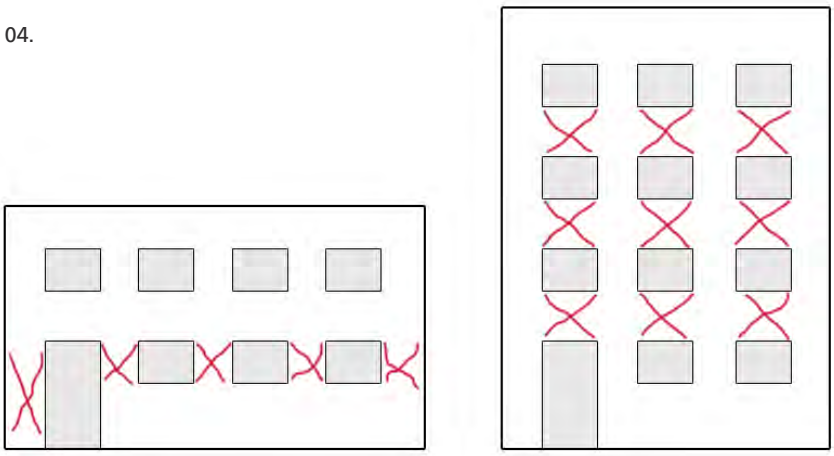


Wall collapsing on its own plane:

For walls parallel to the direction of breakage action it can occur in two ways:

- For the collapsing of full built masonry if the plane hoops are more resistant;
- For the collapsing of the plane hoops when these have less resistance than the full built parts of masonry.

04.

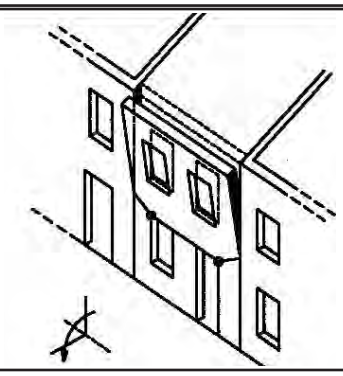


OBSERVATION OF THE DAMAGE STATUS OF THE BUILDING

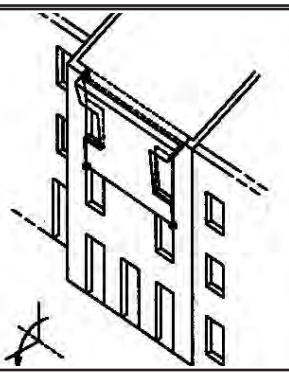
Missing connections in the wall web;	→	Cladding or plaster detachment
Inadequate integration between masonry and wood flooring;	→	Overturning of partial or whole portions of walling;
Uneffective connection between the walls and the horizontal system; openings near the building angles;	→	Partial collapsing of building angles;
Scarce internal mass connection of the walling;	→	Damages in correspondence of the construction joints;
Scarse masonry quality and presence of openings - discontinuities;	→	Collapsing by shear force distribution;l piano

EXTERNAL WALL

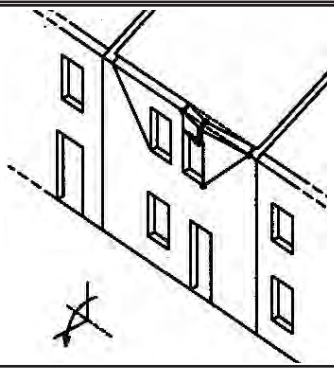
MECHANISMS SCHEME



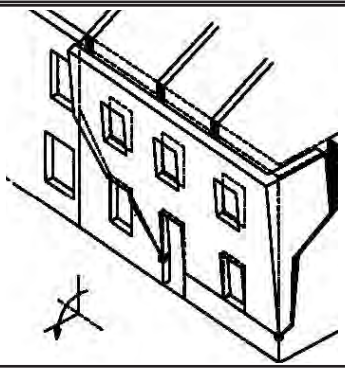
MECHANISM 1.1
External overturning out from the plane - whole extension rotation



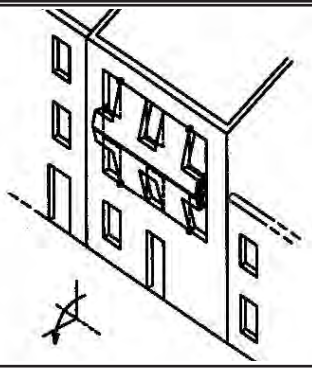
MECHANISM 1.2
External overturning out from the plane - partial rotation



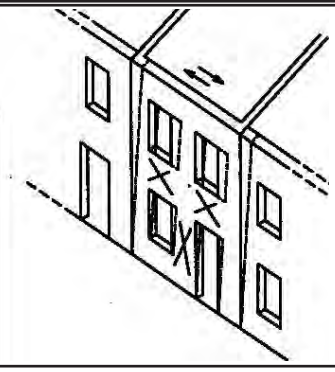
MECHANISM 1.3
External overturning out from the plane - partial rotation (top edge))



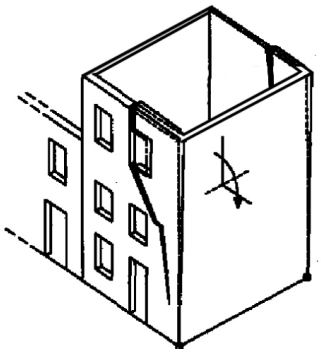
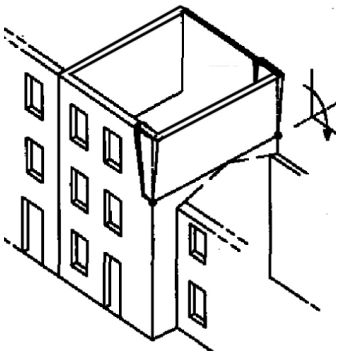
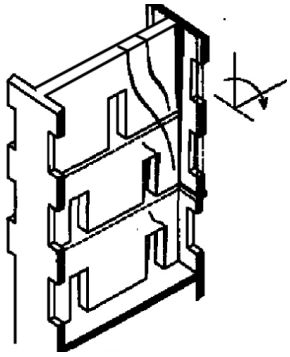
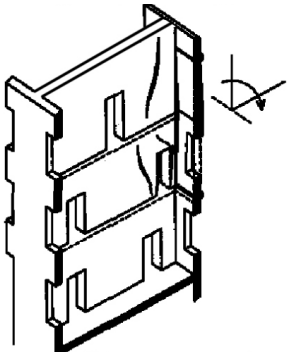
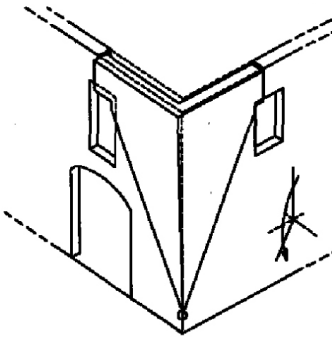
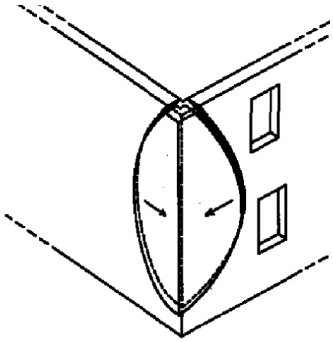
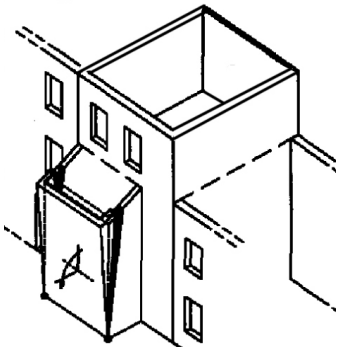
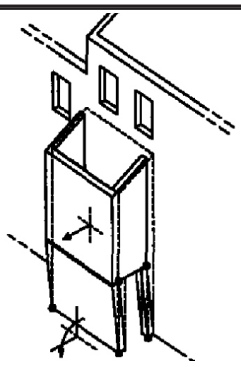
MECHANISM 1.4
External overturning out from the plane - with angle involved



MECHANISM 1.5
External overturning out from the plane - in presence of fixed joint on the top edge



MECHANISM 1.6
Angular deformation on the plane (shear load damage)

HEAD WALL	 *MECHANISM 2.1* *Total rotation out from the plane toward outside*	 *MECHANISM 2.2* *Partial rotation out from the plane toward outside*
MIDDLE WAL	 *MECHANISM 3.1* *Damages on the plane of the wall*	
FREE ANGLE MASONRY	 *MECHANISM 4.1* *Rotation toward outside*	 *MECHANISM 4.2* *Expulsion with arc effect*
SECONDARY LEANING CONSTRUCTIONS	 *MECHANISM 5.1* *Rotation out of the plane toward outside of the outstanding wall*	 *MECHANISM 5.2* *Total skew horizontally*

B_METHODOLOGICAL PREMISE

Seismic improvement techniques has to be not invasive and reversible, established the fact that the original status has changed and that probably the mechanism is still in progress consequentially there may be further rebalancing of the structures, it is necessary to stop it without aggravating the system with new weights or unnecessary connections. The insertion of extraneous structures in a traditional wall boxed structure (for example frame structures in steel pr armored concrete) may cause hybrid interactions between the two entities, without any possibility to anticipate any result of a new equilibrium.

Redescovering of traditional techniques:

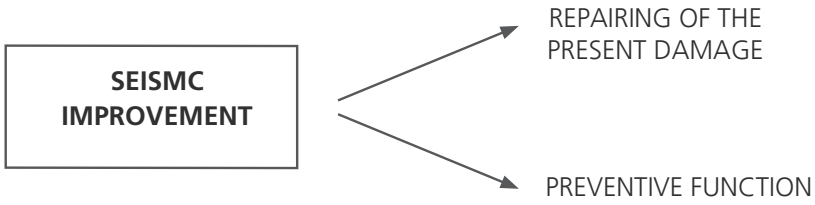
- Preservation of the original wood floor elements;
- Slight anelastic consolidation of the floor deck system;
- Insertion of steel rods - chaining;
- Steel belt installation;

A careful usage of reinforcements, also with the adaption of new technologies.

- Reinforcement of the walling by usage of injection and horizontal steel clamps (diatones);
- The usage of composite materials (FRP);

To achieve a seismic resistance improvement it is necessary to know the real preservation state of the building, his history and physical relation with the surrounding buildings, and the analysis of the structure. The survey phase is necessary to record information about multiple aspects of the building, it is required to analyze the structural resistant parts, the type of materials involved in the construction, the status of instability and deterioration, the type of ground, and the type of foundations. A interpretative model of the building shall be definite which shall be the necessary to filter all the information of the static and dynamic situation.

The next step shall be the calculation of the buildings seismic vulnerability, the actions or reactions of the changing status has to be considered in a perspective of causes and effects, in this specific case the cause is an earthquake and the detachment of a masonry work is the effect. It is possible to analyze the most critic situations and consequently to plan the optimal operation to be adopted for the structural improvement, it is possible to intervene on a specific portion of the structure or involve the entire system. It shall be adopted the less invasive solution, which integrates itself in a more strengthened way avoiding any sort of drastic modification of the original load distribution.



Seismc improvement planning phase

- In depth analysis of the building;
- Examination of the fissures as a whole;
- Examination of specific vulnerabilities;
- Detect the possible collapsing mechanics in relation to the typical vulnerabilities of the building;
- Choose the optimal operations necessary to avoid any collapsing deterioration. Any solution detected has to correspond to a deficiency of the building.

The seismic improvement can be applied with two distinct procedures:

- Reduce the seismic effects on the building
- Reinforce the structural reaction characteristics

To reduce seismic effects it is possible to modify the building's structure or to reduce the energy that is transferred.

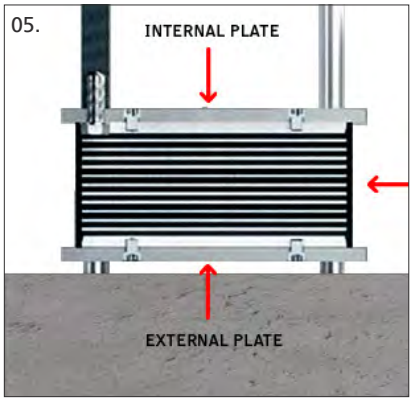
Operations on the building could be:

- Minimize the mass weight, especially at the top floors, moving installments or machineries from the high floor deck to the lower floors, or in the basement, this is related to the distribution of the horizontal forces optimization, which are less drastic as they are closer to the source of energy (as an earthquake - from the ground);
- Reduction of not symmetrical location of the weights, if not well planned a distribution of masses not well connected can generate cumulative torsion effects, which increases the energy inside the walls and on the joints. An asymmetric disposal of building parts or a different resistance of specific part of the structure, a not balanced location of concrete based sub structures, or location of stairways lift shafts, drastically different height of buildings parts.

In case a part of the building has characteristics that varies from another, to absorb or eliminate the concentration of forces in a single area it shall be necessary to reinforce the connections, inserting tie rods, specific anchors or steel belts, or creating a expansion joint adapting particular cuts in the original structure. The structural reaction improvement is the most solid solution as the most simple to apply. During an earthquake the single parts of a building reacts in different and specific ways, each element has to avoid specific actions that could lead to a collapsing danger, as the foundations has to avoid vertical instability the wall system has to avoid detachment of related elements that are supported such as wooden beams or linear connections like vaults. It is necessary then to seal the connections and the joints as to comply an uniformity of the distribution of forces. The realizations of these improvements is a prerequisite necessary, and it shall be described in particular on the following chapter.

C_DESCRIPTION OF THE INTERVENTIONS

C.1_Seismic deterrents inserts



05_*Schematic representation of an elastomeric isolator*

06_ *Photo of an elastomeric isolator sample.*

07_*Photo of the isolator placing in a construction site.*

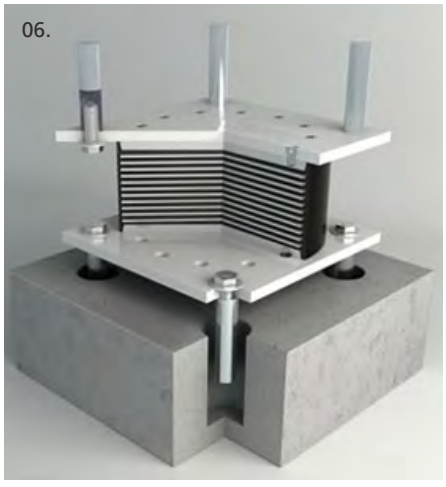
Trying to reduce the quantity of energy that can transfer on the structure is a solution complicated and expensive. It is obtained inserting seismic insulators in the foundations, otherwise it is possible to operate locally insulating floor decks on the connection to the walls. Insulating the floor decks results as a cut between the major parts (and weights) of the building. An accurate dimensioning may limit the actual energy transmitted to the building to values compatible with the resistance of the structure reducing the forces under a predetermined value.

There are three categories of seismic isolators:

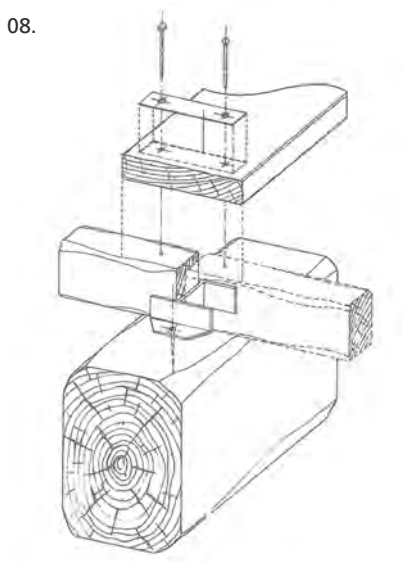
- Elastomeric isolators: they have high vertical rigidity but low horizontal rigidity; that means they can keep the insulated structure out of the frequency field of the seism. They can be reinforced with metal sheets or with a lead block which helps to improve structure's seismic performance;

- Sliding isolators: they're usually composed by steel and Teflon elements that slide and allow to limit to an extremely low value the total horizontal dynamic force of the seism;

- Metal rolling isolators: they have a sphere or roller shape and allow to insulate even lighter and more flexible structures. Widely adopted in Japan;



08.

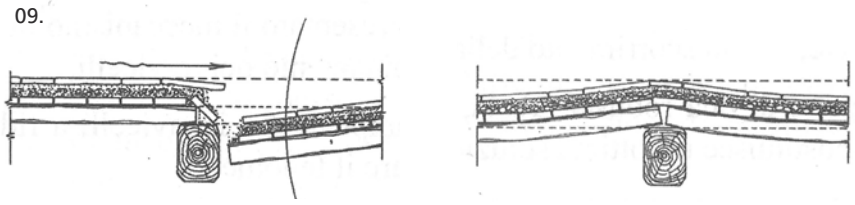


C.2_Internal conditions improvement

Wood floor decks are characterized by the assembly of elements relatively supported in a very simple order. The floor deck is realized to transfer the weight of accidental loads on the walls, but are not optimal to resist horizontal force transmissions, the only friction resistance between the wood elements and the masonry contrasts this type of force distribution. This simple static scheme, which is quite efficient with all the parts functionally and geometrically well dimensioned and not consumed, could become dangerous in a deteriorate situation with the single parts deformed or partially ineffective at their functions, and could not resist to a seismic stress situation.

The horizontal movements caused by a seism can cause the extraction of the wood elements from the wall supports, in case of double frame it can cause the rolling of the second trusses on the main, it shall be required basic operations to avoid these type of dynamics.

09.



A.SLIPPING OF THE SECONDARY TRANSOMS ON THE MAIN BEAMS

B. DEFORMATION OF THE SECONDARY TRANSOMS

10.

08_*The operation suggested is a nail procedure of the wood boards on the beams by the fixing of metal plates transversely as to avoid any sort of fissure on the long direction. In case of double frame wood floor decks, a peculiar steel shoe shape joint has to be placed between the two wood elements. These systems avoid any sort of sliding or rolling of the secondary element on the main truss, consequentially reducing the whole deformation of the floor.*

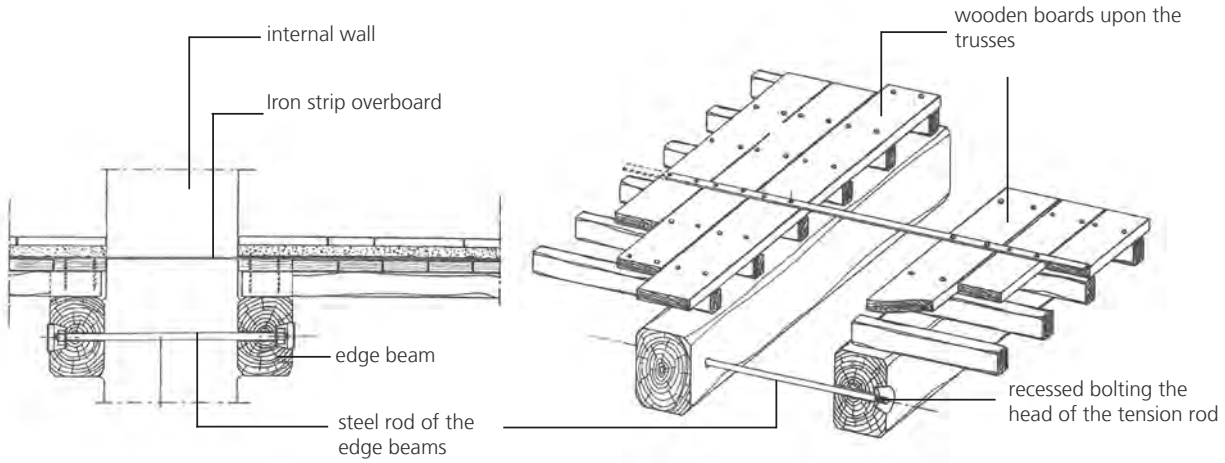
09_*Specific internal connections are necessary to contrast horizontal seismic movements, as also to avoid lowering of the floor plane as a consequence of excessive bending of the wood bearing trusses.*

10_ *Wooden floor badly damaged in Jeddah: extremely bent, it has broken in several parts and the lintel-beam as some primary beams had slipted out from the masonry support.*

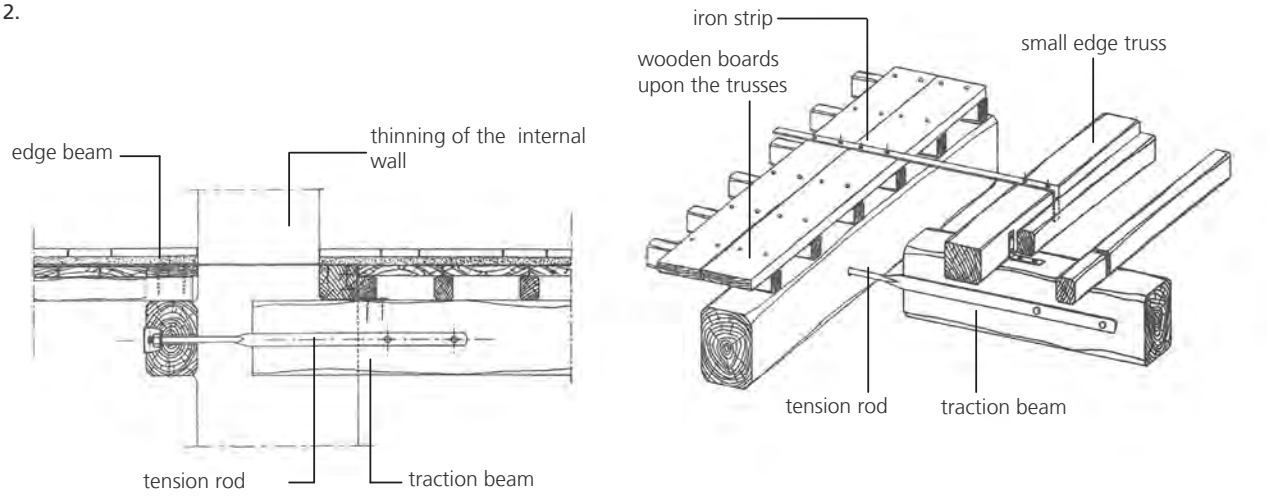
It is necessary to ensure the connections between the floor decks and the masonry work, this has to be achieved for multiple reasons:

- To avoid wood beams extrapolation from the supports;
- To facilitate the load distribution on the vertical part of the building;
- To ensure horizontal connections;

11.

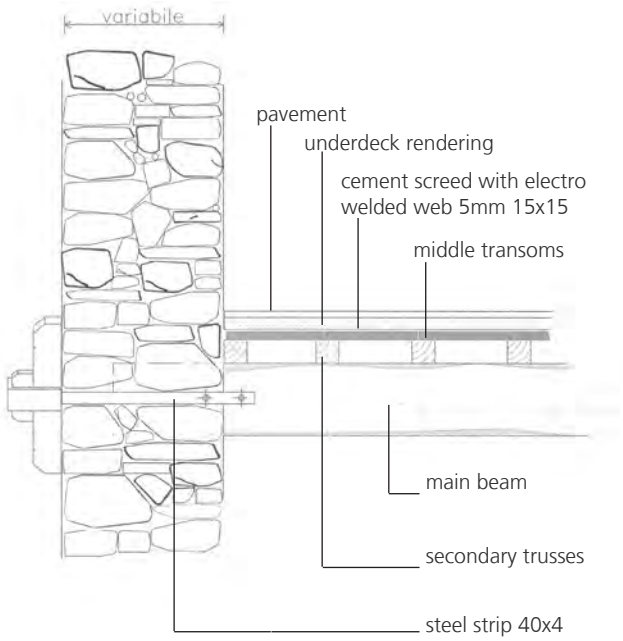


12.

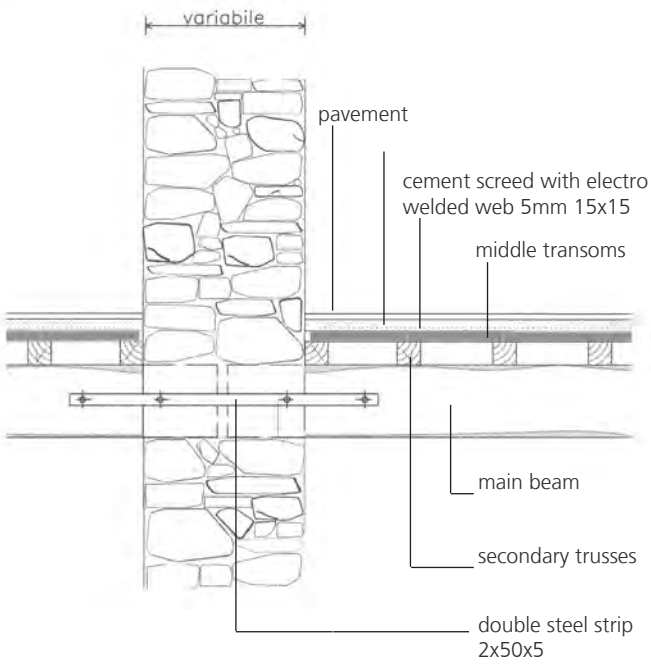


It is possible to position connections between the floor decks and the walls as to transfer the horizontal loads directly on the walls.
The wood floor decks should be able to hold the wall oscillation, when the wall pushes inside the truss works as a shore, meanwhile if properly anchored with metal parts and joints it could tighten the external walls avoiding the wall to flip outside. These steel parts has to be dimensioned in a proper manner in proportion to the loads and the horizontal forces, usually the connection is between the main beams and the wall support and linearly the wood boards and the opposite wall.

13.



14.



11_*Connection between contiguos rooms with parallel frame.*

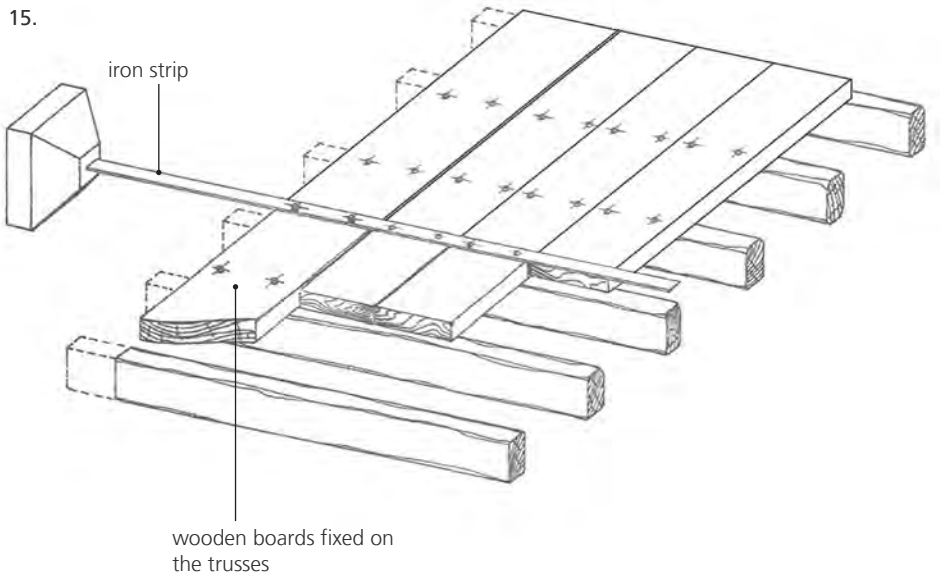
12_ *Connection between contiguos rooms with perpendicular frame.*

13_ *Masonry wall header anchored by a steel tie.*

14_ *Masonry wall header anchored by contrasting beams.*

15_ *Wall - floor connection by steel bar nailed to the wooden boards by a steel tie.*

15.



C.3_Steel tie rods insertion

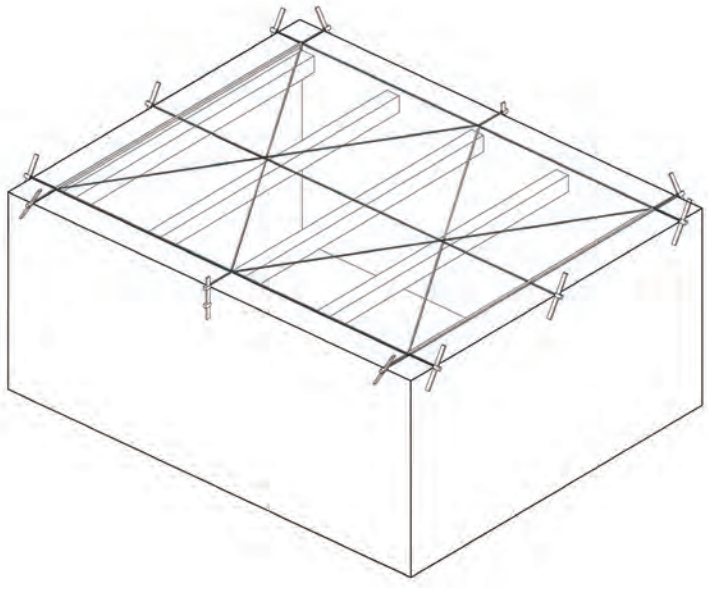
Stainless steel rods can be considered mono dimensional elements, which shall be set in a slight state of tension to ensure a state of restraint condition of the wall system by the anchorage of so called tie rods. The setting in tension of the rod requires the presence of an element that contrasts the pressure as to avoid to transfer to the wall such new forces that could cause unnecessary flex deformations. The shore element can be an internal wall or a floor deck, in this case the steel rod is bedded in the screed.

This type of operation is quite an optimal reinforcement because it confers various advantages:

- Confers an high grade of connectivity between the orthogonal wall set granting a reinforcement to the masonry box system.
- Avoid the flipping of wide portions of wall
- Has an esthetic benefit for a minimum visibility of the insertions (tie rod is visible for the only plate on the outside of the walling box)

The stainless steel rods can be inserted internally or externally of the structures to reinforce, positioned horizontaly or angled as required by the distribution of the loads to absorb. The optimal combination usually requires a cross positioning fixing the ties flushed in the wall. The type of technology permits to proceed to eventual future adjustments and re tensioning to compensate new deformations of the building structure system

16.



16_ *Steel tension rods disposal in an elementar cell.*

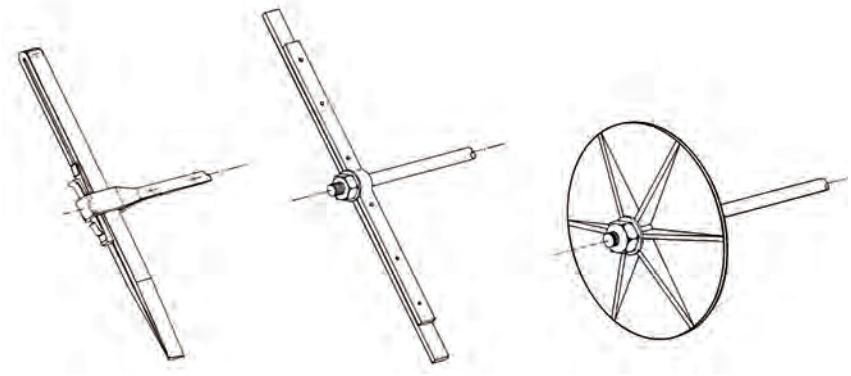
17_*Examples of steel ties:*
a) eyelet tupe - hooked rod
b) tension threaded bar - bolt tighted
c) plate with tension threated bar.

Execution phase

- Preparation of the walls, local reinforcement of the support area of the force transfers;
- Drilling the holes on the walls/floor decks;
- Bedding in the walls the steel plates that will work as ties;
- Insertion of the stainless steel rods;
- Bedding the rods on the floor screed;
- Set in tension phase;
- Fixating the steel rods on the tie plates

A preliminary operation shall be the analysis of the structures status, it is possible that the area that has to be strengthened is missing parts or entire portions of masonry, since this type of structures distributes the forces in a proper way only if there aren't missing portions that would compromise the uniformity it is then necessary to proceed with a traditional masonry work based on the removal of the single bricks that are loosen and collocate them in a proper bed of mortar as to rebuild the original status of the walls web masonry.

17.



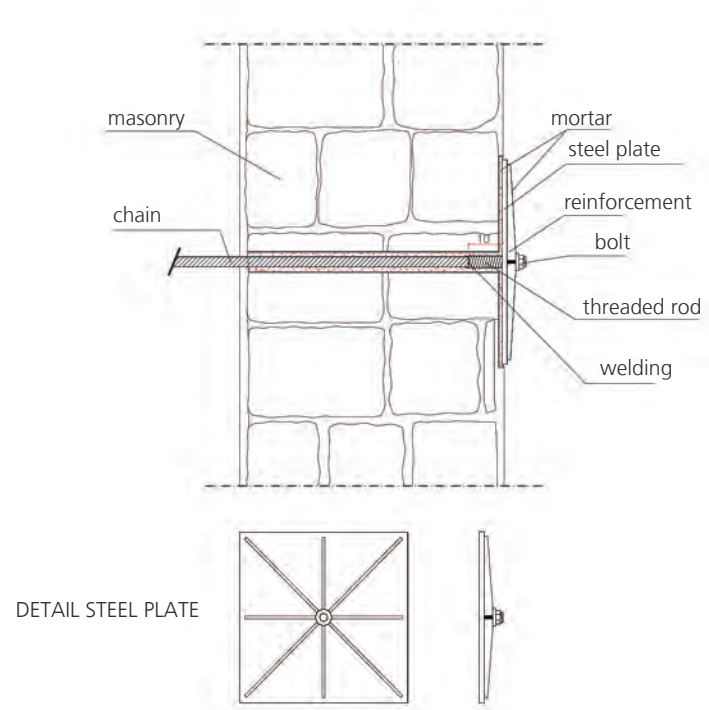
a) b) c)

As tie node it is possible to use steel bars knotted or if it is necessary knotted to a steel plate which distributes the rod tension on the wall surface; this last technique is required when the wall is not properly done or not very solid, otherwise of this situation it is better to use a steel bar knotted that is easier to collocate and involves a more extensive part of wall and has the flexibility of the turning position of the bar usually positioned angled to avoid dangerous inclusions in the wall (as breaking on the brick line). The dimension of the steel bar has to be thick enough to ensure a proper transmission of the rods tension on the wall without bending or breaking in the tightening phase. It is important to calculate properly the length of the steel cable/rod because if it is too long it could deform in proportion with the distance of the force sources. If the cable is longer than 10 meters

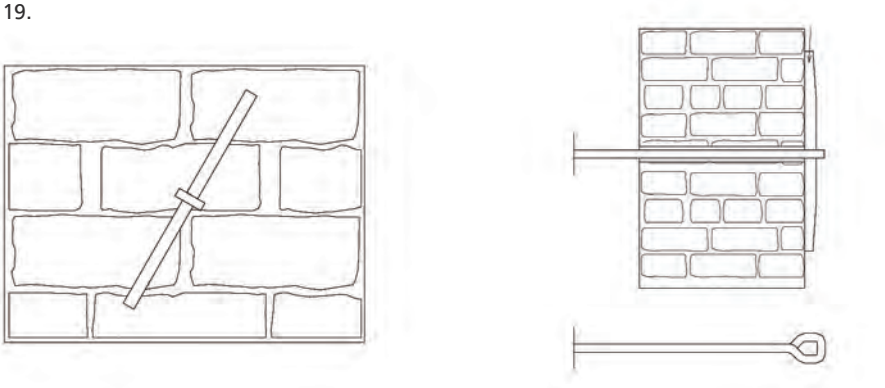
it has to be positioned by portions, the jointing of these type of cables can be done with a tensioner element that could pull the rod step by step, in any case it is important to avoid cables longer than 20 m.

The solution of a tie knot bedded in the wall is an option to avoid, more than ever when the masonry has more than one plaster layer detached.

18.



19.




20.

It is suggested the usage of steel anchors that transfers bearing forces superficially by adherence,(by epoxy resin injections or specific mortar cement based inside the original masonry wall web). It is to avoid for several reasons, the difficulty to control the result, the fact that it is a new and diverse material from the original materials, and if in the tensioning phase creates problematic fissuring in the wall it is not reversible.

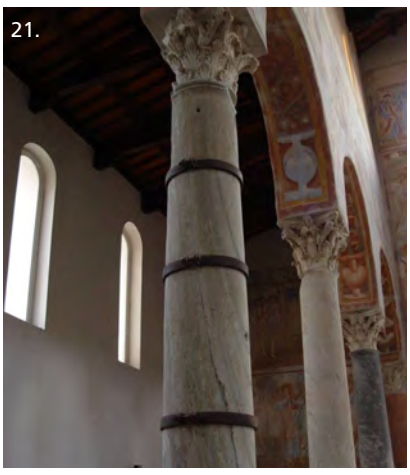
C.4_External hoops

Hoops technology consists in the application of a belt formed fastening that circumscribes an object, with the objective to limit or to stop any sort of lateral deformation with the consequence of interior breakings. It is possible to proceed with this operation on small size buildings where the structural parts to be fastened are short. it is applicable to single elements as pilasters or vaults, or in a more macroscopic scale to entire buildings to ensure the solidity of the whole wall box continuity.

It is possible to realize with two technologies:

- Metal based elements;
- Composite materials;

It is important to avoid concentration of high tension state in the angles of the building, in a hoop bracing positioning, when it has to 'turn' on the angle of the building it is required to fix in such situation a steel angular with steel rods welded as to reinforce the local masonry work an ensure a transmission of the tension on a large portion of the treated angle, if instead the hoop consists in a composite material a chamfer of the angle shall be necessary to be prepared before the positioning of the belt.
The technique of the positioning of composite material hoops consists in gluing (epoxy resin based products) to the wall structure, fiber based strips conglomerated in a polymeric matrix, which are very high resistant.


21.


22.

18_ *Anchor scheme of a steel rod or double sided anchor.*
19_ *Particular of the chain-plate anchorage.*
20_ *FRP Metal hoops*
21_ **22**_ *Metal hoops.*

These composite materials (FRP) consists particularly in one material a fiber hoop which each fiber has a diameter of 8mm, linearly positioned as to form a strip of various thickness and conglomerated in the execution phase with resin products, that seals them together and ensures them to work contemporary, this amalgamate protects the fibers from temperature variations too.

The manufactured fibers marketed are:

- Ceramic based fibers
- Carbon based fibers
- Glass fibers

The characteristics of this technology are:

- Mechanical and chemical resistance;
- Light weight and slim thickness;
- Easiness and ductility for the pose, this material adapts to complex forms as not well even surfaces;

Execution - the application procedure varies in relation to the structure and the deterioration status, the sequence of working phases:

- Surface preparation;
- Primer coating;
- Application of the adhesive resins product;
- Fiber pose (strips, web cloths, bars);
- Fiber covering with a protective pellicle or plastering;

The surface has to be without any presence of friable or non cohesive base. In the case of plastered walling it has to be removed to uncover the brickwork on which the hoops strips has to be applied on.

The main recommendation for the realization of this type of hoop bracing are focused on the preparation of the surfaces and the angle chamfering, reason why the preparation requires specialized operators.

The strips of composite materials has higher performance in comparison with the steel hoops, they guarantee an perfect adherence with a very thin dimension that can be bedded under the plasterwork. The technique is reversible, the fiber strips are removable with heat treatments.

C.5_Edge beam reinforcement

The building of new edge beams is focused to reinforce the connection of the wall with the roof and consists in building in the higher part of the wall box system, on the perimeter of the walling a structural element the confers a hoop resistance to the masonry work. If the roof structure isn't solidarized with the masonry work of the wall box, a seismic movement can transfer involuntary forces on the edge of the wall system causing an dangerous uncontrollable situation. Roof system is as always an area particularly deteriorated for his wide exposure, reinforcing the attachment between the roof and the wall system requires a good status ov maintenance of both.

Functions that the connection wall - roof has to accomplish:

- Mutual connection between the interior and the external plaster/cladding
- In case of an earthquake the non presence of a vertical load over the wall system confers an increased importance of the horizontal forces, the inadequate state of the connections let the external finishings to detach and to weaken the wall system which is to be considered as a thin wall structure system, and would certainly crumble for the inertial actions that work out of the roof border plane. usually this is the first part to collapse of these type of buildings;
- To preserve these type of wall systems it is necessary to attach the two layers of plaster/cladding has to be transversally clamped;
- Increase of the cohesive characteristics of the masonry on the top border;
- Support and anchoring of the wooden roof structure;
- Connection between the roof and the wall

Edge beam structure functions:

- Realize a connection between the roof structure and the supporting walls;
- Destribuates the vertical loads in a more evenly way on the wall box;
- Redistribute the earthquakes horizontal forces;
- Connects the orthogonal walls;
- Hoops the masonry edge by creating a closed element connected with a dense web of armored holes (1 each 50" - 60")

The edge beams can be made of:

- Armored concrete;
- Steel armored masonry;
- FRP armored masonry;
- Steel strucutre;
- FRP hoop system;

EDGE BEAM OF ARMORED CONCRETE:

Execution:

- Casing formwork predisposition;
- Armor disposal;
- Overlaping of the armor in middle beam section and on the angle situations;
- Enclosing of the secondary steel reinforcement bars;
- Drilling of the holes for connections to the masonry edge; if the masonry on which the edge beam is located as to form an ideal solid and linear connectivity. If the wall masonry is incoherent the drilling and the pin fixing shall be done with angled holes as to avoid mono directional connections;
- Concrete casting;

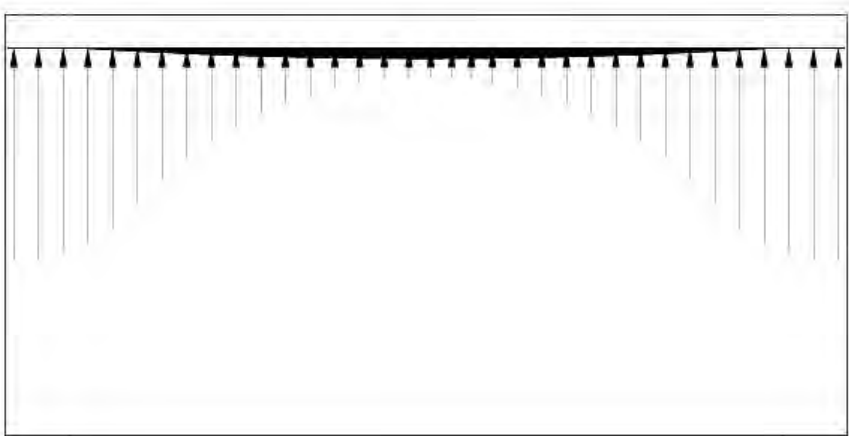

23.

The edge beam has to have a height thickness inferior of the wall thickness, and shall never be thicker than 40 cm, and shall be covering the whole section of the wall.
The armor of the concrete is usually constituted of 4 steel bars, if the distance between the supports is consistent there shall be supplemental bars in the middle course, the secondary reinforcement shall consist in 6 mm steel bars bent as the shape of the edge beam and spaced constantly till the area of support where the transversal bars shall be more closer. To ensure a better connection with the wall that supports the edge beam it is suggested to bed on the edge border of the masonry steel bars injected of specific mortar calcium based.

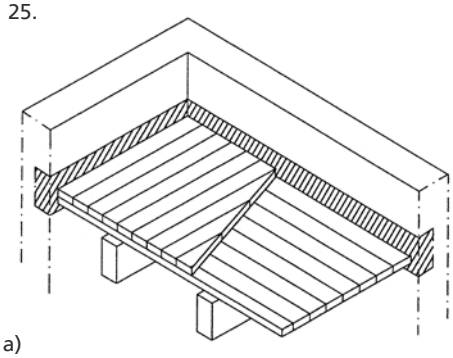
23_ *Edge beam of armored concrete.*
24_ *Beam effect: inhomogeneous distribution of the tension forces to the masonry.*
25_ *Reinforcement of a wooden floor through a second order of boards and floor's connection to the walls with an edge beam (a) or steel plates (b)*

The connection with the roof system can be done in a two phase technology; in a first phase it shall be placed on the superior edge of the box wall a sequence of steel bars (one every 50cm) that outfits the border, these steel rods are threaded as to be bolted in the second phase. In the second phase a beam shall be placed and bolted.

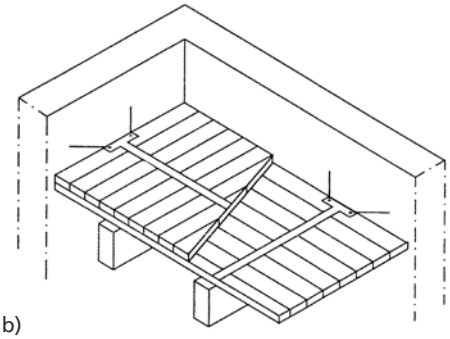
24.



25.



a)



b)

This type of operation can be applied on many situations but presents some limits that can reduce this technology to an ineffective choice. The edge beam built in such a manner are particularly adapt to absorb axial loads, but contemporary confers a rigid anelastic hoop on the top edge of the building, since it is casted with an armor that is very similar to an armored concrete beam it actually risks to work as an armored concrete beam delivering the loads not evenly on the masonry but concentrating the tensions on the extremities usually coincident with the crossing sections of the walling or the angle, where the masonry could be more weak and more vulnerable.
Consequentially a seismic action that transfers horizontal tensions can cause flipping situations or even partial collapse of the brickwork not stable, meanwhile the edge beam can preserve the entire roof in its integrity, the support below can collapse all together. This is the reason why these edge beams of armored concrete shouldn't be more than 40 cm thick, ore it's thick and more it's rigid.

A practice widespread is the procedure to insert concrete edge beams at each floor deck inside the wall masonry connected to a armored slab casted on the wooden deck. The same considerations done for the upper deck concrete edge beams are applicable to this type of edge beam, it is not suggested to use this technique because it is at the end unrelated

to the original structural system and not compatible to the preservation criteria. It is preferred to use techniques as the fixing of a secondary wood board on the original one or reinforcements with steel strips or composite hoops taking care of the wall connections or steel 'chaining' bracing.

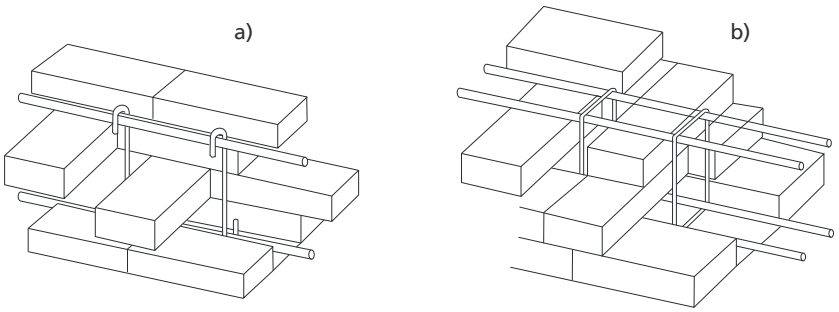
EDGE BEAM OF MASONRY ARMORED

Consists in a brick or stone based construction which is armored with a steel cage fixed on the top edge of the building by a injection of cement. This technology is suggested because conserves the same materials used in the original masonry wall. Since this type of reinforcement is made of the same material there shall not be any sort of discontinuity avoiding the dangerous situation that could happen with a discontinuous system where the seismic energy tends to separate in such a connection area. Other than this it is an optimal technique to avoid thermal loss.

Execution

In reference to the wall thickness it can be chosen two distinct solutions equally valid:

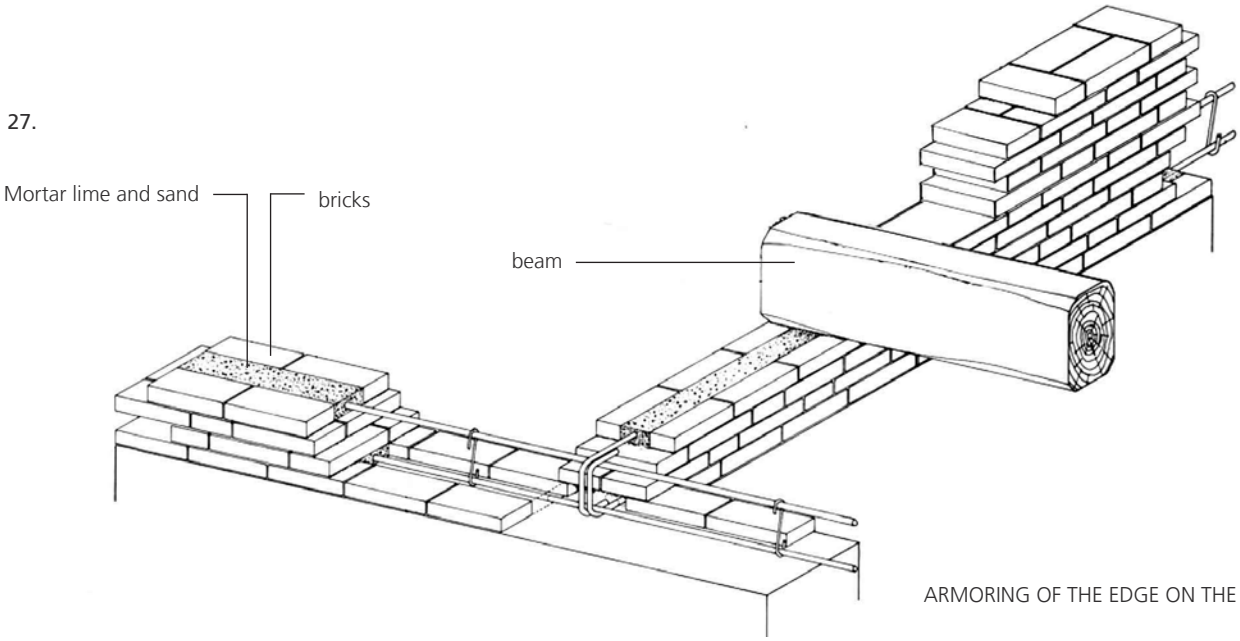
26.



2 Brick course edge beam:

- Position 3 lines of bricks distant the space enough for a ϕ 22 steel bar;
- Fill the hollow with liquid cement;
- Transversally allocate diatones and steel connections of ϕ8/20 on the main steel rod below;
- Position another two lines of bricks leaving a distance enough for a ϕ 22 steel bar as below, this bar shall be connected on the secondary rods of ϕ 8/20;
- Fill the hollow remaining with liquid cement.

27.



ARMORING OF THE EDGE ON THE WALL

3 Brick course edge beam:

- Position two lines of bricks distant the space enough for a ϕ22 steel bar;
- Fill the hollow with liquid cement;
- Transversally allocate diatones and steel connections of ϕ 8/20 on the main steel rod below;
- Position another 3 lines of bricks leaving a distance enough for a ϕ 22 steel bar as below, this bar shall be connected on the secondary rods of ϕ 8/20;
- Fill the hollow remaining with liquid cement.

The usage of casing formwork is not necessary because the top edge of the original wall shall be in contact with this edge beam.
The steel used should be of improved adherent in galvanized steel, stainless steel or normal steel but treated with anti carbonation products; usually a beam of 3 bricks uses a cage armor of 2 + 2 ϕ16 mm and secondary steel bars of 8/200-255 mm, meanwhile in smaller beams could be enough 2 ϕ 22 -24 mm knotted with 2 pins of ϕ 8-10/200 mm. If the roof shall be provided of a concrete slab the beam shall be provided of secondary armor of ϕ 8/400 mm to be connected to the welded web of the superior slab. The limit of this technology is the fact that it shall require a demolishing of the op edge for the installation.

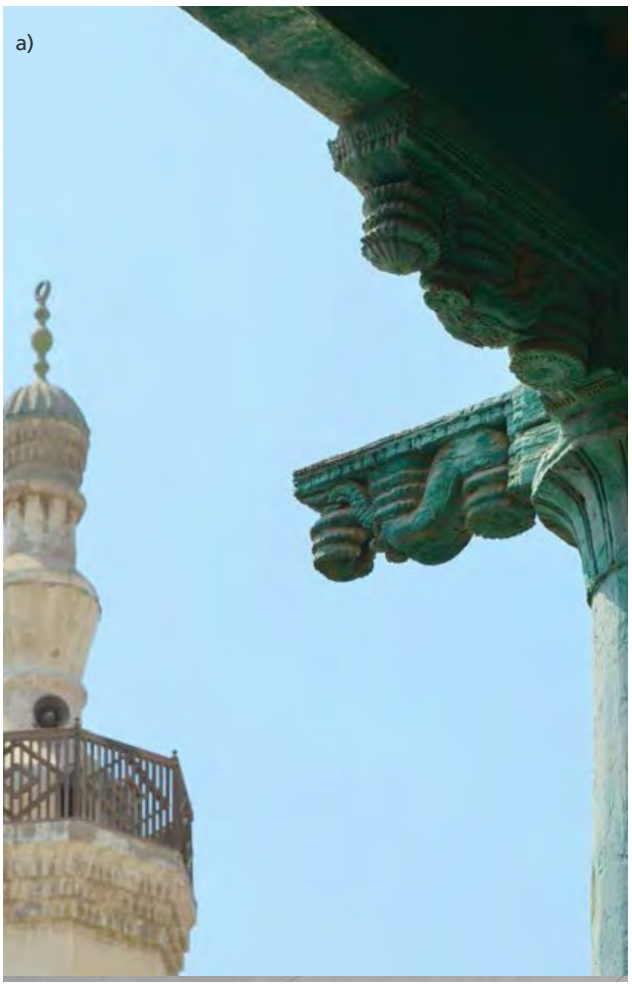
Wooden edge beam
The edge beam can also be realized by inserting a wooden beam specifically sized, generally 250x250 mm, in the top bearing walls. The timber used shall not present any sort of defect, must be perfectly seasoned and of an essence type hard and durable. The edge beam should be laid on a perfectly leveled plane in the masonry, solid, stable, and anchored to it by threaded rods in stainless steel verticaly or slightly angled variable by length (minimum length within the masonry 60 cm), linked to the edge beam by blting with washer of stainless steel. The 'rosetta' has to lie on the wood throughout its whole surface. The contact surface has to be isolated frome the edge beam of the masonry, for example by a double sheet of neoprene (synthetic rubber resistant to the harmful action of atmospheric agents).
The edge beams must be previously treated with specific anti-fungal and anti-mildew products.

26_ *a) 2 brick course edge beam*
b) 3 Brick course edge beam.
27_ *Angle solution of an edge beam constructed with armoured masonry.*
28_*The restoration of Masjid ash-Shafe`i, which counts among the oldest buildings in the old city of Jeddah, has been entrusted to the Turath Foundation. The office of prof. Lamae, from Egypt is in charge of the conservation and rehabilitation works.*
a) c) d) photos
b) survey drawings.

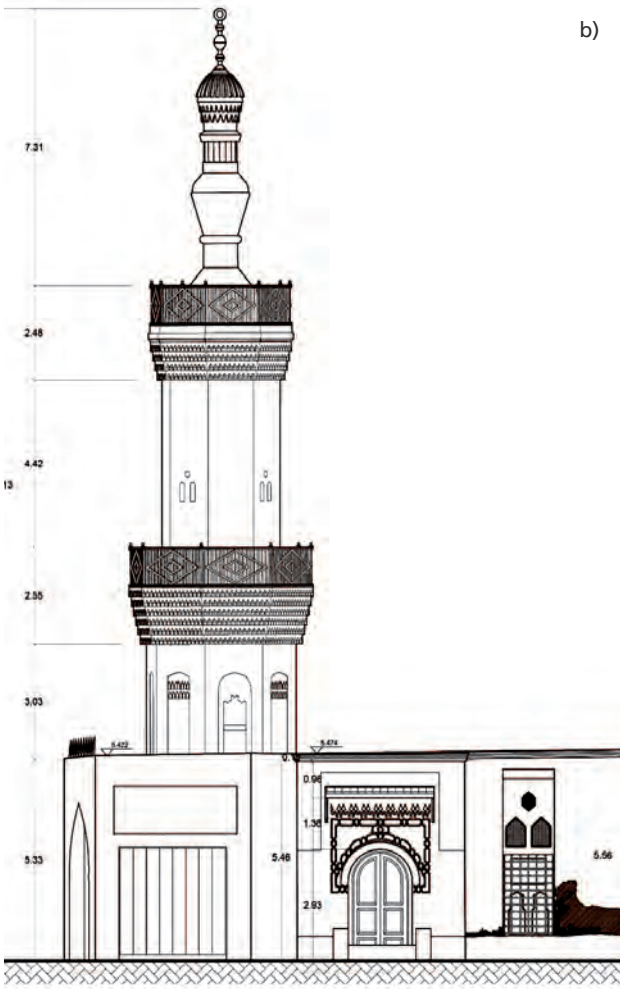
INTERRELATION BETWEEN INTERVENTIONS TYPOLOGIES AND PROPOSED SOLUTIONS	Foundation consolidation	Floor's deformability reduction	Vertical resistant elements distribution's improvement	Increase of the masonry's joint mechanical resistance	Switched roof system	Connection's deficiency reduction
Ground consolidation	■					
Enlargement of the foundation's base	■					
Elongation of the foundation with armored concrete edge beams	■					
Foundation construction with micro piles	■					
Traction tie rods		■			■	■
Hoop belts made of composite materials		■			■	■
Crown edge beams					■	■
Opened hoop belts			■			
Unstitched and sewing			■	■		
Anti expulsive traction rods				■		
Connections between the floors and roof with the wall					■	■
Armored concrete slab with crossed perforations (not suggested)		■				■
Tie-bar wall insertion		■			■	■
Store floors and roof reconstruction		■			■	■
Stiffening of the flooring systems		■			■	■
Insertion of new elements and/or realization of new openings		■				
Re-grouting of the brick joints			■			
Artificial transverse rods				■		
Mortar injections				■		
Armored injections (not suggested)			■	■		■
Wall's rebuilding				■		
Armored plastering (not suggested)			■	■		
roof system consolidation			■		■	
Joint's and wooden beam's heads reinforcement					■	■

28.

a)



b)



c)

d)

8 | Historic wood restoration

01_02_ *Wooden elements that characterize and decor the traditional buildings facades in Jeddah.*

Visible woodwork characterizes Jeddah's building in the structures as in the finishes.
The floor decks are usually built with wood, wooden trusses are inserted inside the masonry work of the walls, redistributes the forces, connects the parts of the walling working in an antisysmatic protection, the facades are characterized by the presence of Roshans and wooden portals.
Wooden bow windows are a common and characteristic element for all the local housing, particularly in Cairo and in Istambul, but in comparison Jeddah's Roshans are different for a major complexity and for a extensive presence on the facades, in some cases it can be totally covering.

Roshans are emblematic symbols of the architectural heritage of the city of Jeddah: they are everywhere in Al Balad. Roshans shape light and shade on the facades, conferring vibrance and importance. They are found on ground floors, and the most majestic models are at storey level. These richly ornate paneled elements overhang on the street, alternating openings, shutters and mashrabiyas.
The Roshan unit is made up of a facade and side panels, of a floor and a ceiling. Made of wooden, it mixes fixed and moving elements.
The whole structure is firmly tied into the masonry by a series of wall brackets or consoles. These consoles are made in such a way as to integrate elaborate and sometimes polychrome ornamentation.
The design of the under-face includes a unit made up of small wooden surfaces, in ' steps '. They are carved and painted.
This unit rests on console supports, within the masonry. The side panels are ' stapled ' over the opening, using metal cleats fixed into the wooden elements, tied into the wall thickness.
On the lower part, the panels are assembled in grooves, constituting a full plinth.
Above, sliding wooden shutters, full or louvered, are fitted at interior eye-level. These moving parts slide in the grooves thanks to a system called a guillotine system. They can be opened or closed onto the street.
On the higher level, mashrabiya elements are fitted for inside ventilation.
These structures are surmounted by a wide elegant cornice.

02.

A_INSTABILITY CAUSES | PATHOLOGY ANALYSIS

Defects that can affect joinery and woodwork are related to the status of the wood elements, improper assemblage, as an inadequate maintenance:

- Improper seasoning of the original wood log;
- Inadequate cuts and assemblies;
- Maintenance status;

A freshly cut wooden log contains an high percentage of water, at this status this material can't be used before a proper seasoning phase. The seasoning process is based on a sequence of two phases: the first is related to the loss of water present in the microstructure of the wood cells and the second is the balancing between the water that the peripheral cells contains and the amount of water present in the environment. Wood is a hygroscopic material with high capacity to absorb the water in form of vapor present in the environment. After the ageing process, the wood remains susceptible at the changes of humidity and temperature in this perspective his preservation can be compromised: the consequential change of status of the wood that can be subject to shrinkage or contraction for moisture loss, dilatation and swelling by absorption of moisture. The expansions related to the change of temperature are negligible.

The cutting has to consider the direction of the woods fibers as to avoid differential deformations, an inappropriate setting of cuts can compromise the structure resistance, as an example a mechanical cut with a saw that chops off the surface of the fibers can lower the resistance toward flexibility than a hand saw procedure.


03.

The preservation status can be compromised with the presence of biotic agents or parasites. To preserve the wood elements against excessive humidity status of the environment for the reason to avoid the growing of microrganisms which proliferate in such contests. Inside the wooden parts affected by biotic aggression - such as fungi or insects - there will be a decrease of the mechanical resistance in consequence of the reduced active section usualy not visible externally. This pathology can be very problematic in particular area of a wooden structure or element, particularly in the area where the wood beam is supported where generally the shearing force is at maximum valor, an weak section in this point can have as consequence an instant breaking. Analyzing a beam that is under a bending movement and has the central part weaken for an biotically affected can bring to sudden cracking and disruption. A healthy wooden beam breaks gradually with ample and visible fraying in the specific stressed section and is characterized of losing of single ropes of wooden fibers usually on the lower side of the beam which is suffering of traction force and a collapse for crushing

03_04_*Damaged Musharabyas photograph.*

status in the compressed parts whenever happens that the force is superior of the wood resistance.

External causes can damage the wooden elements such as climatic factors as solar radiation, direct raining or anthropic reasons. A consistent cause of weakening of wooden elements and frames is related to the fixing of air conditioning installments inside the Roshan's frame structuress

Multiple layers of painting without any kind of painting removal has caused a loss of the original millwork shapes visibility but also an weakening of the wood elements as it negates the possibility of the wood to 'breath', enhancing the risk to rotten inside without any visible sign.

Deterioration and instability of the masonry can affect the integrality of the wooden parts, bending, deforming and in some cases breaking the single or multiple elements. As an example on the superior parts of doorways frames which is usually a weak spot in the wall system can be visible also with small movements of the masonry.

B_METHODOLOGICAL PREMISE

Preliminary operations focused to the safeguard of the integrity of the material are listed below:

- Identification of the wood essence or type;
- Identification of any kind of filling or deposit not coherent with the woodwork system that has to be removed;
- A proper sequence of tests and sample tests as to verify the original chromatic evidence;
- Eventually a preconsolidation of the wood before the polishing of the surfaces;
- On selected samples of wood there shall be applied specific and scheduled type of polishing;
- Analysis of the tests results of the samples before to apply any kind of methodology of polishing on the entire woodwork frame system, in any case any kind of polishing has to comply the fiber direction and never orthogonally at such direction;
- Crafting of specific portions to integrate in case of poor status or missing parts;

In case it is necessary to disassemble a single part or multiple sections of a frame system, to allow the working in a laboratory or in a more compliant condition it is required a complete draft of the system for the final assembling. If a disassembly procedure is required it has to be considered a evaluation of the weight and dimensions of the single parts and in case it is necessary provide appropriate lifting systems and protection equipments.


05.

05_*Details of the decorative elements of wood.*

06_*Removal of an Roshan : the artifact should be restored and relocated in the original position.*

C_DESCRIPTION OF THE INTERVENTIONS

C.1_Removal and disassembling operations

For simple elements, doors, windows, opening frames, cover strips and battens must be removed, and door frames unsealed from the masonries. If the damages only concern mobile elements, panels or the leaf, it is useless to dismantle the frame.
For suspended roshans, scaffoldings are necessary. Disassemble the unit from the top level down, the top is often made up of a more or less elaborate layered cornice. Weak elements must be handled with care, especially where the wood is nailed and superimposed.
Then, for more handiness, unlock the side frames from the facade, as the side elements are fixed to the masonry. Once the façade is taken down, using ropes (or hoists, when heavy), dismount the trim and dressing of the side walls.

When the structure is taken down (and made steady where necessary) the actual disassembling can begin. Disassembling must be systematic. Dismounting the whole structure calls for a prior scaled sketch, an accurate drawing listing and representing the position of the wooden elements, followed by a classification of those elements and careful storage in a clean area.
Photographs and sketches can help understand the structure and guide re-assembly.

Methodology

- First, remove all movable, swiveling and sliding parts.
- Then, the frames or frameworks can be dismounted.
- Once disassembling is accomplished, the issues can be addressed:
- The whole woodwork may need to be pickled or scoured;
- The restoration itself can be carried out: first a glossing with a soft metal brush and steel wool or a sanding of the whole surface;
- When material or wood is missing or highly damaged, it may be necessary to carry out a graft or some patching.
- Only dismount elements to facilitate the graft. As it is a tricky operation, it should only becarried out where necessary;
- When remanufacturing or reproducing elements, make a 1/10 scale sketch of the element, then establish a l/l scale sketch that includes every characteristic: carving, profiles, joinery systems and pegging should naturally be identified and visualized;
- Straighten up warped elements where possible;
- When joint cover strips or battens are missing, replace them entirely;
- when all the repairs have been carried out, the elements must be re-assembled in the right order, as noted during the disassembling.


06.

Regardless of the condition of the elements that are to be dismounted, make a scaled sketch of the elements and supports, taking into account any warping and sagging of the masonry. If the supporting structures (walls) are kept in their present state, it is necessary to make perfect copies, identical wooden structures, so they will fit and adapt to the bearing structures: for example, take into account faulty squaring; test moving parts to chock they can open and close, like sliding shutters of 'mashrabiya' panels.

C.2_ Wood protection works

Wooden elements preservation state can be compromised for the presence of parasites as mould, fungi and insects which especially in hot and humid environment can create serious damages leaving the surface of the wood elements any sign of the infection state.
The reduction of biotic attacks can be accomplished reducing the nutritional factors necessary for these microorganisms such as a privation of water and light and granting a good ventilation of the environment which the elements are located. When the prevention fails, or contemporary to this phase it could be necessary an chemical disinfection procedure by liquid injections, impregnation sponging or exhalation of gasses.

The wood surface has to be without any sort of macroscopic anomalies that can cause appearance of deterioration actions once the treatment has been done (such as marcescence, rotting or missing parts) there shall not be presence of old paintings, wax layers, any sort of grease patina or consolidated dust.
Before any sort of treatment the wood consistence shall be inspected using tools as bradawl, chisel, and specific hammer as to remove small portions to be analyzed at the specific laboratories in a way to find where the infection of insects and fungi are located; an electric hygrometer for wood shall be used to measure the humidity to determinate if an fungi onset is in progress; to investigate the real preservation status it shall be necessary a planning of coring procedures. Not all the insect infestation can have as consequence the presence of larvae, in this case there will be a typical hole pattern visible outside the element

The protection coating and the disinfestations treatments has to be low toxic emissive, shall not be visible on the surface or create a changing of the chromatic characteristics as to allow the application of the indicated painting layers.
The surface treatments shall be applied by brush or spray procedure as to comply a uniform coating. Once dried (after approximately four to six hours) the surface shall be sanded as to eliminate any sort of wooden fibers that has been risen during the painting phase.


07.

In the case that it shall be revealed the presence of insects inside the wood truss it shall be necessary a local and punctual disinfection. Once it has been analyzed the type of insect it shall be treated when this microorganism is in his major activity. The products has to be able to penetrate inside the wood (such as dissolved insecticides in organic solvent) to eliminate the larvae and the chrysalises; contemporary to this phase these treatments shall be applied on the external surfaces as to avoid any insect penetration. The treatment shall be applied with brushes or sprayed on the external surfaces of the wood elements, and shall be injected inside by the insect holes.

The type of insecticide shall be chosen in relation of the specific insect, the mainly used types are based on Polychlorinated Naphthalene (PCN), Paradiclorobenzene (PDCB), Tributyltin (TBT) Tin Oxide.

In case of termites tunnel presence it wouldn't be enough to limit the treatment at the weaken wood elements that has to be considered as the last stent of the infestation, consequentially it shall be required to follow the termite presence to the original hive and interrupt the flux of the insects present inside the ground under the building; around the building block there shall be injections in the soil of grown-control products that prevents chitin production as to kill the termites at the molting phase.

If the building hasn't any direct contact visible with the soil but only a paving, it shall be planned a sequence of holes to be drilled in a way to permit the injection in the ground.

To avoid a fungi aggression inside a wood element it could be applied mixtures of fluorides (mixture of fluorides with arsenicals salts of sodium); the humid valours are important as well to be limited between 0% and 15%, this because a fungi aggression state is generally visible when the wood has an humidity superior of 20%. Maximum attention meanwhile the wood shall be treated is required in joint sections, especially where a wood beam has an dovetail joint or similar, hollows of nailing or bad saw cuts not finished.

The fireproof coating is very important, in case of fire these kind of protection layer protects the structural section delaying any sort of subsidence increasing the beams resistance. These fireproof coating in presence of high temperatures, expands generating a insulating foam that uniformly protects the structure. generally the most common products used are Sodium Silicates or Potassium Silicates mixed with Talcum powder or Kaolin (80/20 mixture)

To classify and state the effectiveness of a fireproof treatment the standards that has to be complied are:

- Simple standards for application procedures;
- Simple standards of maintenance status;
- Elasticity and stability at high fluctuation of temperature;
- The peculiar characteristic to allow to reset the pre treatment status and to be suitable to the original geometries of the structure.

The working phases has a sequence of steps to be considered:

- Preparing and polishing of the wood frame surfaces with the removal of any sort of wax coating or painting layers
- Humidity audit of the wood that has to be treated, this verification has to be inferior of 12%
- Antimould and antifungal treatment with in dept applying procedures;
- Double layer Fireproof coating on all the surfaces
- Light sanding on all the surfaces has to be allpied after 48 hours after the drying of the fireproof coating

Fireproof class shall be related to the function and position of the wood element.

C.3_Manual machine polishing

During the first stage of polishing it is necessary be sure that the surface has no presence of oils or grease layers on any kind, if otherwise these patinas of oily substances has to be removed with the usage specific solvents. v suitable tools for the polishing with hand work are: metal brushes, scrapers, spatulas, chisels, steel wool sponges, sand paper of different graininess, special tools shaped in a manner to penetrate inside the interstices of the wood work. The bristle of the plastic brushes has to be of harmonic steel. Old paint splinters has to be removed with a combination of scraping and brushing procedures.

Once treatment work is complete, the wood surface has to be brushed, dusted and blown with compressed air as to remove any sort of residuals of material detached and in final phase a light and dry hand sanding.

C.4_Sanding and manual milling

The smoothing of the surfaces is a procedure of hand removal of a thin layer of material of 0,2 to 1 mm, compromised that requires the following working phase:

- A preliminary test on small size samples.
- A first hand sanding with medium size graininess (40 to 80 grains per square centimeter) as to remove deposits of encrusted dust, and eventually spots or patinas present on the surface, this procedure

07_08_*Details of the decorative elements of wood*

will level the surface near the elements that has received improper movements or detachments of the wood elements
- Last sanding done with small graininess papers done by handwork

This procedures can be done in a dry or wet condition. If it is chosen to do the wet treatment it will be required to stop any sort of other operations if not after the dryness of the surface is complete, in this procedure it has to be set particular care to avoid to mix the sanding with the painting cleaning it continuously with clear water. The dry smoothing produces a lot of dust that has to be removed.

The counter bore process provides a complete smoothing of the paint layer or coating present resetting the appearance of the surfaces of the wood elements, revealing the wood veins this is usually called 'a vivo'.

C.5_Paint removal neutral degreaser

This work is necessary to eliminate from the wood surface old paintings and deteriorated coatings, it shall be removed with the application of a stripping pellicle generally composed by solvent mixtures with additions of evaporation retarders, these sort of products can be in liquid state as in gel form. This procedure has a particular subjective application in Jeddah where wood frames and elements has been repeatedly covered with new layers of painting without ever any removal of the old layers of paint.

Preliminary operations:
- Analysis of the wooden structures status checking the non presence of damaged portions or falling portions
- Removal of all metal parts, such as hinges, handles, locks, as to avoid their damage for the usage of solvents on the wood surfaces
- Tests on portions of sample materials as to analyze timing of dryness and procedures of application

The procedure consists in a brush or spatula pose of the product on the interesed surface with a thin and uniform layer as to soften the pellicle of old coatings. A various amount of time is required to have a detachment of the old coatings the time varies from an hour to twenty, the effectiveness is related to the type and number of paint layers to remove.
After this phase it shall be necessary to remove the final portions of coatings with a hand work of chisels, spatulas, in this phase it is important to have care to not damage the cortical part of the wooden elements. in the niche parts it is suggested the usage of specific tools as bradawls and small brushes.
Once the scraping is done the surfaces shall be washed manually with cleaning solutions (not with water, that could swell the wood fibers) as to eliminate any residuals of the products used.

C.6_ Hot Air/flame polishing

The painting removal with the usage of hot compressed air is another procedure for the removal of coatings from wood elements, it removes dust, residuals of salinization, organic and inorganic crusts and old protective pellicles. The different expanding of the painting coats and the wood elements allows the detachment of this pellicle from the support, this sort of treatment has the characteristic to evaporate the water present under the paint.

This operation has to be handle with extreme care as to avoid burning marks on the wood. The procedure consists in heating up the surface with a specific thermal air gun that is blown on the wood surface, the distance and the direction varies and is related to the preservation status of the wood elements and the type of dirt that has to be removed. once the parts that has to be removed starts to detach the work shall be finished by handwork. finally in the last stent there shall be a sanding phase as explained above.

C.7_ Jos system polishing

Is a polishing technology scalable and selective, based on a low pressure rotative vortex process: a cleaning mixture composed by water, air and inert is blown on the surface that has to be treated, with elliptical trajectories.

The inert dust moves on the surface polishing uniformly the patina of agedness, without creating any micro fractures or damages on the surface.

Pros:

- Not corrosive;
- Scalable, the quantity of air can be chosen in reference to the nozzle and the distance between the gun and the surface to be treated;
- Ecologic;

09a_09b_09c_*Photograph before degreaser - jos wooden surface.*


09a.


09b.


09c.

C.8._Integration of missing portions, substitution of damaged parts

Once the removal and polishing phase is done there shall be a phase that substitutes the damaged portions of the wood structure.

The insertion of new parts of wood can be necessary when the wood elements has suffered missing portions for the following reasons:

- Age of the wood elements
- Missing maintenance
- Mechanical strain stress
- Missing cohesions inside and on the surface

The presence of cracks or slits requires the a filling with stucco that can be composed of different mixtures related to the type of wood. Generally it is used a mixture composed of a inorganic binder that can be plaster or organic glue, bee wax or a organic binder (synthetic polymer as acrylic resins) and of a inert (with the function of anti-shrinkage and dying) composed of sawdust of microfibers. Interiorly at this mixture it shall be possible to insert a small part of pigments to match the final color to the original one.

It has to be provide a dusting of any sort of crack or fissure to prepare the wood to a sponging of denatured alcohol as to eliminate quickly humidity and to facilitate the adhesion of the chosen mixture. When the support is dry the fissures shall be filled with stucco with the usage of spatulas or specific wooden tools as to tap all the holes. The stucco will shrink during the drying, for this reason usually it is applied a major quantity of filling. After the stucco filling is dry there will be a sanding phase with medium graininess sand paper as to eliminate any exceed of filling.

When there are revealed grievous deformations or major missing of wood parts or it is necessary the substitution of an entire element of a structural truss or the entire bean itself, it is important to find the same essence of wood with the same cuts of the original and already ready to be placed with any sort of pre treatment to preserve the wood from the same aggressions the substitute suffered.

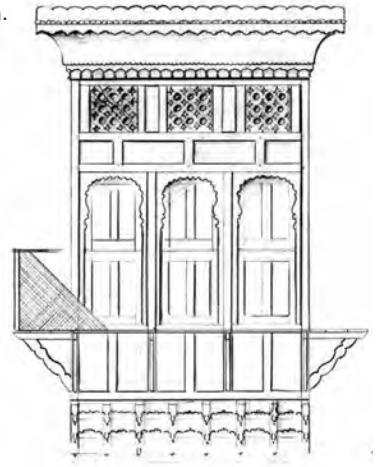
C.9_Roshan maintenance and/or repairing

Carrying out an intervention on Roshan structures, it is important to distinguish among their different elements: floor consoles, framework, cornice and panels.

Floor consoles

These main wooden elements, about 10 cm/10 cm squared at the base, sometimes suffer from the same pathologies as the wooden ties of the walls. In most cases, termites damage the wood so much that they must be replaced entirely. The anchorage of Roshan units in the masonry is carried out with a mason. One must scrape out the sealed part completely and replace it with a wooden element, lined up with the other structures. As the edge of the wooden elements do not bear much load this operation is not too difficult. These wooden pieces are grooved to fit in small painted wooden elements, and rounded. Il is also necessary to check the condition of the inside cross-piece in the wall, holding the consoles.

10a.



10b.

Framework

The framework is made up of jambs and cross-pieces. The jambs work as posts at the angles and are squared. On the façade, they are rectangular. These jambs or studs are slotted (mortaised) and are fitted with cross-pieces with tenons. The frameworks have grooves adapted for panels or elements. The roshan structures are completely interlocked with the masonry, deforming or sagging like the walls. In this case, the units can disunite, pieces tend to play, moving parts, such as sliding shutters, don't work well. Jamming becomes inevitable and wearing appears at points of friction.
When the framework is very damaged, dismantle the whole unit

Cornice

The cornice is made of thin boards, from 10 to 25 m/m, jig- sawn like 'lace'. This style of decoration is created by nailing boards one on the other: the effect conferred by the superposition is quite beautiful. Though these elements are rather thick, they tend to deteriorate badly, due to heavy exposure. The solution consists in replacing the missing parts: be sure to copy the wooden motives and work well. Usually, the most damaged missing part is the piece that was nailed on top. Ideally, remove the successive layers of wood, disassembling them from one another. The main elements constituting a Roshan unit are jambs, cross-pieces and panels. Its main characteristics are related to the jig-saw profiles, the carving and the panels. Using larger sections, at properly calculated and targeted places, (loading and fitting), could slightly reduce deterioration. Don't forget the units get their genuineness through an impression of suspension and lightness, conferred by the delicate thinness of its wooden elements.

Panels: mobile pieces

10a_10b_ *Roshan details.*
11a_*Wooden corbelling.*
11b_*Under face ornament.*
11c_*Cornice of the Roshan.*
11d_*Lateral side of the Roshan.*
11e_*Facade of the Roshan.*

11a.

11b.

11c.

11d.

11e.

12_*Details of the decorative elements of wood on an historic facade.*
13a_13b_13c_13d_*Descriprion of the rehabilitation Like any restoration of joinery work, dismantle the unit. If only the doors (leaf) are damaged, patching or grafts can be carried out without dismounting the structure. Inside doors are generally fitted on reveals, on stop blocks, the jambs in a framework.*
The restoration of a highly damaged inside door includes the
following operations :

- *remove the two doors*
- *remove the cover strips*
- *dismount the framework from the masonry. Scour or pickle the wood*
- *after dismounting the door, identify and organize the various parts of the structure*
- *pickle and sand the surfaces*
- *then only, if need be, disassemble the panels to make grafts*
- *if a piece needs to be entirely replicated, to the identical, make a 1/10 scale sketch followed by a 1/1 scale layout pattern including all the mouldings and profiles*
- *once the grafts and corrections have been carried out, reassemble the structure ; slightly enlarge the holes and use larger pins for better strength,*
- *when cover strips are missing, make new ones.*

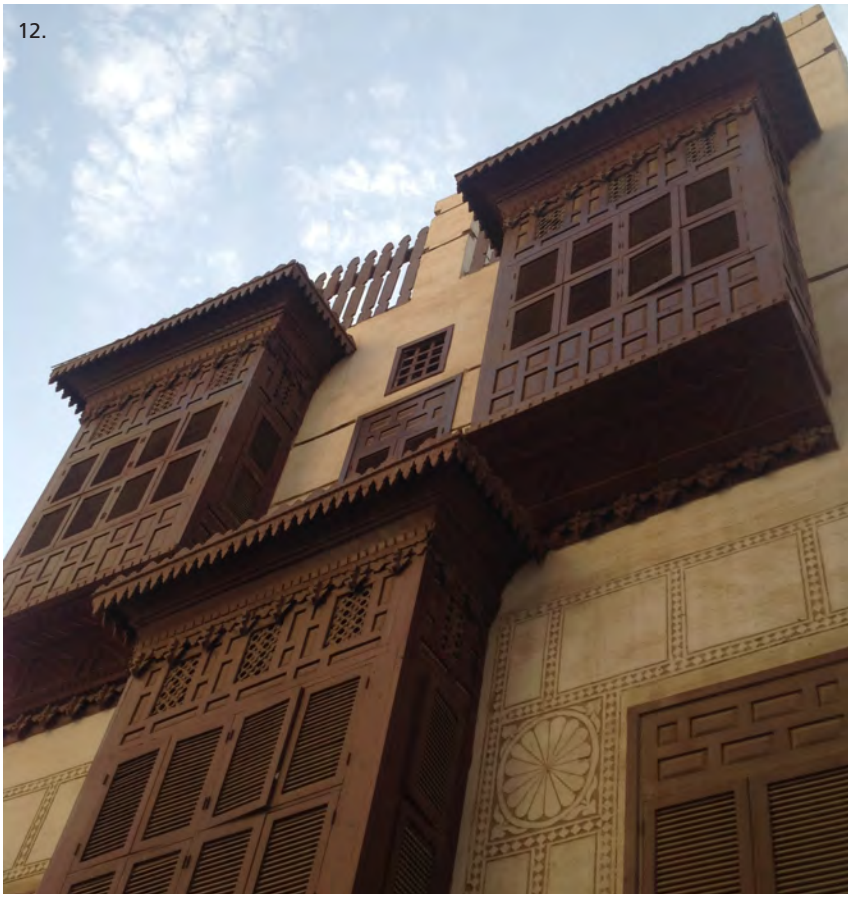
14_*Naseef House: window sistem survey.*
14a_*First floor windows system survey elevation.*
14b_*Geometric reconstruction of windows front.*
13c_*Windows section.*
14d_*Windows plan.*
14e_*Sliding windows details*
14f_*Positioning of the sliding windows.*

The damage concerns mobile panels: disassemble the wooden elements of the grooved system. Remove the sliding shutters and restore them (disassemble, patch or reinforce), in a workshop, or just fix them up (remove some material, using a plane or a scraper, when a shutter jams, for example).

Panels: fixed pieces
Mashrabiyas are easy to remove from the grooves. They can be mended or repaired, and, in the best cases, simply pickled.It is possible (but not recommended), remove the bottom fixed panels without disassembling the whole unit. You would have to remove an interior side, replacing it with a panel. This type of work usually generates irreversible damage.

Special care should be given to the overall dimensions of the roshan, during removal and disassembling. Do not use glue when re-assembling the wooden elements. The goal is to preserve the structure and its flexibility with the building.

12.



13a.

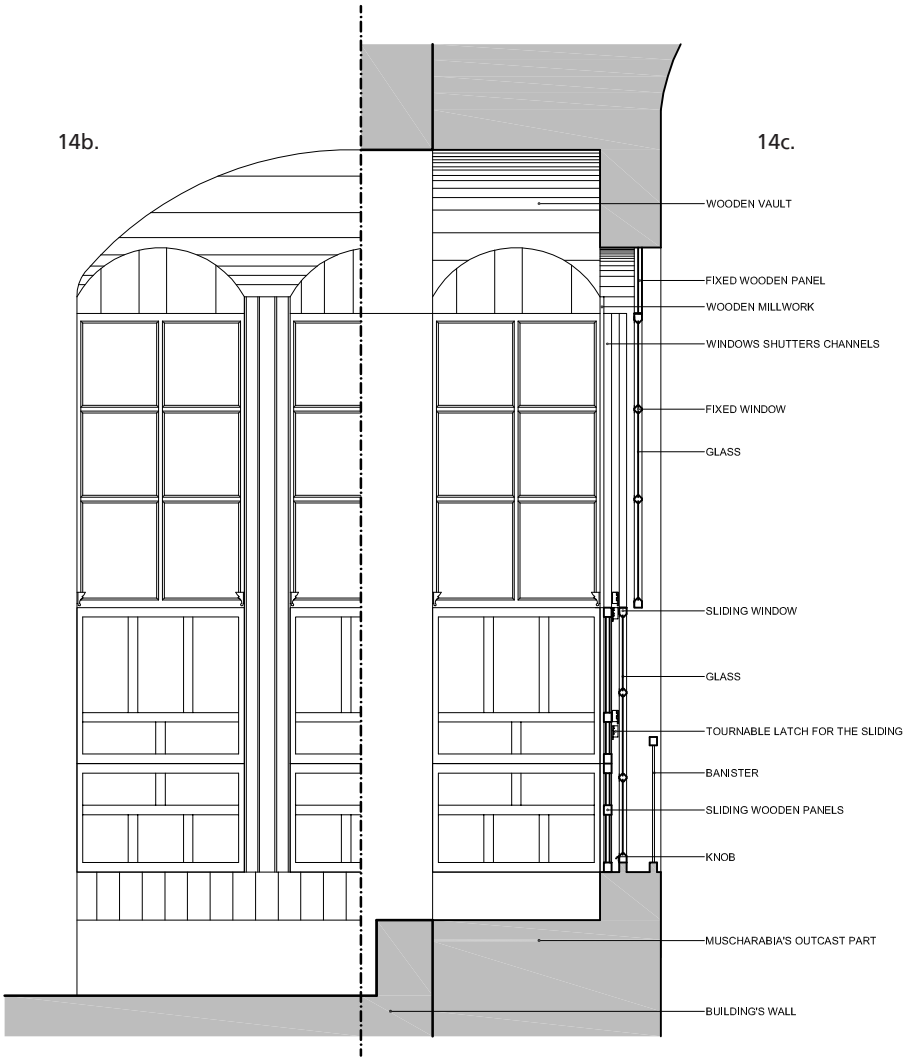
13b.

13c.

13d.

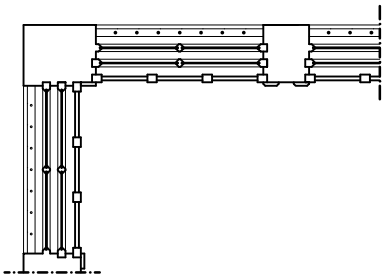
14a.

14b.

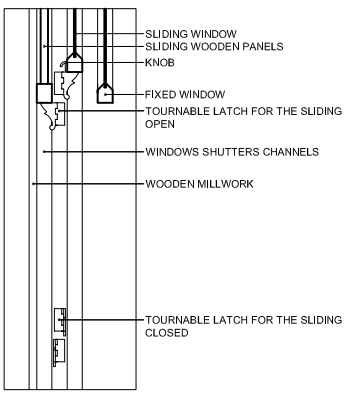


14c.

14d.



14e.



14f.

9 | Metal restoration

Metals are chemical elements in a solid natural state (except of mercury) ductile and malleable, good conductors of heat and electricity: modern industry uses more than 30 of the 75 metals existing, in the past (from the IV millennium BC up to XIX century) were used only seven: gold, silver, copper, lead, tin, zinc, iron.

In nature only some metals, such as gold, are found in a pure state, all other combinations exist under various fors as oxides, carbonates, sulfides, sulfates, silicates; the reduction of the oxides of copper and tin is relatively easy, more complex is the oxides of iron or aluminum, for this bronze then iron are the oldest metals. From the nineteenth century industries began to make use of aluminum and only in our century of titanium.

In ancient age metals were often used in alloys (of two or more metals) which possess properties different from their components (lower melting point, color change and reduction of production costs: the oldest alloys are: gold- silver, gold-copper, copper-tin or copper - tin - lead (bronze), copper - zinc (brass).


01.


02.


03.


04.

Metal alteration

In natural environments metals tend to degrade with time returning the energy absorbed during the process of extraction and forming more stable compounds; this process, during which the metal is degraded in minerals similar to those from which has been extracted, is called corrosion.

The term defines only the corrosion attack on the metallic materials by chemical reactions, while in the case of deterioration due to mechanical causes it comes to erosion or wearing.

Corrosion manifests through the formation of a surface film more or less tenacious, that will always be produced at the cost of the metallic core: there are some protective coatings which are compared to the metallic core that is with the time the presence of the patina stops the process of corrosion, if the patina is porous and soluble corrosion progresses with greater intensity.

We must distinguish two types of corrosion:

- Chemical corrosion: consisting in a simple reaction between metal and a specific element or chemical compound, the frequent case is the oxidation reaction between oxygen and metal, but can also happen with carbon dioxide, hydrogen sulfide and other reagents;
- Electrochemical corrosion: reaction that takes place only in presence of water and in solution consists in sending, by the metal atoms in the form of positive ions with production of electric current.

Metal alteration is manifested in different ways, in some cases can lead to full dissolution of the artifact, in other cases it is localized or shallow and uniform or penetrating, selective, intergranular. Equally varied is the nature of the corrosion products that depends on environment and substances with which the metals are in contact: can form compounds adherent, compact, layered, flaky, inconsistent, soluble.

Iron alteration

Iron produces rust which is a coating consisting of oxides (with different degrees of oxidation and hydration) including goethite and limonite.

The goethite, dark in color, it is very compact but often poorly adherent to the substrate, the form consisting of layers that reached a certain thickness decomposes loosing flakes of variable size. The thicknesses of these corrosion products are proportionately much major than those of the metal which is not degraded and this leads to the formation of a film laminated very bulky that not having space (especially if in holes for pins or attachment brackets) determine very strong tensions capable of fracturing even large blocks.

The limonite, yellow, is dusty and precisely because of this characteristic it is difficult to detect with the exception of some areas protected from the solvent action of the water.

Alteration of copper, bronze, tin, lead

The alloy copper tin-lead (not essential) forms bronze while melted with zinc forms brass; the products of the alteration of bronze are those of copper and its alloying.

There is a quantity of products of alteration that determines a variety of patinas not only for the chemical nature but also for the environmental conditions.

If the products of corrosion are not solubilized by agents of deterioration and tend to form laminated coatings, compact and of variable thickness, while the patina soluble water Atmospheric acidic or basic (for guano) are in powder form (copper sulphates).

The bronze there may be differences in color patina at any welds (always performed with different league to lower melting point), the color difference helps a lot in identifying cast parts separately and then welded; the color and texture of the patina of the bronzes may vary depending on the proximity of iron elements of structures, supports, nails and clamps.

The products of corrosion of the lead are litharge (compact oxide red-pink or yellow), the cerussite (white color carbonate), and the Cotunnite and the fosgeanite (chlorides porous), anglesite (a sulfate).


05.


06.


07.


08.


09.

B_METHODOLOGIC PREMISE

The cleaning is the most delicate operation and characterizes the entire intervention: the deterioration of the metal is manifested through its transformation into products of corrosion, which constitute the patina on which intervenes when it restores the surface of a metal.
The corrosion products are divided into two categories the protective and non-protective.
The protective are always compact, tough and adherent to the substrate, their formation inhibits corrosion processes up to extinguish them completely; non-protective are porous, with little hold, poorly adhered to the substrate stimulate the deterioration processes, the greater is their thickness.

Before starting the cleaning phase of a metal is a good idea to identify the cause and nature of deterioration, thus recognizing the metal and corrosion products. Taking a sample of patina from the surface of the article and submitting it to the X-ray method diffraction are obtained answers useful for the diagnosis of the state of deterioration and in the understanding of the morphology of the patinas.

Before proceeding to restoration phase it is important to determine the consistency of the metallic core to proceed with confidence and understand how it is possible to go in depth with the cleanup.
Determine the causes of the alteration, the type of corrosion products and the texture of the metallic core may be undertaken cleaning operations.
In the case where the patina of alteration are deposits, concretions or deposits of materials not relevant to metals (calcium deposits, siliceous or earthy origin) may be employed: de-ionized water (removal simple ground or powder), solutions with ammonium carbonate (100 grams per liter for thin crusts limestone) always taking into consideration that the metals are sensitive to aggressive chemical solutions, in such cases must be provided cleaning interventions through intensive washing or wraps of paper pulp and de-ionized water.

Are to be excluded acid based cleanings or common bases (hydrochloric acid, sulfuric acid, ammonia) because they are too energetic and may damage the coatings, in particular cases may be used citric acid or acetic acid with low concentrations 2-3%.
For removal of thicker crusts limestone and siliceous deposits, perform mechanical cleanings with stonemasons, vibro-engravers, small strikers compressed air.

C_DESCRIPTION OF THE INTERVENTIONS

C.1_ Methods for cleaning

Once deleted the outer deposits it shall necessary to proceed to the removal of corrosion residuals from the metal surface.
Manual cleaning is done with scrapers, wire brushes or other similar tools; must be performed and carefully controlled to ensure that the cleaning is complete and that rust removed, as for calamine or flaking, miscellaneous debris and in general any foreign body. Particular attention must be paid at joints, nails, corners and cavities.
The mechanical brushing must be executed by high speed machines, equipped with a wire brush with steel wire of 0.5 mm. The support must be clean, free of chips calamine or flaking, rust and any other foreign body.
The mechanical grinding must be carried out by means of high speed machines equipped with grinding wheels of fine grain, and next pass rotating brush with steel. The operation will be performed to reach down to remove the flakes of calamine or flaking, rust and any other alien part. Completed the treatment of mechanical grinding should be applied, at the latest within 24 hours, the first coat of rust to zinc chromate or lead chromate; if in the said interval of 24 hours, for particular environmental conditions, there shall be on the surface mild traces of oxide layers, it must be deleted before the rust-proofing coating.
The blasting should be carried out by a jet of air on the metal surface with silica sand (not marine) or quartz, or with metallic grit to a pressure of 5-8 atmospheres.
The sands or grit should have a particle size of about 10 microns to 25 microns for the sand and grit metal.
Before the start of the protective treatments artifacts shall be cleaned of any residual by mechanical brushing or blasting. Wet sanding is forbidden.
Completed the sandblasting treatment should be applied immediately to the first coat of rust zinc chromate or lead chromate. If, for particular environmental conditions, slight oxide layers appears on the surface, it must be deleted before the antirust treatment.
On artifacts completely mineralized it shall be necessary to intervene with great caution because of their fragility without insisting with the cleaning procedure: on corroded manufactured elements with still a substantial metal core it is necessary to tend to keep the patina as thin as possible so that the metal will act as reference for cleaning. In artifacts where there core is no more present, without references, there's a risk to no longer configure the original shape of the object.
The chemical cleanings are almost always to be avoided, especially in cases where the coating should be safeguarded since the solvents solutions are very difficult to control the level of cleaning without damaging the patina.
Manual cleaning - mechanical (although more complex to be executed)

01_02_03_04_*Hardware details.*
05_06_07_08_09_*Bayt Naseef: second floor window and hardware details*
10_11_12_*Photos before and after cleaning intervention.*
13_14_15_*Khushk of Bayt Naseef: hardware details.*
16_17_18_19_20_*Ain Al-Qusiyah: door's hardware details.*


10.


11.


12.

has better results than the chemical because you can make a selection by distinguishing texture, appearance and distribution of minerals and allows you to choose what you want to keep, reduce or eliminate.

Cleanup of iron

The iron manifests abnormal forms of deterioration compared to the other metals in particular the nature of the corrosion products, which are compact and tough but little adhere to the substrate.

If there is no longer any metallic core reference during cleaning operation, it is preferable not to remove the layers of alteration, removal of these layers with small grinding machines - abrasive diamond provided is likely to give shape to the object according to the interpretation of the operator.

If the thickness of the corrosion products is not excessive (such as rust) can act either by mechanical methods (for example abrasive paper to various particle sizes) and with chemical methods (bathrooms in paraffin oil, diluted phosphoric acid, acid solution oxalic 9%). For large structures in cast iron or presenting rust and / or waste paint changed may use chemical paint removers or neutral to the action of the flame, methods that require time, when possible blasting is the method that provides a better grip with protective coatings be applied immediately because iron is vulnerable against corrosion.

Cleanup of copper, bronze, lead

The copper oxides are soluble in acids and bases, substances to be used with caution because they do not limit themselves to attack the alteration products but also solubilized the metal; it is always necessary to provide at the end of the cleaning systematic washing in de-ionized water to remove any residual of these solutions.

The oxides are considered noble patina, are one of the most frequent patinas because appreciated aesthetically and because the easiest to produce; for removal must be used solvents such as acetone, trichloroethylene or nitro.

The carbonates (prerogative of archaeological) form crystalline deposits, which must not be removed entirely because they perform a protective function for the metal as well as being considered a noble patina.

The chlorides instead must be absolutely removed because strong activators of corrosion, can sometimes creep into the structure of the building, forming holes (pitting) and alter the inner core. Since you can't eliminate them all must perform a partial removal by mechanical methods without damaging integrity of the artifact.

Sulfates form inconsistent and powder patinas that shall be mechanically eliminated with brushes and micro-drills as rotating brushes; chemical cleaning methods are not recommended because this procedure determines an inevitable "de-patina" action from the surface, distorting the color of bronze.

C.2_Operations subsequent to cleaning

Degreasing should always be complement to each treatment of preparation and shall be followed by vigorous washing with suitable solvents (see separate article regarding solvents).

The paint removal should be performed when you need to remove old layers of paint, varnish or enamel applied over a support that was not initially prepared in an appropriate manner; otherwise you will have to proceed with a new preparation. For stripping it should be used specific preparations (free of acid, alkali, water), softening the film, it allows an easy removal of large flaps and strips. The corners, edges, the grooves etc. must be scraped and cleaned with the utmost care. The surface must be stripped cleaned of any residual by means of wire brushes, and then washed with a suitable solvent.

The choice of the solvent is usually a compromise between different requirements: solvent power, stability, non-corrosiveness, toxicity and flammability.

Considering the solubility parameters (fs dispersion forces, polar forces fp and fh Hydrogen bonding forces) of the organic solvents it shall be advisable to replace an organic solvent with another solvent or a mixture of solvents whose solubility parameters of triad was analogous to that of the solvent to be replaced especially if this latter is detected very toxic. The use of gelling solvents in cleaning operations of polychrome surfaces will be preferred since it will allow to obtain a more controlled and selective on the layer that has to be removed, in addition of a lower volatility of the solvents themselves, hence greater safety for the operator .

To use, manipulate and / or store such products it is necessary to refer to what is stated on the labels and safety data sheets. The products will also be for the exclusive use of qualified personnel. In any case it must always be used the individual safety device an adequate protection of the skin, eye, face and respiratory functions.

The **solvents** may be divided into two sub-categories namely **polar solvents** and **apolar solvents**.

- Amyl acetate aprotic polar solvent, penetrating volatile media retention. Great for the removal of nitrocellulose resins, natural resins not aged, synthetic resins.
- Butyl acetate polar aprotic solvent, penetrating volatile low retention. Very effective for the removal of nitrocellulose resins, natural resins not aged, synthetic resins.
- Acetic acid, colorless liquid with a pungent odor, miscible with water. In concentrated form (for more than 99%) and said glacial acetic acid (freezes at room temperature) solvent acid pH used for the cleaning of carbonate coatings or for cleaning of frescoed surfaces.


13.


14.


15.

- Ethyl acetate polar aprotic solvent, penetrating volatile low retention smell pleasant and characteristic. Great for the removal of nitrocellulose resins, natural resins not aged, synthetic resins.
- Acetone anhydrite polar solvent, non-toxic volatile usable both for the removal of oils, waxes, fats, natural and synthetic resins, inks, and by dilution of paints and resins based synthetic protective and / or consolidating.
- White spirit apolar solvent used as a diluent of other solvents or paints or as a solvent for resins. The de-flavored version will present a lower toxicity, recommended for use in well-ventilated areas.
- Benzyl alcohol solvent to moderate toxicity, active for the removal of natural and synthetic resins, as well as for certain substances of proteinaceous nature. Viable alternative to dimethylformamide.
- Butyl alcohol protic polar solvent, is not very volatile, with medium retention and medium penetration. Good solvent for grease, oil, natural resins, including coppali and shellac removals.
- Denatured ethyl alcohol 99% (Ethanol) protic polar solvent is non-toxic, flammable, volatile and miscible with water, acetone, ether used effectively for the removal of natural resins, including copal and shellac.
- Isopropyl Alcohol protic polar solvent usable non-toxic for the dilution of reagents, protective and consolidating.
- Petrol 100/140 rectified average volatile apolar hydrocarbon solvent used for the removal of waxes, paraffin, bitumen and fats. For gasoline includes mixtures of saturated hydrocarbons, or unsaturated, more or less branched, they collect in the low boiling fractions of the
- oil (30 to 200 ° C).
- Chloroform clear, colorless liquid, volatile ethereal odor, toxic. Good solvent for oils, resins and fats. Like all chlorinated solvents must be protected from sunlight. Given its toxicity we recommend a limited and controlled use.
- Methylene chloride volatile non polar solvent has a strong action on fatty materials, medium action of natural resins. In order to decrease the volatility can be used in mixture withmaterials thickeners.
- Di-acetone alcohol solvent colorless, odorless, toxic medium polar miscible with water,has a high boiling point and a good solvent power towards resins and some protein and polysaccharide. Because of its toxicity, it is recommended limited use and controlled.
- Thinner nitro fog mixture of various solvents (toluene, acetone, dichloropropane, isopropyl alcohol) some toxic polarity media to rapid evaporation, has a good solvency for nitro and synthetic in general, oils and some protein materials.
- Dimethylformamide aprotic polar solvent highly toxic, unpleasant odor, miscible with water, esters, alcohols, ethers, ketone, aromatic and chlorinated hydrocarbons. Solvents suitable for many polymers

including, epoxy resins, polyurethanes, and vinyl. Given its high toxicity, it is recommended a limited and controlled use by taking the utmost care in handling and aeration.

- Hexane denatured aliphatic hydrocarbon odor light, volatile. Excellent solvent for waxes, grease, paint.
- Essence oil apolar solvent used as a diluent of other solvents or paints, as a solvent for resins or to saturate, temporarily, a color. It leaves no residue evaporates.
- The version de-aromatized present a lower toxicity; will, however, recommended for use in well-ventilated areas.
- Turpentine non polar solvent, colorless to slightly yellow corrected version pure, characteristic odor, is effective as a thinner for oil paints and for removing paint, grease and partially waxes and paraffin.
- Ethyl ether organic compound obtained by the dehydration of the ethyl alcohol with sulfuric acid.
- Colorless, pungent, very little miscible with water miscible organic solvents with very volatile and highly flammable. Used as a solvent for fats, resins, waxes and gums.
- Ethyl lacquered excellent solvent for dilution and removal of paint and varnish. Can be used as an alternative to a more toxic xylene in the cleaning of polychrome surfaces.
- - Limonene polar solvent with non-toxic high degreasing power, usable as a percentage appropriate together with other so as to obtain mixtures of polarity calculated, as an alternative to nitro or chloroethylene.
- Ligroine apolar hydrocarbon solvent used as such or as a diluent for other solvents and for cleaning artifacts polychrome. Viable alternative against petroleum.
- Methylpyrrolidone amide solvent penetrating, medium polar, harmful, very strong solvent for paints, acrylic polymers and resins; miscible with petroleum, white spirit, ethyl alcohol.
- Soluble in water there was an excellent replaced the dimethylformamide.
- Methyl ethyl ketone polar aprotic solvent penetrating, colorless with characteristic odor (similar to acetone). Counterpart higher acetone presents, compared to the latter, less volatility.
- Be used for the removal or dilution of oils, waxes, natural and synthetic resins (epoxy, phenolic, acrylic, etc.), inks.
- Toluene, Toluene non polar solvent, characteristic odor (similar to benzene) great for the removal of fresh natural resins, synthetic resins, oils, fats, waxes and paraffin. Free from benzene, contains 10% of dichloropropane.
- Tributylsolphate light liquid, colorless, odorless, stable. Used as an agent before injection of wet mortars for fresco and wall plasters, can also be used as a carrier for grinding of pigments and to facilitate their dispersion in water. Miscible with most solvents and thinners is

detected a good solvent for lacquers, vinyl resins and inks.

- Trichloroethane clear, colorless liquid, ethereal odor characteristic. Nonflammable solvent
- great for oils, fats, waxes and resins, both natural and artificial. It is moderately volatile and has poor retention phenomena.
- Trichloroethylene (trichloroethylene) clear liquid, characteristic odor reminiscent of chloroform. Good solvent for oils, fats, waxes, bitumen. Used for the cleaning and degreasing of metals and fabrics. It also presents an insecticidal effect.
- Xylene, apolar aprotic solvent, characteristic odor great for removing fresh natural resins, synthetic resins, oils, fats, waxes and paraffin. Free from benzene, contains 10% of dichloride propane.
- White spirit, mixture of hydrocarbons, clear liquid of characteristic odor. Insoluble in water but miscible with most organic solvents.

The mixtures used more will be the so-called mixture 2A formed by water, ammonia (6%); 3A mixture formed by water, acetone, pure ethyl alcohol (usually in the ratio 1: 1: 1), mixture 4A
formed by water, acetone, pure ethyl alcohol, ammonia to 6% (in the ratio 1: 1: 1: 1). All reports indicated are approximate and may be modified by balancing the components.

C.3_ Corrosion inhibitors

After the finishing of the cleaning operation, mechanically or chemically, it must always perform washes with de-ionized or distilled water to remove soluble salts present on the surfaces; this operation is considered as a corrosion inhibitor very useful for the conservation of metals.
Not all the metals have the same resistance against water, for example iron and lead are very sensitive to moisture.
Chemical inhibitors are organic substances which form on the metal surface protective layers that make the products of corrosion more stable and more resistant to the attack of aggressive substances; sodium nitrite (dissolved in water as a percentage of 1-3%), tannin (vegetable substance) with which they manufacture commercial products including Fertan, which forms on the corroded surface a thin layer of iron tannate which is weather resistant.
An effective method to evaluate the success of the intervention of inhibition is achieved by maintaining for 2 or 3 days the artifact in a humid chamber with 95% RH, the article passes the test if it shows no sign of corrosion active, in which case it must repeat the treatment locally or fully to get a good stability of the whole patina.

C.4_ Integration of the gaps

The integration of the gaps is carried out with the criteria of the material on which you are working and can be integrated to facilitate reading of the article; it is preferable not to integrate gaps too large, the intervention must always be distinguishable.
The metals can be integrated with resins that have a cosmetic purpose, having mechanical characteristics inferior to those of metals; the resin can be colored with earth pigments, applied in the gaps with a spatula after the positioning of a temporary support to contain it. The hardened surface is mechanically finished with a scalpel, pyrographs, limes, sandpaper. Integrations are signed with the date of the restoration.

C.5_ Surface protection

There are two types of corrosion protection chemistry imbibitions: the method of the protective films (for artifacts) and the cathode protection (for metal artifacts modern partially buried or immersed in water.
The first method consists to isolate physically the surfaces of the metal with one or more protective films (synthetic in nature) that can be transparent (acrylic resins or silicone in a suitable solvent or melted wax) or opaque (paints consist of a charge of pigmented and a binder; are more protective)
To protect iron structures, both internal and external, it is suitable for the use of cycles of paintings studied by manufacturers such as: a first treatment rust converter, after cleaning and only for irons with compact coating, a second layer of epoxy paint but very little adhesive weatherproof; a final layer of polyurethane varnish very resistant to atmospheric factors.
In general, these protective films do not have a long resistance (those transparent resist outdoor for not more than three years those opaque resist almost double), constant maintenance is very useful, but it is to be avoided to coat the knife without removing the old paints since the increase of the thicknesses of the films involves the loss of the elastic qualities of the same that break creating numerous points of infiltration for the water wetting the metal again and consequentially generates corrosion.
The **cathode protection** provide electrical power from the outside so to hinder the corrosion of the metal making it thermodynamically stable, there are two types: **cathode protection expendable anodes** (is to electrically connect the structure to be protected with a metal electrode potential more low - expendable anode - so as to reverse the polarity of the system and corrode this new metal) and **cathode protection with impressed current** (connects the metal to be protected to a current generator to vary the starting potential increasing them). Finally climatic conditioning the metallic environment in which it retains the artifact can protect it from any corrosion provided that it maintains the level of relative humidity below 50% in this way even without protective surface the metal does not corrode.

16.

17.

18.

19.

20.

10 | System installations in historical buildings

Primary urban works

The entire district of Al Balad shall be provided of an infrastructure intervention for the implementation of an underground sub-services network. This network will be concentrated in a gallery of services consisting of prefabricated elements to be located under the road commonly called 'smart tunnel'.
By the term 'Smart Tunnel' indicates a technological solution of recent application, made of reinforced concrete Vibrato (CAV), which allows the allocation of the network systems of the sub-services in a single location under the road surface.
This solution allows a considerable economy of management services and connections to utilities, and concerning changes and implementations, providing contemporarily an advanced and flexible solution to interruptions of urban traffic and to the consequential disservice.
The gallery shall be accessible for maintenance as be controlled by an automatic detection system to ensure the operability avoiding any excavation work and interruption of services.
During the planning it shall be defined in detail the dimensions of the tunnel services, access points, the connection to the users, the remote control mechanisms installation and positioning in relation to the pavement surface.

01_02_*Adopted solutions for systems modernization disfigures the city, in such cases the installation has consequentially meant the demolition of the decorations.*

The underground systems allocation, that shall be verified during the planning, can be:

- drinking water
- electric ducks
- optical fiber
- street lighting
- street signage
- preparation bays for future services

It shall be evaluated the opportunity to enter in the same gallery also collectors of waste water discharge.

Customers residential

Wastewater Discharge

The soil pipes within the building shall be placed near the restrooms in such a manner to be no more than 1 meter from the toilet. It should therefore in the design phase that toilets are positioned vertically overlying at the different levels of the building. Where possible, such as in the presence of a small court/internal courtyard, it is preferable to locate the vertical soil pipes outside. At the foot of the building the different columns will be collected in a inspection shaft before the inlet in the public drainage.

Reference Standards

- SASO - Saudi Arabian Standards Organization
- ASTM - American Society for Testing and Materials
- ASME - American Society of Mechanical Engineers
- ANSI - American National Standards Institute
- HI - Hydraulic Institute Standards

Exhaust Rainwater

The rainwater shall be conveyed in most cases and collected in suitable tanks or discharged to lose on the road. Where this is not possible they will be conveyed via downpipes to the public drainage.

Reference Standards

- SASO - Saudi Arabian Standards Organization
- ASTM - American Society for Testing and Materials
- ASME - American Society of Mechanical Engineers
- ANSI - American National Standards Institute

Plumbing Systems

The point of convoy of water shall be positioned outside the building and abutted on a counter for each building and installed in a box embedded in the external masonry. Downstream on the main connector there shall be installed the water meters in a number equal to the served users. These meters as the water service risers shall be placed in a common room (hall or courtyard) which position shall be described on drawings.
Risers of each unit shall be installed in public areas (stairway or courtyard) to be identified on the project, preferably in exterior air shafts.
The distribution of the pipelines shall be made preferably without inclusions in the load-bearing walls, when unavoidable it shall be necessary proceed to local consolidation of the masonry (reinforced plaster) as to not compromise the static nature of the structure.

Reference Standards

- SASO - Saudi Arabian Standards Organization
- ASTM - American Society for Testing and Materials
- ASME - American Society of Mechanical Engineers
- ANSI - American National Standards Institute
- ASSE - American Society of Sanitary Engineering
- AWWA - American Water Works Association
- MSS - Manufacturers Standardization Society of the Valve and Fittings Industry
- HI - Hydraulic Institute Standards

03_*Gargoyle used for the rainwater runoff from the terraces of a building in Jeddah.*

Domestic Hot Water
Each unit shall be equipped with an independent water heater powered by electricity.

Reference Standards
- SASO - Saudi Arabian Standards Organization
- ASTM - American Society for Testing and Materials
- ASME - American Society of Mechanical Engineers
- ANSI - American National Standards Institute
- ASSE - American Society of Sanitary Engineering
- AWWA - American Water Works Association
- MSS - Manufacturers Standardization Society of the Valve and Fittings Industry

Electrical installations
The point of delivery of the electrical appliance shall be placed in a common environment or room (entrance hall), near the public area. The point of delivery shall be provided of individual meters in reference to the single housing units and single ones for the service of the common areas. The meters shall be located in a suitable cabinet which location shall be identified on the plan drawings. Each unit shall be equipped with an electrical panel with proper protection devices for each area. The power supply at downstream till the electric meters shall be convoyed in a specific pipeline deployed in special shafts, concealed inside the wall or externally in specific ducks.
The distribution of electricity within the housing units shall disposed preferably embedded in the floor.
The distribution of the pipelines shall be made preferably without inclusions in the load-bearing walls, when unavoidable it shall be necessary proceed to local consolidation of the masonry (reinforced plaster) as to not compromise the static nature of the structure.

Reference Standards
- SASO - Saudi Arabian Standards Organization
- IEEE - Institute of Electrical and Electronics Engineering
- UL - Underwriters Laboratories Inc
- NEMA - National Electrical Manufacturers Association.
- ANSI - American National Standards Institute
- LIP - Lightning Protection Institute

04.

04_*Air conditioning*

Phone And Data Transmission

The point of delivery of telephone services will be located in a common environment or room (entrance hall), near the public area. The point of delivery will be served the individual units through pipes placed in special shafts, concealed or externally to the wall.

The distribution within the housing units shall be disposed preferably embedded in the floor. The distribution of the pipelines shall be made preferably without inclusions in the load-bearing walls, when unavoidable it shall be necessary proceed to local consolidation of the masonry (reinforced plaster) as to not compromise the static nature of the structure.

Reference Standards

- SASO - Saudi Arabian Standards Organization
- IEEE - Institute of Electrical and Electronics Engineering
- UL - Underwriters Laboratories Inc
- NEMA - National Electrical Manufacturers Association.
- ANSI - American National Standards Institute
- ISO - International Standards Organization
- EIA - Electronic Industries Association
- ICEA - Insulated Cable Engineers Association
- CCITT - International Telegraph and Telephone Consultative Committee

Air Conditioning

The air conditioning system of each unit shall be connected to a dedicated external unit (chiller) to be installed on the roof of the building. Where it is not possible for lack of space or inaccessibility cover external drives it can be placed in the courtyards floor in positions that shall be identified on the drawings.The placement on the roof should be such as to ensure to not compromise a proper static load-bearing distribution on the structure.

Downstream of each unit the piping (supply and return) shall be provided with a insulated protection that supplies the fan coils located inside the individual rooms.

The distribution of the pipeline inside the habitat unit shall be disposed under the floor, the distribution of the pipelines shall be made preferably without inclusions in the load-bearing walls, when unavoidable it shall be necessary proceed to local consolidation of the masonry (reinforced plaster) as to not compromise the static nature of the structure.

The air-conditioning/fan coil indoor units shall be wall hanged type or floor cabinets, in any case the system shall not be concealed if not in non-load bearing walls/structural.

11 | Concrete structure restoration

01_02_ *Contemporary buildings of armored concrete*

After the demolition of the city walls in 1947, the city has grown quickly into a modern metropolis, the planning and building in 1970 of the new main street Dahab Street, passing in the center of the old city has caused in Jeddah the lost of several blocks of the city's historical quarter, which has been substituted with a modern skyscraper type of buildings near the coast. In a very short period of time, between 1950 and 1980, a large number of historic buildings had been demolished and replaced with contemporary facilities, while the remaining traditional housing had been abandoned and started to an accelerated process of decay and disuse.
The oldest part of the city, that has entered in the list of UNESCO World Heritage, has preserved the original historic matrix and urban layout: there are about 280 historic buildings, and only 20 newly built that do not respect the architectural features of the place in contrast to the traditional image these buildings are recent constructions, and have no value of historical evidence, on a scale perspective instead they have a proper dimensioning and size in comparison to the historic quarters.
The 'buffer zones', areas around the heart of the city preserve groups of historic buildings but the main blocks has been lost, and the new building over the years has been characterized by the presence of skyscrapers and modern style buildings. The presence of these modern constructions in the old city areas and 'buffer zone' around it requires to conserve the historic quarter as an essential pre-requisite. Reinforced concrete has been used for years for the construction of structures such as buildings with the assurance that this material would never have any problem of durability, but the reality shows that this material does not last forever and requires protection and preservation as well as the traditional masonry constructions.
The problem of preservation and safety of existing buildings is of great importance, in first place for the intrinsic high vulnerability, especially to seismic actions, and in second place the for its historical, architectural, artistic and environmental requirements.

A_INSTABILITY CAUSES | PATHOLOGY ANALYSIS

Concrete base structures deterioration can be classified in two categories:

- Structures with corrosion problems of the steel reinforcement bars;
- Deterioration of concrete itself with appearance of fissures, splits and cracking;

If the steel armor of a concrete structure suffers of a corrosion deterioration the concrete will be consequentially damaged.

Concrete deterioration can have different sources:

- Not adequate structural design;
- Not uniform process of curing during the casting in formwork phase, the lack of injections of proper protective products which helps the contraction phase especially in the local temperature gradients;
- External factors, mechanical, physical, or chemical;

The location is near to the sea coast so if not properly protected concrete structures can be attacked by salts inside the sea water and in the air. Concrete is vulnerable to acid substances present inside the industrial fumes, to consistent changing of temperature as brusque jumps from wet hot to rigid cold environments.

The main reason of deterioration of concrete artifacts is the chemical reaction between Carbon Dioxide (CO_2), Water (H_2O) and the cement itself. This chemical process is called *Carbonation* and affects the concrete reinforcement's steel bars that can adduce to their oxidation. Cement acts as a protection of the steel because contains *Calcium* (CaO) that is highly alkaline, this environment consents the development of Stabilized Ferric Oxide and is impermeable as it defends the steel bars of the armor from the presence of oxygen and water. Even so water can penetrate through the porosity of the concrete, this reaction is called steel rod *Passivation*. Carbon Oxide chemically combines with the calcium present in the cement transforming it in Carbon Calcium $CaCO_3$ and Vapor. The carbon calcium has lower ph valor of calcium (9 vs 13/14) but when the ph valor decreases under 11 the environment becomes hostile for the steel rods and rusts.
Since the rust that is formed in this chemical reaction has an major volume of the steel (2,5 times) there will be unintended high pressures status inside the concrete structure, leading to the appearance of fissures and consequentially the breaking of cement portions that covers the steel bars. These reactions once started are irreversible and evolves in progress weakening the structure with the pass of time.

The damage is not only esthetical but also structural as all the steel bars detached from the concrete won't work anymore in a proper way.

A concrete structure can show the following pathologies:

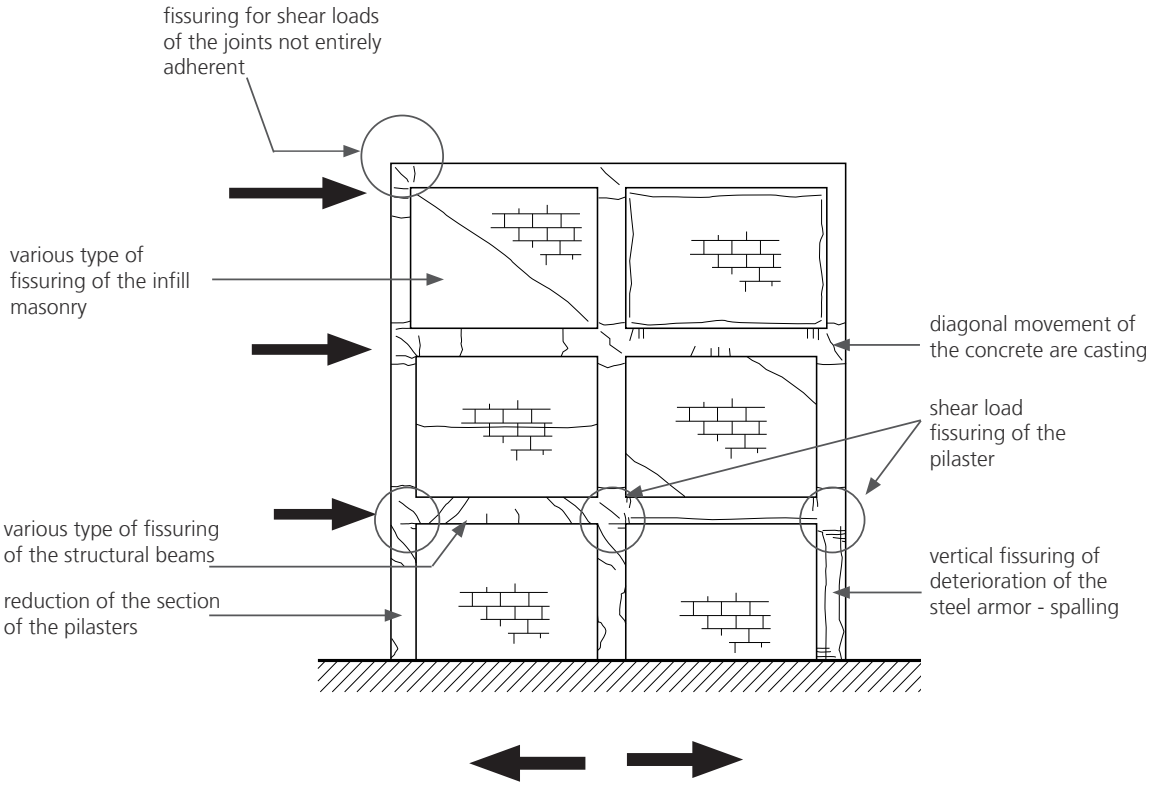
- Visible swelling of the concrete surface.
- Chalking of the external surface of the concrete structure
- Detachments of concrete surface portions and consequentially the uncovering of the steel bars
- Unwashed inert that has not solidified with the cement and separates when the structure goes under pressure.
- Corrosion stains and rust color that derives from the uncovering of the steel rods.

When lost portions of concrete relieves the steel armor it is required to restore the missing concrete after protecting the steel rods with proper products.

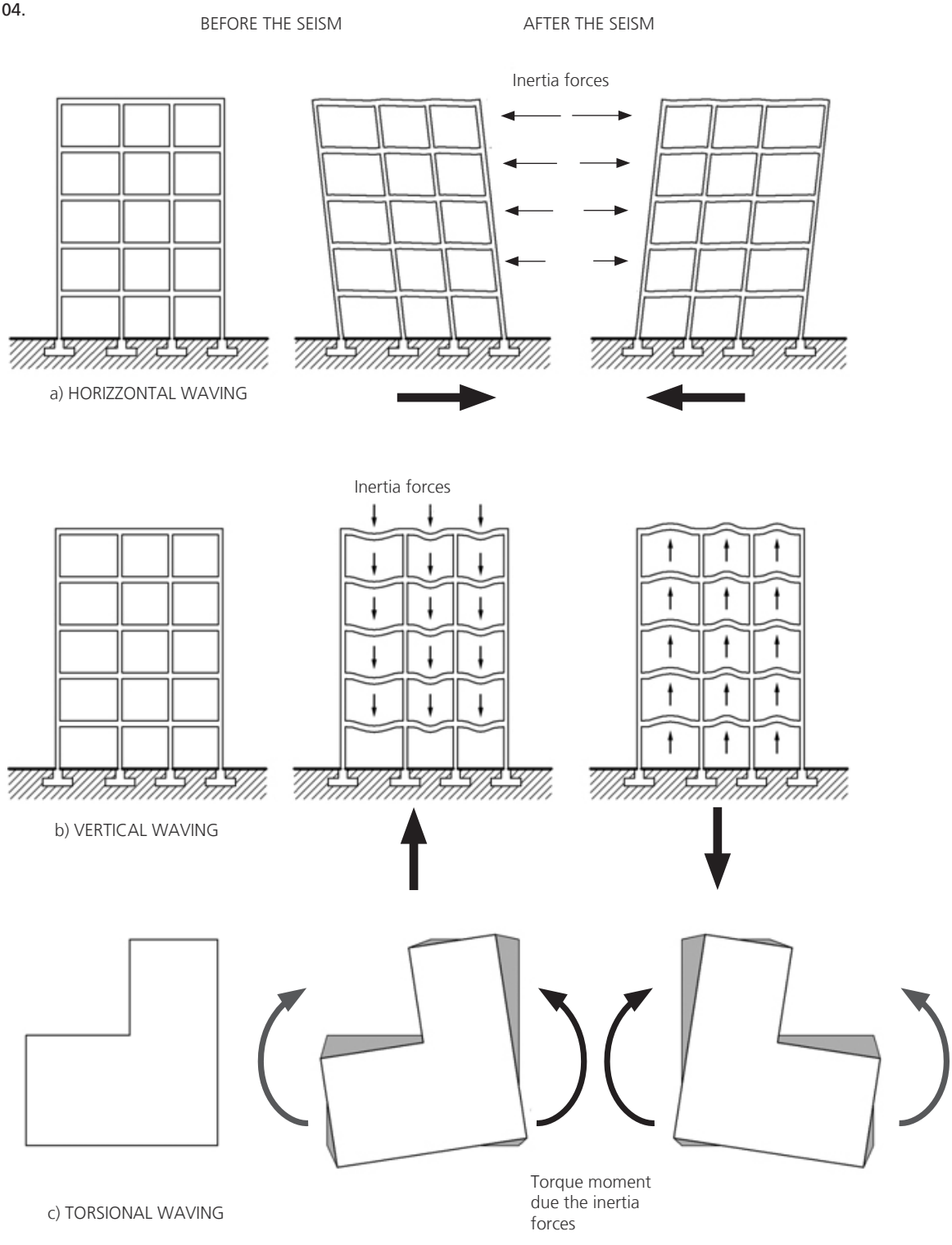
03_ *In the figure there are represented the movements during a seismc.*

04_ *Scheme of the damages of the structural elements and joints in a armored concrete frame designed for only vertical loads subject to seismic actions.*

03.



04.


BEFORE THE SEISM
AFTER THE SEISM
Inertia forces
a) HORIZZONTAL WAVING
Inertia forces
b) VERTICAL WAVING
c) TORSIONAL WAVING
Torque moment
due the inertia
forces

B_METHODOLOGICAL PREMISE

Armored concrete structures consolidation consists in restoring the original geometrical section of the elements, treating the cement part as the steel armor as well.

A sequence of preliminary tests on the structure that has to be consolidated is required to choose the proper procedure to be applied:

- An historical analysis and gathering of the original drawings of the building - The first step is to rebuild the process of realization and the subsequent modifications that the building has suffered in the past, with a particular attention at the operations that has involved the structure, reinforcing (seismic adjustments) or had weakened (risen floor decks, internal reorganization, the opening of doorways in structural walls), eventually any sort of information about seismic events reported;
- Survey drawings and real state of the structure drawings, type of structure, comprehensive the foundation structures;
- Survey drawings about the fissures and damaged parts visible on the building's surface;
- Structural investigations about the characteristics of the materials, contemplates:
  - Deterioration of the cement and the steel armor;
  - Verification of the compression resistance of the concrete used by destructive and non-destructive tests;
  - Geometrical characteristics (diameter, smooth surface or improved adherence type of rods) and mechanical (enervation tension limit, breaking tension limit) type of steel used;
  - Constructive details of the structural elements, of the foundations and of the elevation frame, in particular:
    - beams and pilasters armor
    - steel armor of the joints between beams and pilasters
    - steel reinforcements of the full concrete floor slabs
    - steel reinforcements of the stairway beams
    - bending type of the steel bars especially if the type of steel rods used is smooth externally
  - Flexibility reaction of certain structural elements (beams, slab floors, overhanging structures) under load tests

The analysis of the building has to establish:

- The functions of the build can proceed;
- The functions of the building has to be modified in relation at the structure deterioration;
- If it is necessary to proceed to reinforce or to restore the original load distribution and resistances of the structure;

Preliminary operations that has to be executed on the deteriorated building is the removal of ineffective superficial concrete portions using manual tools to avoid not necessary vibrations of any mechanical tool. This phase is necessary to remove any major detached piece of concrete meanwhile to remove any small alternated portion near the steel armor it will be necessary the usage of specific tools such as manual needle scalers, sandblasting machines or water based sandblasting machines which are able to work the interstices between the steel rods and the concrete without any source of vibration load on the structure. Hydro-demolition, which is a procedure that consists in high pressure water blasting on the damaged parts has the ability to remove any sort of chemically deteriorated part also from the steel armor.

It is absolutely to avoid the usage of demolishing mechanical tools or any sort of equipment that can transfer on the building structures unnecessary vibrations. When treating the rust portions of the armor it is necessary to avoid any sort of flame based tool such as blow torches or cutting torches, the reason is related to the different gradient of expansion between the steel and the concrete, metal actually expands more than the cement based material consequentially the usage of high heat source tools can cause involuntary detachments between the concrete and the armor.

The preliminary phase of removal is to intend finished once the examination tests about the carbonatation and the sulfation of the concrete and the presence of chlorides are negative, and when the armor steel rods that are uncovered has been cleaned with the sandblast procedure. A positive result of the concrete's armor polishing status rate is required to consider the whole recovering operation accomplished

05.

C_DESCRIPTION OF THE INTERVENTIONS

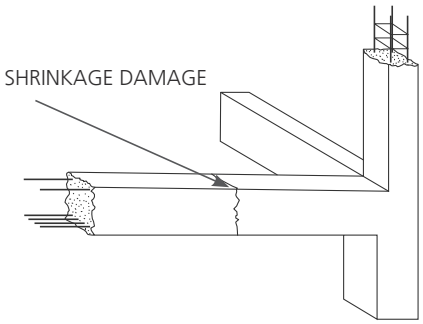
Whatever events or causes has determined the presence of detachments and fissuring from its surface it has to be stated that the final reasons of the concrete volume restoration are:

- Elimination of any forms and presence of the steel's reinforcement corrosion;
- Removal entirely any altered cementitious material to reach the core of undamaged concrete;
- Filling the gaps with a mixture that determines a proper environment with high alkalinity values necessary to obtain steel's passivation ;
- Back filling of fissures on the whole surface;
- Realization of an outer layer that regularize the surface, protective and waterproof and at the same time that shall be a barrier to carbonation reactions.

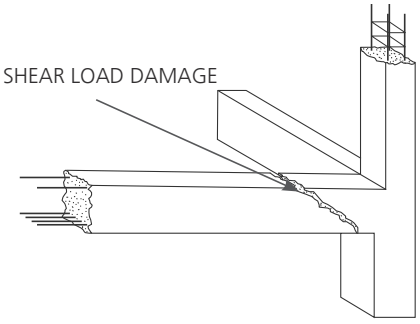
C.1_ Fissure's sealing by epoxyresin injection

Filling medium dimension fissures; the following description is the case when there are splits, fissures or cracks of a dimension so tight that it is impossible to be treated by the usage of mortar or cement by manual wok. When the spacing is less than an tenth of millimeter the pressure to fill the micro fissures with a cement mixture can bring to ineffective results or in some cases a weakening of the borders of the fissures structure. The procedure to adapt is based on a low pressure injection technology of cement mixtures such as epoxy resin based or polyurethane based that is an excellent adherent on concrete and steel surfaces. It is to prefer the usage of resins more than traditional cement mixtures because this material penetrates more deeply and more easily. It is possible if the resin based filling shall be chosen for the fixing the implementation of selected micro inert powder.

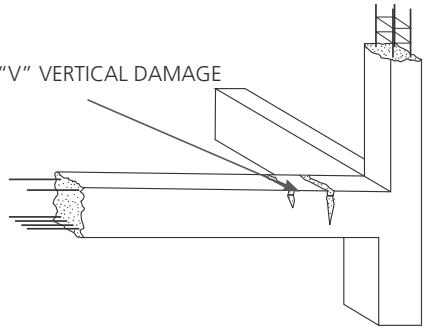
06a.



06b.



06c.



Operations procedure:

- Preliminary polishing of the surfaces with micro opening of the fissures to eliminate any not resistant border of the crack;
- Preliminary cloy work of the surface with rapid hardening mixture;
- Micro copper pipe or polypropilene (6-8 mm);
- In depth polishing of the damaged area with a jet of compressed air, the injections has to be done on a dry and clean base;
- Injection phase with a low pressure (2-4 atm) of epoxy resins that has the characteristics to be a fluid mixture without any sort of solvent;

The injections has to be done following a process from the lower part rising to the high edge as to fill the entire web of the micro pipeline, once filled it will be welded on the extremity at the injection point and it will be continued to the next part of the pipeline.

C.2_ The rebuilding of the missing parts of concrete on the uncovered steel bars

The procedure consists in:

- If required an resistant electro welded steel web can be bent on the angles of the concrete structure where the steel armor is uncovered;

- The portion of structure that has to be treated has to be damp before the application of chemical products, it is required that the structures shall be soaked of water but the surfaces well dried to let the product grip, it has to be avoided any visible water stagnation on the surface, it is allowed to blow the surface with an air compressor gun;

- The armor that has to be treated shall be prepared by applying uniformly 1 mm of passivating anti-carbonation coating (anti rust protection). Once 2 - 3 hours has passed it is possible to apply a second pellicle of 2 mm;

- Recovering the original effective dimension - Rebuilding by manual tools as towels or spatulas. Once 24 hours are passed after the second layer of anti rust coating has been applied and the structure well damped of water, it shall be applied a consistent layer of hydraulic binder cement 25-30 mm in an single coating, this special cement has peculiar characteristics: has shrinkage controlled reaction, it is microfiber reinforced, it is high adherent on surfaces which are treated with organic corrosion inhibitors. It shall be mixed only with water and does not require any sort of

05_*Contemphorary building of armored concrete.*

06a_*Damages that are consequences of cement shrinkage after the tightening and hardening.*

06b_*Shear force damages.*

06c_*Bending damages.*

casing or form boxing. It is applied by manual tools and requires a minimum of specific ability meanwhile laying the mixture, it has to be applied firmly giving a proper pressure on the first layers and keeping the following layers compact as possible.
If the uncovered armor that has to be cladded requires a filling thicker of 30 mm it shall be required a multiple passages of cement to the maximum thickness of 100 m. Once finished the filling shall be kept in a damp status for at least 24 hours, this can be done by a proper usage of nebulise procedures as to comply a firm settlement. To achieve a good grip of the product on the surface also when the geometry of the structure is irregular, once the filling has been done it shall be necessary a cement rendering phase. The product that shall be applied as rendering is based on a high-strength hydraulic binder, and siliceous selected aggregates (maximum graininess 0.4 mm), that has to be mixed with only water and applicable with towel for a maximum of 3 mm of thickness for each layer. The finishing shall be done with a specific sponge towel few minutes after the application.
Recovering by spraying process - with this procedure it is possible to apply multiple layers of cement with the usage of a specific plastering machine, this operation is more effective considering the productivity aspect especially if the area that has to be filled is wide. The cement mixture that is applied by this machinery doesn't requires any sort of fixative or adherent product because the curling effect that the mixture receives in the spraying when the aggregates bounces on the support surface. To achieve a good adherence it is required to prepare the surface that has to be treated as to be quite rugged before any spraying. The spraying has to be done by even multiple passes, starting from the bottom and rising overlapping the horizontal passes (minimum thickness 20 mm, maximum thickness per each pass 30-35 mm maximum thickness once finished 80 mm) once the under layer has ripen after 60 minutes. When in the area treated the steel armor is visible then the mixture shall be sprayed by two layers, with the first not entirely covering the steel as to permit the second application to grip as well on the steel to avoid any sort of post fissures in the concrete applied for a to quick shrinkage of the mixture it shall be required a proper damping procedure with a nebulise process and keeping the treated part under wet textile sheets for at least 48 hours.

- Protection - The final phase that protects the surface shall be achieved by the application on specific coating that has anti carbonation additive in the mixture. This protective coating has

to be applied on perfectly dry, by two passes with not more than 24 hours between the two applications; this sort of coating can be applied by manual brushing, hand roller technique or specific low pressure sprayers (0.200 l/m^2 for each pass).
The application shall be extended on the whole structure surface not only the treated parts as to confer a coating a uniformity necessary to seal any point of infiltration possible and before the operation of spraying it shall be required a coating of specific primer. If the executive drawings requires the concrete structures to be left visible it is necessary a coating agent, solvent based, containing Siloxane reagents (to be applied with manual tools as brushes or hand rollers, mixed in proportions 0.300-0.600 l/m^2 i n relation of the absorbance of the product on the surface).
During the consolidation preparing applying and for 72 hours after the surface has to be protected from air currents, rain water, solar irradiant and heat or frozen gradients.

C.3_ Rebuilding of the effective structural section - steel reinforcement addition

The operations shall involve structural parts as pilasters and beams, it contemplates the rebuilding of the ideal geometrical section of such elements, which had suffered the loss of portions and has then lost a part of structural effectiveness, the process consists in applying for same amount of the concrete loss a specific mixture of cement that is shrink controlled with the presence of a micro net of reinforced fibers.
The portion of structure that has to be treated can require a proper shoring, by suitable supports and adjustable upright construction elements.

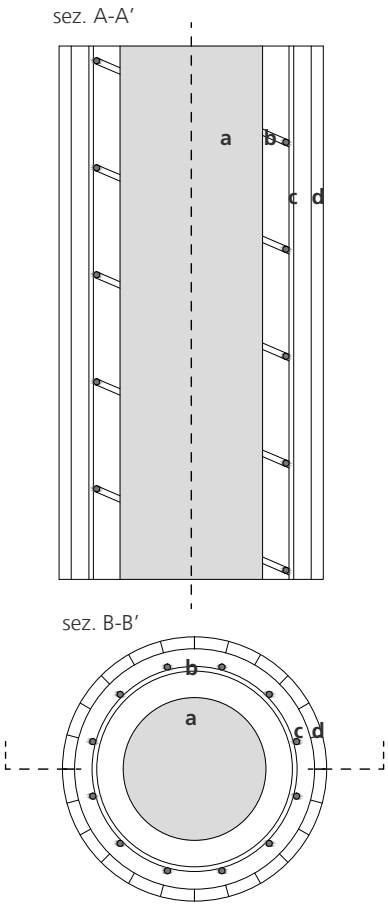
Cement removal

It is necessary to remove any sort of not attached concrete portion that has lost any sort of effectiveness, it shall be required then to free from such concrete the steel armor parts near to the broken area.
Additional reinforcement armor preparation- the removal of weakened concrete portions shall be done revealing the original armor, it is necessary to uncover the portions of concrete where the new steel bars shall be placed and to consent a proper anchoring, (the suggested length shall be at least the double of the distance of the stirrups or of the secondary transversal reinforcement).

Sewing up the damaged parts

Eventually any damage present, which is not pass through the core of the beam (thickness 0,3 - 3 mm) has to be filled (read chapter about injections of epoxy resin).

07.



07_*Schematic example of pilaster lining reinforcement*
a) Pilaster to reinforce
b) Primary reinforcement armor
c) Secondary reinforcement armor

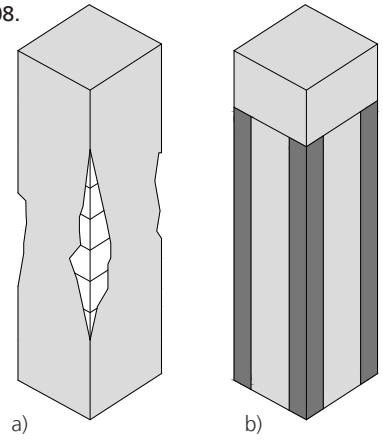
Positioning the new armor

- Straitening of the original steel bars
- Removal of the longitudinal steel rods that are elasticized (deformed, ineffective)
- Laying of new stainless steel rods or galvanized Fe B 44K and eventually transversal reinforcement pre - bent which dimensions and spacing is as the executive drawings displays. Usually these secondary steel rods are placed in a major number and less spaced near the cross joints between pilaster and beams for example, in any case the section of the single rod shall never be less than 12 mm for the long running rods and of 8 mm for the secondary reinforcement. The joint rods sequence (when a rod is extended to another shall it be a longitudinal or a transversal reinforcement) shouldn't be distant more than 2 diameters and not more than 20 mm; the stent that has to be overlapped (better if more) at least of 2 times the distance between the secondary reinforcement bars or at least 35-40 times the diameter of the rod extended. In case the section that has to be recovered is more wide than 40-50 mm it is suggested to position a electro welded web Fe B 38K of galvanized steel or polypropylene net (PP); this surface reinforcement helps also as support for the rendering.

Restoring of the effective section

The recovering of the effective section of a armored concrete beam shall be done with mortar made of hydraulic binders, fiber-reinforced, thyrotrophic, shrinkage compensated.
In case of wide surfaces to be treated (thickness 50 to 100 mm) instead of applying with trowel or spray it's recommended the casting procedure of high adherent cement mixer in formwork with shrinkage compensated characteristics. Before the concrete cast it is required to uniformly apply a layer of gripping product epoxy resin based characterized of high adherent qualities and very high mechanical valor to resist at bending or traction deformations in such a manner to guarantee a structural continuous between the old and the new castings.
The formwork has to ensure an adequate resistance, has to be waterproof and sealed as to avoid the losses of the slurry cement. The wood formwork has to be damp of water as to avoid that the casting can lose part of water for absobation from the wood formwork; in the end it has to be applied a form-released compound to facilitate the removal of the formwork.
The high adherent grout has to be casted in the first three hours from the preparing of the formwork and the applying of preliminary products, once casted in the formwork it shall be in casing for at least 48 hours.
To have an optimal ageing and to avoid fissures or cracklings consequences of a to quick evaporation it is possible, once the finishing is done, to add specific anti evaporation product, in a maximum of three days after.

08.



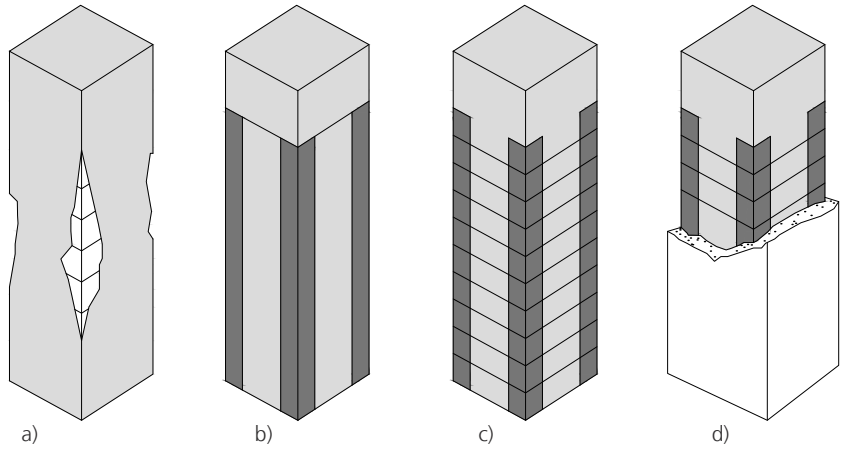
C.4_Pilaster's reinforcement:

When the pilaster that has to be treated has a circular section it is possible to strengthen the compression resistance increasing the resisting section of the element.

Executive procedure:

- Demolition and removal of the damaged concrete
- Injections of the interior core fissures
- Straitening of the longitudinal steel rods
- Positioning of a secondary reinforcement armor, generally an elliptical steel cage type and a secondary vertical
- Cleaning and humidification of the supports surface
- Casting from proper distance in the formwork

09.



To reinforce the rectangular section pilasters, when it is not possible to enlarge the dimensions, it is possible to confer the angles of steel profiles. The angles surface has to be prepared applying an adhesive mixture to ensure a good grip beyond the nailing which fixes it mechanically.
If it is possible to enlarge the pilaster it shall be optimal to reinforce it with a new steel armor cage and cast on it a high adherent grout, the cage can be welded with special pieces as angular shape profiles.

Another technique is to apply a plate steel welded as a belt on the external profile of the pilaster, these steel strips can be glued on the old cement surface preventively treated with epoxy resins and shore up till it has gripped

08_ *Damaged pilar (a) consolidated through steel sections (b).*

09_ *Consolidation with enlarging of the pillar's section:*

a) Element to be consolidated

b) Application of the angle sections with epoxy adhesive

c) Application of the stirrups

d) Realization of the concrete mixture.

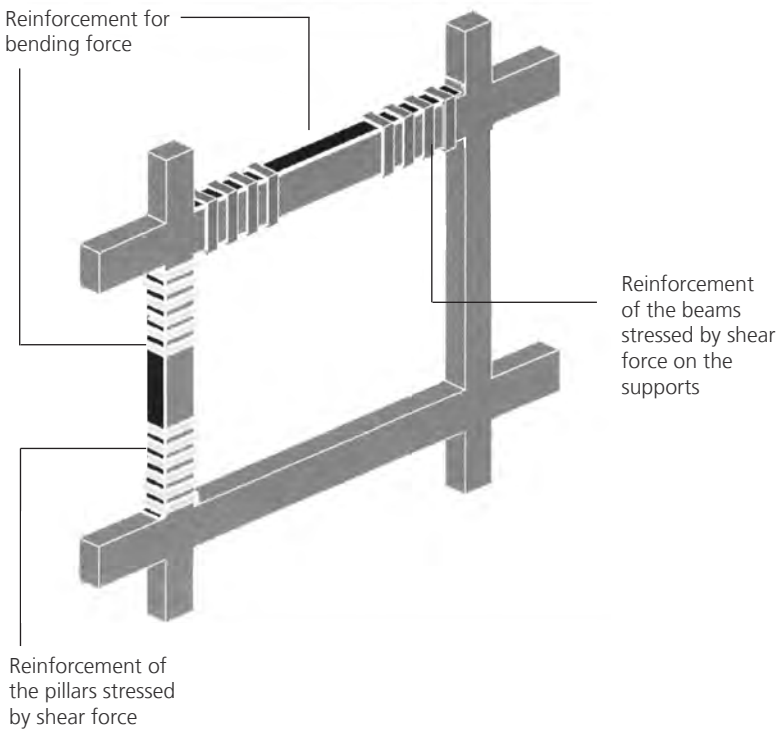
C.5_Consolidation with composite materials (FRP)

The operation interests particular buildings that is in a condition to be unable to resist any sort of traction or shear force which they where structurally planned, in these cases it will be necessary the increasing of the section of the structure with the usage of steel plates or steel strip applications as to confer to these new additional reinforcements the characteristics of belt and the transfer on them of the traction forces

Advantages:

- High performance in exchange of low weight
- High resistance in a time perspective to any sort of atmospheric agent
- Easy adaption to any sort of geometrical structure
- Anisotropy characteristics of the material works effectively only where necessary

10.



11.

12.

This type of operation is suggested in the following cases:

- Reinforce the traction resistance of particular portions of beams
- Reduce the deformation as consequence of a loaded beam
- Higher resistances that confers an major possibility for future reuses different from the original functions

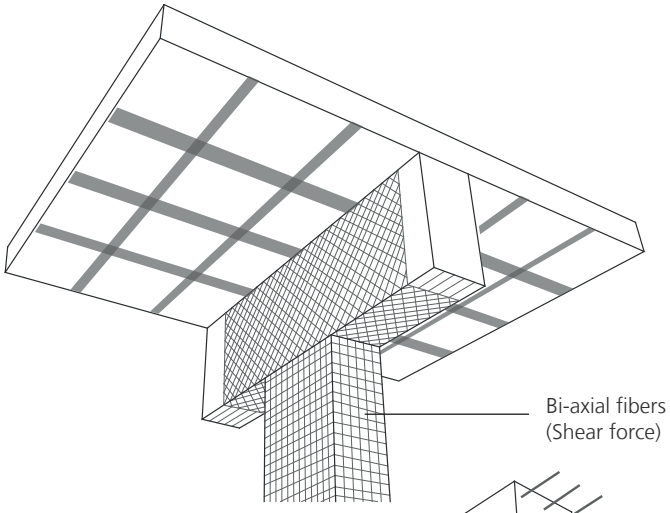
The operative procedure follows the working phases

- Polishing of the surfaces with sandblasting and specific metal brushes;
- Rebuilding of missing volumes of the structure;
- Primer coating based on epoxy resins as to improve the gripping characteristics to the FRP support
- Positioning the steel strip on the concrete surface and keep in pressure constantly as to stretch out the excessive adhesive and then clean the fissure.

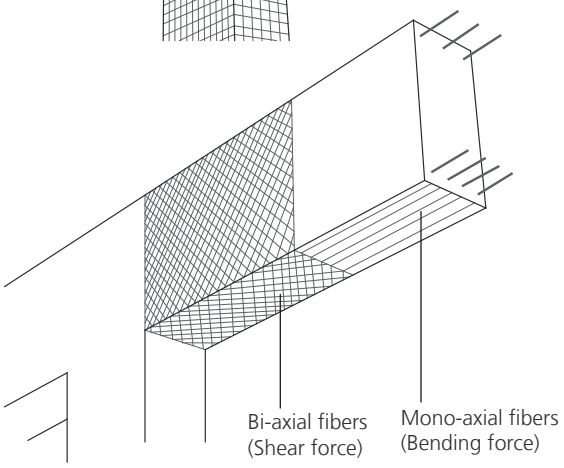
Avoid direct solar irradiation protecting them with specific protective UV resistant.

In case of flex stress conditions (for example a bended beam) it is required a peculiar surface treatment on the faces of the plate belt on the side that works with the concrete, an d more specifically it is required a mechanical transfer of the reactions by a sequence of anchor pins that ensures a solid connection with the old structure. It can be used FRP strips that has the characteristic to improve the shear resistance in particular.

13a.



13b.



14.

10_*System of concrete frames' reinforcements.*

11_12_*Consolidation with composite materials.*

13a_13b_*Adoption of FRP materials to consolidate reinforced concrete pillars and beams.*

14_*Construction phases*

a) Preparing the construction site

beside the usual necessary instruments (brushes, spatulas, rollers, buckets, drill, mixer) it must be prepared a working plan for unrolling, custom-cutting and cleaning (fundamental) of the strips.

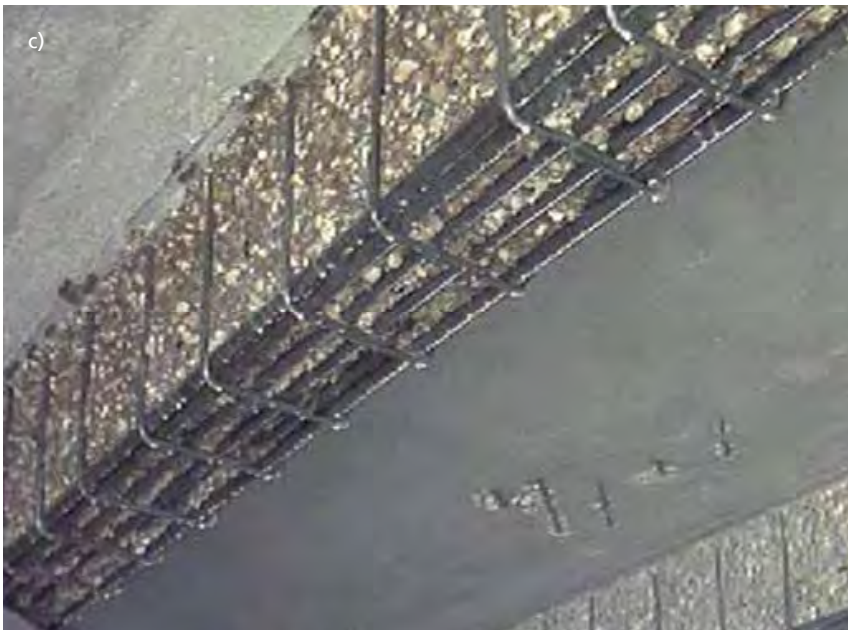
b) Preparing the support:

- *demolition of the degraded surface of the concrete*
- *cleaning of the steel bars surface*
- *cleaning of the surface from dust, dirty, incoherent materials, oils, greases, etc.*

c) Refurbishment of the concrete.

d) Application of the adhesive and of the reinforcement.

c)



SECTION 3 | APPENDIX

Bibliography

MINISTERO PER I BENI E LE ATTIVITÀ CULTURALI, *Linee guida per la valutazione e la riduzione del rischio sismico del patrimonio culturale*; Cangemi Editore - 2006.

G.CANGI, *Manuale del recupero strutturale e antisismico;* Dei-Tipografia del Genio Civile - Rome, 2005.

G.CARBONARA (a cura di), *Trattato di restauro architettonico*; UTET, Torino, 1996, 4 voll.

G.CARBONARA (a cura di), *Atlante del restauro architettonico;* UTET Torino, 2004, 2 tomi.

G.CARBONARA (a cura di), *Trattato di restauro architettonico, primo aggiornamento. grandi temi di restauro*; UTET, Torino, 2007;

G.CARBONARA (a cura di), *Trattato di restauro architettonico, secondo aggiornamento;* UTET, Torino, 2008.

M.DOCCI, D.MAESTRI, *Manuale di rilevamento architettonico e urbano;* Laterza, Bari, 2009.

F DOGLIONI, *Stratigrafia e restauro. Tra conoscenza e conservazione dell'architettura*; ed LINT, Trieste, 1997.

M.DOLCE (coordinatore scientifico), *Sistemi di puntellamento a presidio di strutture murarie. analisi numeriche*; Genova 2004.

M.DOLCE (coordinatore scientifico), *Manuale delle opere provvisionali urgenti post sisma;* Basilicata 1999.

G.MANIERI ELIA, *Metodi e tecniche del restauro architettonico*, Carocci, 2010.

F.DOGLIONI, *Codice di pratica (linee guida) per la progettazione degli interventi di riparazione, miglioramento sismico e restauro dei beni architettonici danneggiati dal terremoto umbromarchigiano del 1997*; Ancona, 2000.

D.FIORANI (a cura di), *Restauro e Tecnologie in Architettura*; Carocci, Roma 2009.

S.FRANCESCHI, L.GERMANI, *Manuale operativo per il restauro. Metodologie di intervento per il restauro e la conservazione del patrimonio storico;* Dei-Tipografia del Genio Civile, Roma, 2010.

F.GIOVANETTI (a cura di), *Manuale del recupero della città di Castello*; Dei - Tipografia del Genio Civile, Roma, 1992.

F.GIOVANETTI (a cura di), *Manuale del recupero della città di Castello*; Dei - Tipografia del Genio Civile, Roma, 1992.

A.GIUFFRÈ (a cura di), *Lettura sulla meccanica delle murature storiche*; Edzioni Kappa, Roma, 1991.

A.GIUFFRÈ (a cura di), *Sicurezza e conservazione dei centri storici. Il caso di Ortigia*; Laterza, Bari, 1993.

F.LANER, *Tecnologia del recupero delle strutture lignee*, Flap Edizioni, Mestre, 2005.

S. LOMBARDO, *Valutazione della vulnerabilità degli edifici esistenti in cemento armato*; Dario Flaccovio Editore, 2012.

M. MARIANI, *Particolari costruttivi nel consolidamento e restauro*; Dei-Tipografia del Genio Civile, Roma, 2014.

S. MASTRODICASA (a cura di), *Dissesti statici delle strutture edilizie*; Hoepli, Milano 1994.

S.F.MUSSO, *Recupero e restauro degli edifici storici: guida pratica al rilievo e alla diagnostica*; EPC LIBRI, Roma 2006.

G.PALMERIO (a cura di), *Appunti di restauro. Metodi e tecniche per l'architettura*; Palombi Editori, 2005.

P.ROCCHI, *Manuale del consolidamento. Contributo alla nascente trattatistica*; Dei - Tipografia del Genio Civile, Roma, 1994.

F.Trivella, *Recupero del Costruito. Manuale di intervento pratico*; Dario Flaccovio Editore

L.ZEVI (a cura di), *Il manuale del restauro architettonico*;Mancosu Editore, 2001.