Rendre compatible les techniques traditionnelles et les modernes
Compatibilizar técnicas tradicionales y modernas
Combining traditional and modern techniques

The 'Svevo' Village of Termoli. The traditional constructive techniques of Molise

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In this contribution the noticeable traditional constructive techniques in Molise will be synthetically exposed, a small region of central Italy characterized by a mostly mountainous nature, with characteristic rural villages, and with a limited coastal area in which the city of Termoli in the province of Campobasso resides. The analysis of the traditional building typologies and the constructive systems of the architectonic patrimony, although not rich of any particular historical building of artistic value, can lead to a handbook useful in order to elaborate the criteria for the plan of recovery and conservation of the local buildings. The survey and the indexing of most common constructive systems and the materials used constitutes the only way to characterize those criteria culturally correct for the formulation of the recovery plan especially in a diversified architectonic panorama like the one of the Molise region with different characteristics in the inner areas and those by the sea. To such purpose the information collection with a standard form is that the author, with Camilla Sansone, is leading for the indexing of the typologies and the analysis of the associated constructive systems to characterize those common characters that can constitute the foundation of a recovery manual. The city of Termoli constitutes an important example of correlation, as it should be, between the historical parts of the city. Molise is known as a mountain region, barren, whose city centers are legacies of the Appennine ridge crossed by a net of "tratturi", historical paths used by shepherds for the "transumanza" of the cattle, that characterize a beautiful territory, rich of valleys and in which the nature constitutes the determining factor. All that sublimes, when it reaches Termoli. The city is laid down by the Adriatic Sea and constitutes a territorial anomaly since it does not present those architectonic-urban values of the inner centers. If, in fact, they are compared, as an example, the plan organization of the city of Termoli and that of the village of Ripalimosani we find and catalogue diametrically opposite ways of building, sure legacies of the different characters of the sites. The village of Ripalimosani is on an emerging rock mass that constitutes, at the same time, a solid foundation for the buildings and part of the same houses being inserted in the border and inner masonries of the constructions (fig.1). Termoli, instead, sees, constructions of various type, ordered on an almost flat territory, defined in a reticular plot that reminds us of the Greek hippodamean system for its regularity. Rural the first, diffusely noble dwellings the second a testimony of the "diversities" of Termoli due to the possibility of sea trade and the development of a wealth unknown in the remaining territory of Molise. The city plan is still today clear. The ancient nucleus, on the sea, the Svevo Village, well preserved, with its defensive walls and its towers, with its buildings collected around to the cathedral built by Federico II and with typological characteristics tied to the mercantile and fishing activities; outside, monumental, isolated and therefore of high value for its high degree of authenticity (fig.2). A short distance from the sea, the city center fruit of a nineteenth-century urbanization, tied to the ancient nucleus in an "alternative" way being external to it.
Such diversities have lead to a varied elaboration of constructive techniques according to the clients. "Poor" techniques for the inner villages, tied to the natural resources, mainly classifiable as traditional in the sense of local development, more open towards the industrial development those noticeable in the Termoli area. The limestone and wood, materials present in abundance locally, constitute the raw materials for the load bearing structure and the noticeable elements of horizontal partition in the rural buildings; the stone and the bricks for the structure united to the iron for the ceilings constitute the materials of base of the termoli historical buildings. Obviously, the noticeable constructive techniques in the constructions of the Svevo Village reveal the adoption of stone and brick for the realization of the vaults as elements of horizontal partition. The realization of the vaulted structures, in particular, sees the uses of bricks, tied with chalk mortar, arranged with bricks on edge preventively aligned on shapes in earth on laggings realized with bundles of branches, that, as Camilla Sansone in other relation connected to this one writes, "... present widely articulate modalities of organization of the blocks that compose it, rich elaborate and accurate in the geometric and technical construction" (fig.3). The vaulted ceilings are found again in the Svevo Village also in order to create protected passages in the public streets and, in more advanced constructive shapes, the cathedral and the castle. The constructive techniques are determined directly by the typology of the buildings. The natural slope affects in a determining way the constructive characteristics, as already mentioned previously for a village like Ripalimosani, that uses the emerging rocks in order to avoid the damage deriving from the land being prone to landslides (fig.4). The position on the slope, with a number of floors limited to three, concurs, moreover, to the complete vision of the land, even if of limited extension, annexed to the house. The first level is always constructed partially underground in local stone coursed rubble and, where possible, partially inserted in the slope in order to realize the inner microclimate useful for the conservation of the food and the shelter of the animals. The ceiling of first level is usual realized with a barrel vault in stone elements. The higher ceilings, instead, are realized in wood in which one finds just one main framework on which a plank surface rests to shape the formwork for a successive base course made with argillaceous earth and straw in which very rarely one finds added

tile fragments and pebbles. In Termoli, on the contrary, it is in the Svevo Village and in the nineteenth-century enlargement, that ceilings realized with iron beams and small brick vault or with pignatielli, light hollow bricks. These small vaults take the name of plaffoni. The foundations are, for the buildings of the coastal area of Termoli, of continuous type in masonry, therefore like the structures in elevation, even if these see several systems according to the local working abilities of the workforces. In particular, the vertical structures are constituted by masonries in stone of varied sizes, with double outer layers filled with incoherent material, with thickness of the walls tapered towards the higher levels; in some areas also well worked squared elements are present. Other type stone masonry with rounded off elements with mortar, or a load bearing structure in squared or partially worked stone blocks. In the building structures integrations are evident realized with various materials (bricks of varied typologies).
The techniques for the realization of the partitions is particularly elaborated. Being non load bearing masonries they were realized with currents of fir or chestnut tree and a filling of canes or planks finished with plaster of chalk. Sometimes, in the coastal area, we can find fillings with cylindrical bricks. The roofs are fundamentally double-pitched roofs in the rural constructions, with the possibility to conserve foodstuff, while in the coastal area the terrace roof prevails with cornice realized with "romanelle", three layers of tiles, jutting out progressively.

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The Swabian Village of Termoli. The vault system: tecniques and recovery

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The ancient Swabian Village of Termoli is the original nucleus of the adriatic town, whose foundation is dated, by archive sources, to the Vth century. It was born as an extension of a fortified emplacement pertaining to a system of sighting towers installed to protection of wraps coastal. This village constitutes an independent entity from the modern city, fruit of an expansion plan of the XIXth century. It presents uniform constructive characters that have been maintained unchanged in the centuries. As centre of the Bishopric and a trades port them Termoli has always been a rich city and this explains the notable characteristics present also in the more modest buildings. Apart from some of the wealthier buildings like the castle, the cathedral and lesser noble mansions, the building of the Swabian Village of Termoli was born in order to accommodate merchants and fishermen.

The composition of these architectures is strongly conditioned by the requirements deriving from the activities tied to the sea. The buildings are on three levels: on the ground floor the storage for the equipment and the stock and a premises with the fireplace; on the first floor the residence for the family and, in the attic, a ventilated area for the conservation of the provisions. The construction materials from the technological survey carried out on these buildings show a prevailing local origin. The construction stones come partially from still existing quarries, for example the breccia del Gargano. The constructors, instead, show a typical technical formation of the swabian constructive culture, imported in Italy by the emperor Federico II, that was the initiator of the construction of the Cathedral of Termoli. The systems of horizontal partition of the buildings introduce a rich technological and constructive variety. The vault system, frequently used for the realization of the ceilings of the first level of the buildings, present widely articulate modalities of organization of the blocks that compose it, rich elaborate and accurate in the geometric and technical construction. The vault system is found also outside the buildings in the planning of the city system. In fact the Swabian Village of Termoli, raised on a limestone block nearly entirely encircled by the sea, is exposed to strong winds. For this reason it is delimited by a wide building curtain that protects the residential area and is characterized by tight and winding roads, made mostly by means of city passages covered with characteristic barrel vaults in stone and brick. (img.1)

Made in limestone and sandstone stone with disarticulated weaving in the ancient buildings, like the castle and the cathedral, the vaults assume, in the course of the centuries, more and more elaborate apparatus by use of the brick that, covered with plaster opportunely mixed guarantees a better capacity of the horizontal partition system.

The simplest vault system is the barrel vault in stone to cover basements and underground spaces. The construction used a arch lagging in earth shaped with uses of bundles of wood, made with stone chips jammed together and tied with chalk or lime mortar. The traditional mortars are based on the baking and the treatment of local limekilns with river sand, in the proportion of 1/3 and 2/3. In order to accelerate the setting processes of the mortar chalk was added, or more often for vaults and hourdis ceiling only chalk mortar was used.

The cladding spandrel was realized with a system known as "*copertina a tre accavallatoi*" cover with three levels, that is a filling obtained in three distinct phases. The first part has the task to fill up the interstices and the sides, the second level renders the surface flat still slightly curve while the third part finishes the surface destined to receive the pavement. In some cases the upper surface of the vault is left without filling or filled up with incoherent materials that offer insufficient support, the pavement is supported by an independent ceiling. The beams of this ceiling, supported on the mid portion of the vault below, can be of reduced dimensions. Structurally different are the vaults placed on the upper floors: with baked bricks, rectangular pianelle laid on edge high 0.15cm united with chalk or lime mortar with sand or volcanic sand (*pozzolana*), or small hollow floor bricks on lancet or skene arch lagging. The geometric configuration of these vaults generally is of versatile shape, pendentive dome or pavilion. (img.2) Less frequent are the groined volts that are found mostly in the covers of the footpace of the stairs

The use of brick in the coastal area of the Molise widespread thanks to the presence of clay quarries; in fact the difficulties in the transports and the inadequate street net did not favour the transport of the construction materials. The activity of brick creation happened near the quarry. The procedure consisted in one first phase in which the clay in pieces was sifted by hand, and then struck with a mallet or crumbled under a stone. After a second passage in the sieves and an addition of water the material was pasted with the feet in appropriate pits lined with bricks. In order to make more valuable bricks the clay was left to sediment for five or six months exposed to the atmospheric agents. Every pit concurred the preparation of approximately 600 bricks. The confection of bricks employed of shapes positioned on a surface covered with sand or ash in order to facilitate the separation of the finished pieces. The shapes were rectangular for the making of bricks and pianelle. After the formation the next step was drying exposed to the air and then baking in appropriate furnaces. The handcrafted bricks, beginning from the 1800 had standard dimensions, with small local variations. Normally solid bricks and the those with two holes were 26x13x7cm while those with three holes were 21x10x4 cm.

For the construction of the light vaults and the vaulted ceiling slabs between the metallic beams of the ceiling special shaped bricks were made: these elements, called *pignatielli* had a cylindrical shape and they were hollow inside. The last system frequently found, beginning from the second half of the eighteen hundreds, the ceilings with iron beams and small brick vaults. (img.3) A variation of the wood ceiling that slowly proposes a mixed system in between the ceiling and the barrel vault. This system has origin from the static concept of the ceiling with wooden beams and planks: in our case the planks are replaced by vaults made with bricks or with pignatielli. These small vaults are called "*plaffoni*". The beams of the main framework of this ceiling can be done with metallic beams or wooden ones. The choice of the material depends on the age of construction (the older ones are in wood) and from problematic of economic nature and obtaining the material. The beams in wood assume the configuration of double T through two straight edges nailed to form the support wings of the vaults. The vaults are prepared with the support of a light jack lagging temporarily fixed to the wings by means of wedges.(img.4) The same structure with metallic beams with double T profile present, confronted with the wooden beams material compatibility problems. In fact the ceilings with metallic structure show a strong tendency to corrosion, facilitated by the presence of the chalk in the mortar. In order to contrast this problem the beams preventively are protected with varnishes made with tar. Another problem of the structures in steel is the excessive flexibility of the load bearing elements confronted with the flexibility of the brick plaffoni. For this reason it is frequent that in these ceilings median or cross-sectional divider beam are present to control the inflection of the beams. These ceilings, even if carefully crafted, usually were hidden with false ceilings. The finish of the outer face consist in a thick layer of plaster that in the chine was rounded. The false ceiling was covered with a glued paper or with burlap. It was connected to the ceiling by means of a truss with lists of wood or suspended from divider beams. Only in the course of a recent operation of diffuse city recovery, aimed at proposing new functions within the historical centre, the positive characters and the aesthetic valences of these systems has been exalted, within project choices that values them, hidden by plaster but made with such care and accuracy to appear as finishing elements.

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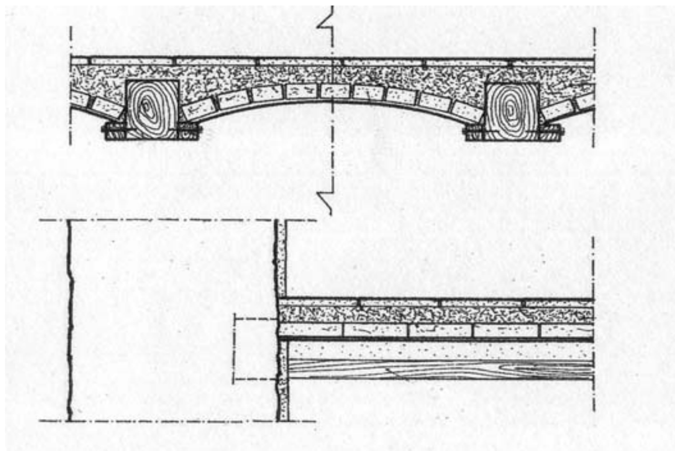

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Building and Rebuilding with earth. Earthen architecture in Cyprus and the problem of its conservation

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Historical Information

It seems that mud brick structures were common in Cyprus from the Neolithic age (7000-6000 BC) to the first decades of the 20th century, The earliest example of such structures were found at Choirokitia, a Neolithic Age settlement. Through archaeological investigation and excavations it was found that adobe was used in several places of Cyprus from the Neolithic, to the Classic Period. The construction of those walls is very simple; mud bricks of different sizes and thicknesses are resting on a rubble-stone substructure. This technique continued to be used throughout the various periods of Cypriot history. Mud bricks were also used in military structures like the Venetian walls of Nicosia as well as in some Medieval churches. Adobe as a basic building material is met mainly today in the rural and urban traditional architecture of the 19th and 20th c.

Types of traditional architecture

The basic rural dwelling in Cyprus is the single-unit structure. Two can be considered the main types of this. In the plains and in the settlements of the foothills of the mountains the type that prevails is the broad-front single-room house (*makrinari*). The maximum width of the *makrinari* varies from 3-4 meters which is determined by the constructional properties of the timber available where the length of the building varies between 6-8 meters or even more. A second basic type of a single-unit house is that in which the almost rectangular room (*palati* or *dichoro*) is divided either by a large, often pointed, arch that supports the roof or by a wooden post on which the central beam rests and carries either a pitched roof or an almost flat roof. In these cases and according to the timber available the dimensions are about 6X6 meters. Of course the variety of the islands rural houses is not limited to the above mentioned basic types. There are many house variations as a result of either successive extensions or additions of auxiliary units to the basic one. According to the plot and the area available a house was built and extended as a single-storey building (plains) or in two levels (mountainous regions). In the towns the typology differs, especially from the end of 19th century onwards, as neo-classical characteristics were incorporated both in typology and façade formation. In this category a central common room (*iliakos*) is surrounded on both sides by rectangular rooms which with the backyard additions, the verantahs etc create a more complex type of dwelling.

The structure

Mud brick construction

Adobe architecture has been mainly used in the plains where soil is plentiful and stone rare and difficult to obtain. Mud bricks were made with the use of local soil and the addition of binders such chaff, straw and ear as the most common ones. Also goat hair and seaweed was used depending on the location and availability. The mixture of soil, straw and water was left for few hours up to a day so as cellulose was released to give adhesive properties and make it mouldable. Mud bricks were prepared with the use of a wooden mould of internal dimensions 30x45x5 cm and were left to dry for at least a week. Mud bricks were only made during the summer.

Building with mud bricks

The foundation of an traditional house consist of a mixture of lime, sand and gravel ("*limeconcrete*") and was used to fill a trench which was dug for the purpose. On top of that a stone base foundation is always built to protect mud brick walls from rising damp. The stone base of the wall, of about 40 cm thick, was built with local stone. The height of the stone part of the wall varies, it goes from 1 meter high, up to the lintel of the openings. Mud bricks were then laid in consecutive layers with intersecting joints. The walls were built with the use of straw based mortar which was as thin as possible to avoid shrinking and uneven settling while drying. The wall was strengthened and "tied" with the use of wooden binding beams (*mantosia*). *Mantosia* was placed at the top of the wall, usually at the external side of it. Wooden beams were also used at the height of the lintels of the openings. The walls were left to "settle" for a long period before any kind of coating was applied. The most common renders were gypsum on the inside and mud plaster with straw on the outside. From the beginning of the 20th century onwards lime based renderings were used as well. Mud plaster is essential for the protection of the mud brick wall from rain but it has to be repaired annually when used externally.

The causes and effects of decay on mud bricks structures

The main cause of mud brick, and its render, deterioration is water penetration.

1. **Deterioration at the base of the wall.** The rising damp penetrates into the mass of the wall and depending on the temperature alterations it is drawn outwards. Thus the evaporating water leaves behind crystalline salts breaking this way the coherence of the soil and creates disintegration of the material which is then easily eroded by wind action. The process continues upwards and inwards, undercutting the wall structure and it may end to a collapse.
2. **Deterioration at the top of the wall.** Water penetrates when the

roof structure at the top of the wall fails. Hair cracks due to excessive wetting gradually develop to channels which become thinner and die out as they progress downwards. This procedure leads to extensive disintegration of the bricks and to vertical cracking.

3. Disintegration of the material. Damp penetrated the wall gradually evaporates and through the freezing-thawing cycle causes loss of the material cohesion which is pulverised and becomes dust.
4. Cracking is developed as a result of structural inefficiency due to extrinsic causes like earthquake or due to poor foundation construction which causes displacements and bending.
5. Human activity. In order to "strengthen" or "protect" the sensitive mud brick material or its stone base from external dump and water, cement plaster was extensively applied. This method proved to be catastrophic for the mud wall as the cement render being stronger than the earthen core does not allow humidity to be released and leads to humidity accumulation in the core of the wall. This leads eventually to the extensive disintegration of the mud brick.

Repair methods

An intervention on a damaged mud brick structure aims at the restoration of those parts by eliminating the causes of its destruction. Also additional strengthening by means of modern techniques must be considered if necessary.

1. Intervention on the stone base of a mud brick wall. The most common techniques for the strengthening of the stone wall and the prevention of the rising damp are, the underpinning, the construction of a proper drainage system and the grouting by compatible injection grout. Stone replacement as well as repointing of the wall are also common practice.
2. Repairs in the body of the wall. Heavily damaged mud bricks should always be replaced. Precaution must be taken in relation with the "soil compatibility" and the proper bonding of the new with the existing. Replacements of mud bricks with other material than that (fired bricks etc) should be avoided as incompatibility may result to poor connection.

If the damaged part is a corner or is accompanied by cracks a further strengthening method must be applied. The most common one is the insertion of a wooden tie beam at an appropriate length and at several levels along the height of the wall (stitching). If it is necessary wooden tie beams could be inserted on both sides of the wall and should be, in this case, properly connected between them. The same way a proper interlocking of the corners must be inserted if the existing one is not appropriate or does not exist at all. It is of crucial importance to create a proper tie at the top of the wall to establish the diaphragm function. This can be done by the insertion of ring beam(s) where the wood structure of the roof/floor can rest.

Other strengthening methods that are widely used is the increase of the length of the sitting of a wooden beam so as load is distributed in a wider area and the increase of the length and section of the lintels of the openings. In an extreme case where a wall has a very low load bearing ability, a timber frame structure (vertical posts and horizontal beams properly connected) can be incorporated to carry the load of the structure.

Récupération des Techniques Constructives Traditionnelles Sismo-Résistantes pour un Entretien du Bâti Ancien

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Introduction :

Pour mettre en évidence la résistance des constructions datant de la période Ottomane (Alger et Tunis) et de la période Alaouite (Fès) durant le XVIII^{ème} siècle, une analogie avec ce que préconisent d'une part, le règlement parasismique actuel pour les constructions en maçonnerie et une comparaison avec la théorie de la dynamique des structures d'autre part ont été établies. En effet ces lois sont immuables et le comportement dynamique des constructions de même type est le même quelles que soient les périodes.

Cette démarche à partir de données scientifiques nous a permis d'éviter les interprétations hasardeuses en matière de techniques parasismiques.

Les normes utilisées concernent tous les éléments structuraux. Dans le bâti traditionnel ont été pris en considération les règles qui régissent les constructions en maçonnerie[1] réalisées généralement en murs de commande simple (brique de terre cuite[2]) ou mixte (briques et moellons).

Les techniques constructives mise en évidence ont permis d'établir que le bâti traditionnel construit après les séismes destructeurs n'est pas aussi vulnérable car il répond aux règles des codes parasismiques actuels établis pour les constructions en maçonnerie.

Les techniques constructives sismo-résistantes :

Il a été mis en évidence suite à une lecture archéologique *in situ* à la Casbah d'Alger[3], dans la médina de Fès et celle de Tunis, des techniques constructives sismo résistantes qui ont été exécutées suite au tremblement de terre de 1716 par la communauté d'Alger[3]. Et probablement depuis les séismes de 1624 et 1755 à Fès et 1758 à Tunis. Ces techniques concernent :

- La structure rigide ; c'est-à-dire la maçonnerie porteuse,
- La structure flexible ; en l'occurrence les arcatures,
- Les diaphragmes représentés par les planchers,
- Les ouvertures.

La typologie constructive de la structure rigide (murs en maçonnerie) :

La structure rigide (murs porteurs) est représentée par des murs de commande en maçonnerie qui peut être classée selon le type de matériaux, la taille et la forme des blocs ainsi qu'en typologie constructive régulière ou irrégulière[4]. Le type principal de maçonnerie rencontrés sur les différents sites (Alger, Tunis et Fès) est :

- Maçonnerie de typologie régulière, réalisée avec des briques de terre cuite de dimensions variables 3x10x20 cm, 3x12x20 cm, 3x12x25 cm, 3.5x12x20cm et 4x11x24cm pour Alger[5] et 2.5x13x26 cm pour Fès[6].

Cette maçonnerie est liée par un mortier de terre ou de chaux. La paroi murale en général a une épaisseur de 60 cm.

Ces murs de commande présentent différentes variantes.

- Une maçonnerie entre laquelle s'intercalent des rondins de bois non équarri de 10 cm de diamètre (thuya Alger[7] , cèdre à Fès[8] et genévrier à Tunis[9]). Le bois dans ce cas-là n'exerce aucune force de traction (Fig 1).

Cette disposition de deux matériaux, l'un rigide et l'autre flexible, permet une absorption des charges horizontales lors des sollicitations sismiques. Par ailleurs, les murs présentent peu de fissures et ne se détruisent pas.

- Une maçonnerie renforcée par des arcs de décharge,
- Une maçonnerie mixte réalisée en briques et pierres à strates régulières ou non présentant un « *opus mixtum* ».
  Dans ces cas là seule la stratification des matériaux fait baisser le barycentre global des masses d'où la sismo-résistance de ce type de mur[10] .

La typologie constructive d'un pilier de voûtes :

Les piliers en maçonnerie supportant les voûtes sont également réalisés en briques entre lesquelles est insérée une rangée de 4 à 5 rondins de thuya à Alger et 6 rondins de genévrier à Tunis (fig 2). Ces rondins sont à intervalle régulier variant entre 80 cm et 100 cm.

A Fès, il semblerait que cette technique soit semblable à celle observée dans les deux autres médinas. Cette technique a été décrite lors des travaux de restauration de *Da r 'Adyal*[11] . Il est dit que des plaques de bois sont intégrées tous les 50 cm aux sections des piliers assurant ainsi la connexion entre les piliers octogonaux des rez de chaussée et les piliers rectangulaires de l'étage. Ces éléments en bois, disent-ils, ont pour fonction d'absorber les éventuels désordres générés soit par les séismes soit par les tassements différentiels du sol de fondation.

Cette technique semble procurer à cet élément structurel sa fonction sismo-résistante puisque le bois intercalé entre les éléments de maçonnerie fait baisser le barycentre global des masses.

Les encorbellements :

Dans le trois médinas ont été exécutés des encorbellements à l'extérieur des constructions. Ils résultent d'une extension en profondeur donnant sur la rue, un avant-corps soutenu en étage supérieur par des rondins de bois débordant largement du mur. Ces balcons de façade appelé *q'bu* à Alger et Tunis et *ru sha n*[12] à Fès sont soutenus par des rondins de bois formant un angle avec le mur porteur et ayant le rôle de jambage. Ce dernier permet à l'encorbellement de ne pas osciller lors des secousses sismiques et de ne pas se briser. Les rondins de thuya et les poutres de cèdres sont en une constante flexion dynamique (fig 3).

Les planchers :

Ceux d'Alger sont constitués par une superposition de deux rangées de thuya insérées dans toute la largeur des murs porteurs créant ainsi une différence de niveau. Entre ces derniers est disposé un voligeage en bois[13]. Cette disposition du bois facilite l'absorption des efforts horizontaux lors du mouvement de glissement ou de roulement. Ainsi les planchers sont préservés

Le détail constructif de la liaison colonne- départ d'arc :

Par ailleurs, un détail particulier a été observé uniquement à Alger. Au niveau de l'articulation de la colonne avec l'arc et au dessus du chapiteau, il y'a une ou deux rangées de rondins superposées à la maçonnerie (fig 4). Cette disposition de matériaux différents l'un rigide et l'autre flexible garantit grâce aux mouvements de glissement une bonne résistance aux cisaillement. Ce détail contribue à la résistance sismique de l'arc algérois.

Conclusion :

- Ces quelques mesures présentées sont un échantillon de celles qui ont été relevées. Le catalogue des techniques sismo-résistantes répond en matière d'entretien du bâti historique localisé dans les régions sismiquement actives à travers les opérations de réparation et de restauration sismiques.
- Il répond également aux besoins d'une reconstruction du patrimoine par une utilisation innovatrice des matériaux et des techniques traditionnelles qui soient compatible avec le temps, l'existant et les aléas naturels (séimes).
- D'autre part Il permet aux différents intervenants (décideurs, planificateurs, bureaux d'études, architectes, entreprises de réalisation, ingénieurs ...etc) de disposer d'une documentation synthétique, relative aux mesures préventives traditionnelles et à la prise en charge du risque sismique.
- Du point de vue Scientifique, cette recherche permettra de développer une culture de la conservation en vulgarisant la méthodologie de mise en évidence des techniques préventives dans les universités pour les disciplines liées au patrimoine.
- Du point de vue pratique, cette connaissance acquise devra être diffusée par la formation d'ouvriers qualifiés dans le domaine de la conservation et favorisera la bonne exécution des techniques préventives pour un meilleur entretien du bâti.

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6 SDU Fès op.cit p 8 et p121

7 CORPUS (2001), op.cit, Typologie Architecturale, les maisons de la Médina d'Alger, p 3 et Abdessemed-Foufa (2005) op.cit pp 28-30

8 SDU Fès, ibidem

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12 SDU de Fès op.cit p 25

13 Ravereau (1985).La Casbah d'Alger et le site créa la ville. P 148.

GLOSSAIRE :

Fahs : la région extra muros

Da r: maison

q'bu : encorbellement

ru sha n: encorbellement

Pilier à Tunis

Détail articulation colonne - arc

Encorbellement à Alger

Bois inséré dans la maçonnerie à Fès

The observed seismic damage of traditional buildings of Western Greece reinforce the need for their strengthening

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1. Introduction

The traditional buildings in Greece as in the most countries around the Mediterranean Sea should be classified in three major groups in relation with their structural type, which is related to their construction period. The older buildings may consist the first group (type A1). The material of the structural walls is adobe or stone, the floors and the roof are of timber joists but sometimes the floors are vaulted. The openings are of a small percentage of structural walls and the height of each storey is relatively high. These buildings are generally stiff structures with natural periods less than 0.10 sec, depending on their height. The second group (type A2) consists of the buildings subsequently constructed of stone or solid bricks, that contain many and large openings. The floors and the roof are of wooden joists. These structures are more flexible than the previous ones, with natural periods higher than 0.20 sec. In the third group (type B) belong the buildings constructed in the beginning of 20th century and have an internal reinforced concrete frame and external structural masonry walls, principally of solid or perforated bricks. The floors are of reinforced concrete and the roof is either wooden or composite of bricks supported by steel beams. A characteristic of these buildings is the asymmetry in plane and in elevation. Their natural periods are lower than 0.20 sec.

These values of natural periods refer to low rise buildings, which are common in Greece. In the present paper the vulnerability of each type of building is examined by the means of finite element analyses. The results of the simulations are compared with the data collected after earthquakes. Furthermore, simple strengthening techniques are recommended. In addition, an assessment of the widely spreading intervention, which is the demolition of internal structural walls and the erection of a new frame of steel or reinforced concrete as a load bearing system, is made.

Group A1 consists of stiff, symmetrical stone masonry buildings with relatively high storeys, and openings of a low percentage of the total wall surface. The main external characteristic is that all the architectural elements emphasize the horizontal dimension of the structure. The type A2 buildings consist of openings with great percentage of the total area. These buildings are also more or less symmetrical, have lower storeys, and are less stiff than the type A1. The vertical dimension is emphasized by all means, structural and architectural. The type B buildings are of a hybrid type between frame structures and structural masonry ones. An internal frame of reinforced concrete beams and columns supports the reinforced concrete slabs while the external structural masonry supports the end of the reinforced concrete beams and the outer side of the slabs. As a result, these buildings have a little percentage of structural walls, but the slab makes them less flexible than those of type A2. Their seismic behaviour is unpredictable as a shearing failure causes severe damage due to the lack of load bearing walls but the bending develops light damage to the upper floor.

The analyses were linear elastic by means of finite elements methods. The seismic forces are according to the Greek Aseismic Code [2], which has many similarities with the specifications of the Eurocode 8 [1]. The loading combination includes the dead loads, plus 30% of live loads, the seismic force along a principal direction plus 30% of seismic force along the orthogonal direction, each one along positive and negative direction. In this study, eight seismic loading combinations are considered. The results presented correspond to the most unfavourable combination of each one of the four combinations in each direction, regardless if the outer or inner fibre of the masonry is mainly stressed. Of course, the reverse of seismic action stresses the opposite fibre of the wall.

2. Buildings of type A1

In situ inspections have shown that the main reason for seismic damage of these stiff structures is the out of plane bending of the upper storey which develops vertical cracks near the upper parts of the corners due to the separation of orthogonal walls and almost vertical cracks of the lintels and of the top of the walls. Also, diagonal cracking of the lower storeys piers and of the strong lintels is observed [6,7].

The results of an analysis of such a building are presented in Fig. 1. The building is of stone masonry with only one internal load bearing wall in the two lower storeys along the x direction. The tensile strength of the stone masonry was estimated to be 0.25 MPa. The building is stiff with natural periods T_x=0.07 sec and T_y=0.1 sec along the x and y direction, respectively. The contours represent the principal tensile stresses developed in the external fiber of masonry. As shown, the regions of the masonry walls with tensile stresses exceeded 0.25 MPa are those predicted to be most vulnerable.

A simple method to strengthen this building is to add a structural wall along the y direction up to the roof level as well as to raise the existing internal wall to the same level. As shown in Fig. 2, this easy to make intervention, results in decreasing the principal tensile stresses up to 50%. In addition, after the intervention, only a few elements of the wall develop principal tensile stresses that exceed the tensile strength of masonry.

A usual modern intervention in order to rehabilitate traditional buildings is the demolition of the internal load bearing walls and the preservation only of the external shell of the building. A new framing load bearing system is constructed independently of the existing walls. This intervention makes the remaining walls much vulnerable as shown in Fig. 3, where the results after the demolition of the internal load-bearing wall are presented. Of course, this intervention, does not affect the seismic behaviour for seismic action along the y axis, because nothing was changed along this axis.

3. Buildings of type A2

The difference from the above mentioned buildings of type A1 is that they are more flexible due to the greater percentage of openings and the weak lintels. So, the difference in the seismic behaviour is the failure of the lintels of all the storeys due to bending and not due to shear [8, 10]. The building under consideration is a two-storey stone masonry building with internal load bearing walls. The natural periods along the x and y axes are 0.23 sec and 0.19 sec, respectively. As shown in Fig. 4, the principal tensile stresses have greater values in the upper floor and are greater at the walls transverse to the seismic direction under consideration. If the internal load bearing loads continue up to the roof, the decreasing of stresses is dramatically. As shown in Fig.5, the developed stresses are lower than the tensile strength of stone masonry, which is 0.25 MPa, the same as in the previous case. The analysis predicts that the demolition of the internal load bearing walls increases the part of the walls that are overstressed, as is presented in Fig. 6.

4. Buildings of type B

The buildings of type B are mainly asymmetric in plane and have reinforced concrete slabs supported by a reinforced concrete frame at the inner of the structure and by brick or stone walls in the perimeter. The roof is generally of wooden trusses and occasionally of bricks supported by steel beams. The main characteristic of these buildings is the low percentage of load bearing walls and their unpredictable seismic behaviour. As is mentioned in [3, 4, 5] the damage may be due to shear failure of the basement or due to bending failure of the upper storey. In the first case the damage is severe because just a few walls carry the shear seismic forces. On the other hand, the bending of the upper storey is not as severe, because the walls are supported by the reinforced concrete slabs and the bending height is limited to just one storey. The reinforced concrete slabs make these buildings stiff despite the lack of walls.

In Fig. 7 the results of the analysis of a building of type B are presented. The building is of solid brick masonry and has natural periods T_x=0.21 sec and T_y=0.19 sec along the x and y axes, respectively. Fig. 7 shows that when the main seismic action is along the x direction, then the bending of the walls of the upper floor transverse to the force is severe, while when the main seismic action is along the y direction the shear of the parallel to the action walls of the ground floor is severe. This is in agreement with the inspection results after earthquakes [9]. In fig. 8 are shown the principal tensile stresses after the addition of new walls and the construction of a reinforced concrete tie belt at the top of all the walls. The decreasing of the tension by these means is considerable and up to 50%.

5. Conclusions

The results of the above mention analyses show that a method widely employed in practice during the rehabilitation works of traditional buildings that is the demolition of load bearing walls make the structures more vulnerable to seismic actions. One reason is that the remaining walls cannot sustain the applied forces. Another reason is that constructing a new bearing system, the dead and live loads of the floors do not apply to the walls, therefore their strength in shear is decreasing. On the contrary, the construction of new walls in conjunction with the existing walls, which are well joined, is a good strengthening technique.

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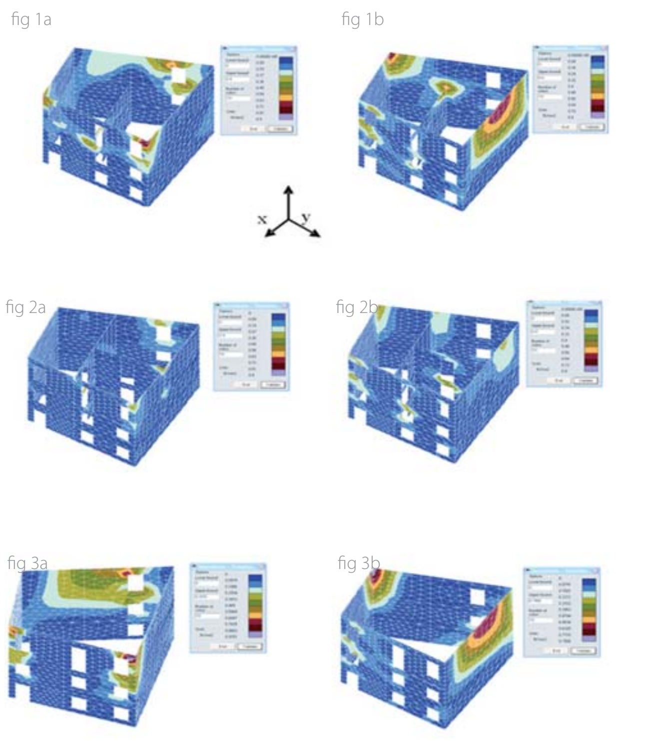

Fig1: Building of type A1. Principal tensile stresses of outer fibers due to: (a) G+0.3Q+E_x+0.3E_y, and (b) G+0.3Q+0.3E_x+E_y seismic action
Fig2: Building of type A1. Principal tensile stresses after adding structural walls, of outer fibers due to: (a) G+0.3Q+E_x+0.3E_y, and (b) G+0.3Q+0.3E_x+E_y seismic action
Fig3: Building of type A1. Principal tensile stresses after demolition of internal structural walls, of outer fibers, due to: (a) G+0.3Q+Ex+0.3Ey, and (b) G+0.3Q+0.3Ex+Ey seismic action

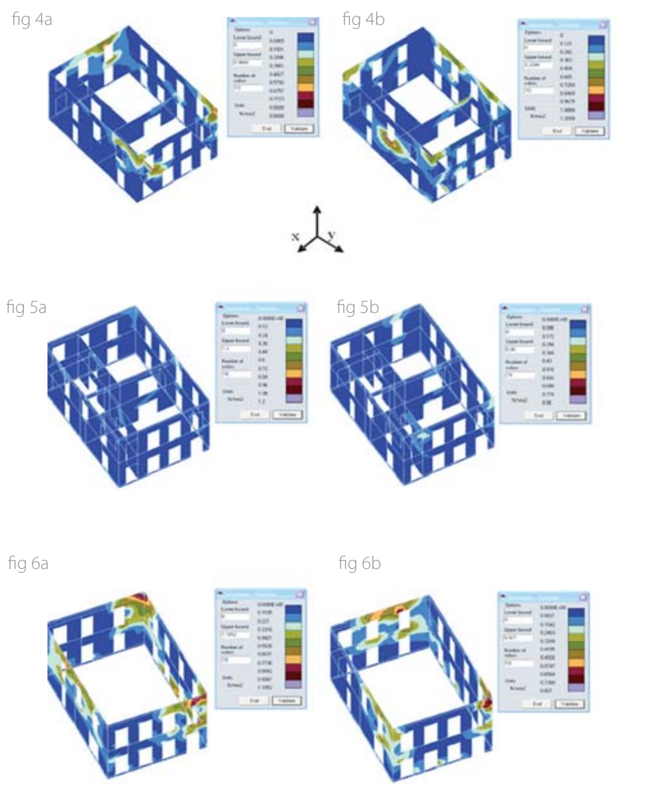

Fig4: Building of type A2. Principal tensile stresses for (a) inner fibers due to G+0.3Q-E_x-0.3E_y seismic action , and (b) outer fibers due to G+0.3Q-0.3E_x+E_y seismic action
Fig5: Building of type A2. Principal tensile stresses after adding structural walls for (a) inner fibers due to G+0.3Q-E_x-0.3E_y seismic action, and (b) outer fibers due to G+0.3Q-0.3E_x+E_y
Fig6: Building of type A2. Principal tensile stresses after demolition of internal structural walls for (a) inner fibers due to G+0.3Q-E_x-0.3E_y, and (b) outer fibers due to G+0.3Q-0.3E_x+E_y seismic action seismic action

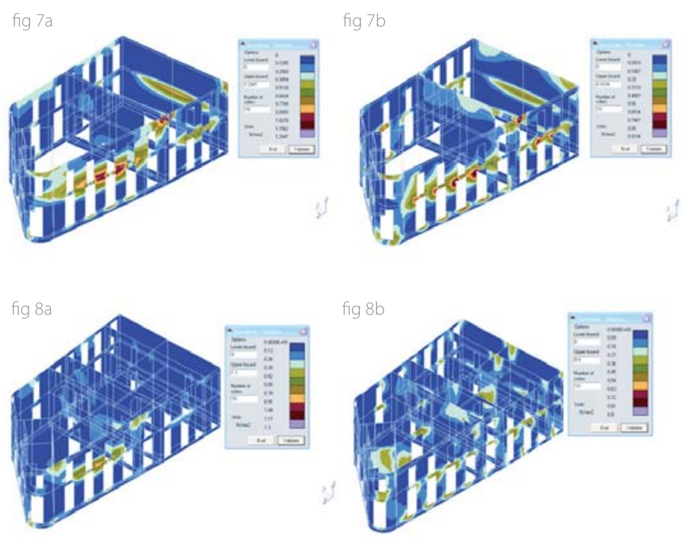

Fig7: Building of type B. Principal tensile stresses for inner fibers due to (a) G+0.3Q+E_x-0.3E_y seismic action, and (b) G+0.3Q+0.3Ex+Ey seismic action
Fig8: Building of type B. Principal tensile stresses after the interventions for inner fibers due to (a) G+0.3Q+E_x-0.3E_y seismic action, and (b) G+0.3Q+0.3E_x+E_y seismic action

A proposal for the development of the traditional construction crafts in Egypt A case study of Aswan City

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Research Problem:
Through studying the current situation of traditional crafts in Aswan we find a clear shrinking in this new constructional result due to the recession of traditional construction crafts and the overwhelming of non local construction ways over stable construction ways.

Research Target:
Offering a proposal to develop traditional construction crafts in the governorate of Aswan to match modern needs as well as to maintain local identity.

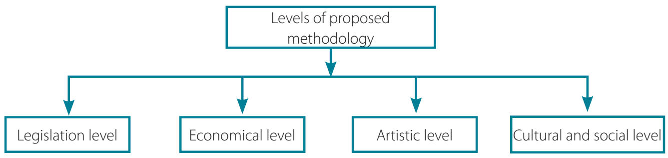
Research Methodology:
The research was based on a theoretical method to recognize the local construction crafts existing in Aswan, their progress, and the transfer of expertise. Along with conducting a practical study of construction models expressing the architectural heritage existing in Aswan to come up with the architectural specifications and local methods of construction and to recognize its positive as well as negative aspects and also to know the extent to which society accepts them, then to analyze the previously mentioned points and to come out with a suggestion to develop inherited traditional ways of construction, to match modern requirements, and then to apply this method to a current projects and measure the extent to which users will accept it as well as the extent to which it will contribute to improve the standard of traditional crafts in Aswan.

1- Types of traditional construction crafts in Aswan:
A variable collection of traditional crafts in Aswan were located as follows: fig(1).

- Manual Manufacturing of Green and Burned Clay Bricks.
- Windows and doors works.
- Vaults and domes achieving wide long spans.
- Shell forming crafts.
- Painting and drawing craft:
- Wooden works crafts.

2- Reasons for the deterioration Of the traditional construction crafts decline in Aswan:
- Lack of development of techniques and the implementation of crafts restructuring.
- The low economic revenue for the workers of traditional crafts.
- The breaking of knowledge transfer movement between generations due to aversion from many people to work in traditional crafts.
- The emergence of social inclination towards concrete buildings and modern construction systems as an aspect of social prestige.
- Lack of legislations protecting the usage of traditional crafts in building.
- Lack of development of construction codes and scientific theories required for the usage of traditional construction crafts.

3- Proposed methodology for developing and maintaining traditional crafts in Aswan:
After analyzing this research, methodology for preserving the traditional crafts in Aswan is proposed and it is as follows:



3-1 Cultural and social level:
- Increasing Awareness of the people of the benefits of the systems depending on the traditional crafts.
- Increasing the trust of people in the traditional crafts.
- Spreading the respect for building using the traditional crafts.
- Putting incentives to attract craftsmen to traditional crafts

3-2 Technical level:
- Developing a way to transfer knowledge, documenting the methodologies and techniques of the traditional crafts.
- Developing building traditional crafts and trying to automate it so it would be economically.
- Developing the materials used, and using engineering treatment to maximize the benefits of the end product.
- Building new training centers to train consecutive generations of craftsmen
- Putting new theories in building codes to organize the means of traditional crafts
- Organizing the craftsmen in their projects to enhance their product and supplying them with the various technical support

3-3 Economical level :
- Increasing the benefits of traditional crafts through the decrease in total cost of construction.
- Confirming the environmentally friendly advantage of traditional crafts, to increase it.
- Tourism and local promotion of building using traditional crafts as to spread the knowledge about it

3-4 Legislation level:
- passing laws that enforces constructors to assign a percentage of the building cost to using traditional crafts

- developing building codes to include more data and theories concerning traditional crafts.

4- Practical application for proposed methodology in a family residential housing Project:

"El herbiyab" projects in Aswan where designed by a two researchers to support the use of traditional crafts in building, fig(2).

4-1 " Al-HERBIYAB" VILAGE PROJECT :

The project aim to construct family houses, under the national housing project in Aswan including 500 units.

4-1-1 Purpose of project:

Support for traditional crafts existing in Aswan through a project that uses traditional crafts in a wide range which does the following:

- Employment of traditional crafts and all that follows it from traditional means of construction using timber, masonry, stone or clay.
- Making the traditional crafts a mean of acquiring high income through incorporating them in big scale projects.
- increasing the awareness of people about how beneficial traditional crafts could be.
- increasing the use of traditional crafts by people.

4-2 Studying the applications of the proposed methodology in project (after Construction of the proposed project):

4-2-1 Craftsmen:

A lot of opportunities were made available for the craftsmen , new craftsmen were trained to preserve the new traditional crafts.

4-2-2 The general Style used in buildings:

IT was taken in consideration the local identity and the local style through using their same style in the design to produce a secure, healthy and comforting living Place that will attract them to buy new units with the same style.

4-2-3 Construction method:

All units used a wall bearing method, using stones and covering spans using vaults and domes built from bricks, , which also decreases cost as no exterior finishing is needed.

4-2-4 Using natural and local materials

Natural stone was used ,which is abundant in to build walls and vaults, also the windows and doors used local timber , manfactured in a local method ,the pergolas also where made from palm leaves and straw which was done by local craftsmen.

4-2-5 Inhabitants participation:

Project includes the participations of the users in design and construction process

4-3 Implementing the proposal:

4-3-1 Social level

- 200 of the users were interviewed to explain the advantages of the project using traditional building systems and crafts. The two researchers, the governor, the officials and the popular leaders have participated in these meetings.
- Increasing the knowledge of the users of the technical and social advantages of the houses which are built using the local crafts.

4-3-2 Technical level

- A building system has been designed depending on local construction systems, local materials, participation of the local technicians who are specialized in the local systems and crafts.
- A documented methodology has been issued to build the project using the local systems and crafts that includes construction systems, local building materials and local crafts.
- A proposed development for the masonry work has been established by developing a system of scaffold and wooden moulds to achieve better performance and saving time.
- A training course on local building systems and crafts has been held for one hundred non skilful workers.
- An evaluation system has been put for all the stages of the project

4-3-3 Economical level

- The construction cost has been reduced from 9000 Euros to 4000 Euros by changing the roofing from reinforced concrete to brick vaults, fig(3).

4-3-4 Legislative level

An official approval for building the project using local building systems and local crafts has been obtained and this generates a new official principal to a lease to build by using local building systems and crafts.

4-4 Results

- Reducing the construction time.
- Creating job opportunities for 200 workers compared with 50 workers if they built the project using contemporary construction systems, fig(4).
- Reducing the cost of the project by 50 %
- Training for200 workers on the integrated know-how for the local building craft.
- Spreading the know how of the building design using the local building crafts.
- Increasing the demand for the houses that have been built using the local crafts that from 500 houses to 4000 houses.
- Encouraging Aswan governorate to take a decision to build new 600 houses extra by the same construction systems and crafts.
- Obtaining a project with a good urban pattern reflecting local Aswanian culture and a unique architectural character.

Recommendations:

- Importance of documentation of the traditional crafts internationally.
- Importance of putting laws the develop and encourage traditional crafts internationally.
- Importance of spreading the awareness to develop Traditional Crafts world wide.
- Importance of people participation in project construction.
- Importance of the participation of countries in national projects to revive Traditional Crafts.
- Using the proposed methodology in preserving and developing Traditional Crafts.

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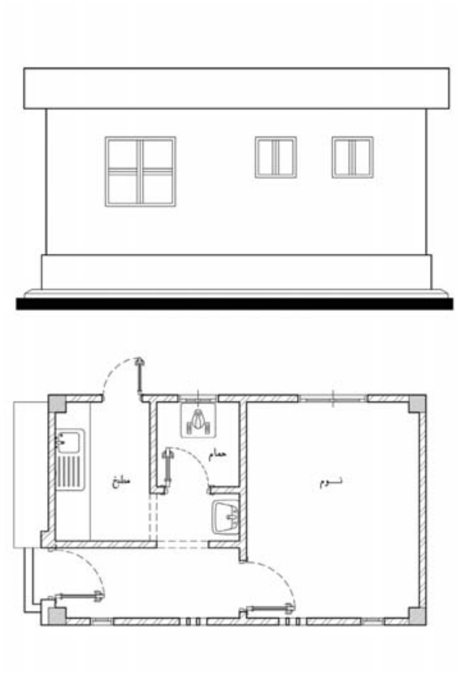

Fig(3) The preliminary design Skelton building, which is changed by two researchers

Fig(1) Samples of Traditional crafts used in buildings in Aswan.

Fig(2) "El herbiyab" projects in Aswan after construction, where designed by a two researchers to support the use of traditional crafts in building.

Fig(4) brick vaults users in project.

Repair and Maintenance guidelines for the inhabitants of a historical district: Papaz Mahallesi in Yeni Foça, Izmir

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Introduction

Traditional buildings in Turkey are at risk mainly because of harmful/lack of repairs due to the deficient knowledge of the users and craftsmen. Studies on the preparations for repair and maintenance guidelines are needed for the continuity of traditional historic sites in Turkey.

Papaz Mahallesi was found suitable for a case study on 'developing proper methods and techniques for repair and maintenance problems and guidelines for users', for reasons such as its values and specific problems. Papaz Mahallesi (Figure.1) is a well preserved 19th century settlement in Yeni Foça, a small town located north of Izmir. The study area, comprising fifty-six traditional masonry buildings, shows architectural and settlement characteristics of its period in the Aegean Region. The values of Papaz Mahallesi are categorized under six titles; "*Aesthetic Value*", "*Value for Architectural Diversity*", "*Value for Functional Diversity*", "*Resource Value*", and "*Value for Continuity of Cultural Memory/ Heritage*", "*Value for Uniformity in Architectural Style*" (1).

1. Problems in Papaz Mahallesi

1.1. Str uctural System Problems

Although there are not many serious structural problems in buildings, some unique cases have been taken into consideration for the evaluation of structural problems (Figure.2).

1.1.1. Interior Structural Problems and Their Causes

Interior structural problems documented in the area are mostly deformation problems in floors, slight deformations of interior walls. More serious problems have emerged in unused and not maintained buildings in the area. Loss of mortar, plaster and other binders are the primary cause of external wall movements that cause interior structural problems, as well. However, rigidity of external walls is sufficient for the rigidity of structural system.

1.1.2. Exterior Structural Problems and Their Causes

Exterior structural problems are mainly small structural cracks and deformations on external walls. Emptied joints and loss of binders are the most important factors that may cause a weakening in these 80-90cm thick walls. As the deformation of walls with emptied joints has led to the collapse of façades in other historic sites of the town, this problem must be taken into consideration rapidly as a primary problem for the structural systems.

1.2. Problems of Materials

Materials are visually examined by grouping the problems of each material in order of emergency. Problems of materials are documented on 1/100 street elevations (Figures.3-4) and 1/200 plan (Figure.2). Stone, timber, mortar, plaster, iron, roof tiles and paint are recorded according to the visual observations made.

1.2.1. Decay Forms of Stone

The decay forms of stone is visually recorded and classified according to the classification of Fitzner et al (2).Stone decay was detected at lower levels of the buildings, areas under the eaves and on the corners. Discoloration, crusts and salt deposits on stone surface are the most widely seen problem types on these areas. The effects of rainfall penetrating the surface under the eaves are very clear. The other problematic area is the lower level of the buildings where material losses, flaking, discoloration, crusts and soiling are visible. Besides these, rising damp causes joint loss in the upper levels and serious problems in the whole structure by loss of its binders (Figures.3-4)

1.2.2. Timber Problems

Observed problems on timber are due to the lack of maintenance – preservative waxes, polishes. The problems of structural timber and architectural timber differ in the area and evaluated in different sub-groups (Figures.3-4).

Structural Timber Problems: There are not any serious problems of structural timber, except in some empty buildings. In three buildings, floor deformation is documented. Roofs have been observed to be quite firm. Ceilings, if maintained, preserve their properties in good condition.

Architectural Timber Problems: Capillary cracks and discoloration as a result of damp are found especially on shutters. The man-made problems are most common like the bursting and deformation of shutters. External timber architectural elements, exposed to environmental conditions, have more problems like discoloration, capillary cracks, deformation and material loss.

1.2.3. Mortar Problems

Mortar is the material having the most severe problems (Figures.3-4). Loss of mortar between the joints is especially seen on the walls, from which the plaster is completely detached. Slight deformations on the walls with emptied joints have been inspected. At the advanced stage of mortar loss, material loss of stones occurs.

1.2.4. Plaster Problems

The plaster problems are classified into four categories; "loss of plaster", "detachment from wall surface", "salt deposition" and "discoloration". Like stone the worst problems are areas under eaves, lower levels of frontal walls, and corners of the jambs due to dampness. Soiling and crusts are also seen deposited on plasters.

Loss of plaster is the first stage of increasing decays on building façades. Where plaster is detached, stone and mortar are prone to problems. As plaster is the protective layer, the maintenance of plaster is very important. As the stones of these buildings are closer to cut-stone, they do not let exterior particles, salts and humidity in as much as the rough cut stones.

1.2.5. Metal Problems

The metal elements are iron in all of the traditional buildings. Problems of metals do not show much variety. Oxidation, inspected especially on shutter hinges, and supports is the main problem. Almost all unpainted iron elements, like doors and shutters, are oxidized.

2.Proposals for Repairs of the Studied Buildings

As a result of the studies on building materials, and repair problems, guidelines are formed for different types of repairs that are widely needed in the studied buildings. Proposals for these repairs and maintenance are prepared to be used as guidelines for users and a conservation program.

2.1. Cure of Rising Damp

There are two sources of water causing rising damp: rainfall and underground water. The comprehensive method of overcoming the excess water is a better drainage system.

- "Designing a sufficient number of drainage grills",
- "Paving the streets with a kind of patchy pavement that can help ventilation, rather than a monolithic one having cement mortar as binder", and
- "Forming a dry area by evacuating a trench with a land drain at the bottom in front of the base of the damp buildings to reduce the capillary action".

2.2. Masonry Repairs

During the repair of masonry, a minimum of stone replacement must be done. The new stones are often more difficult to maintain than the old stones. Repair work to be done to these masonry buildings is gap filling rather than consolidating. Only the buildings, which lost plaster and mortar in joints, started to have small loss and detachment of stone problems. There emerged small gaps and cracks, which may weaken these stones. The stones with special craftsmanship such as inscriptions, panels, keystones, jambs, architraves and some of the eaves needs gap filling or consolidation work.

"Using compatible mortars with stones", and "taking care of esthetical harmony between mortars and stones" must be considered while gap filling.

2.3. Grouting and Re-pointing

Grouting seems to be a appropriate method for some of the buildings, which have completely emptied joints and probably have voids between the layers. Similar building types have collapsed and proved the severity of the problem. Although grouting is not widespread in Turkey, it is the best method for consolidating these buildings.

Grouting Masonry Walls: The consolidation of historic masonry involves the need to stabilise walls by filling voids within their thickness. This operation is most commonly needed when thick walls of double skin construction, with rubble core filling, have been subject to the percolation of water for many years. The important point in consolidating the masonry with a liquid binder is to select a binder that is compatible with stone and former mortar.

Re-pointing.: Re-pointing should be carried out immediately to prevent the rapid weathering of the stones. When the mortar in the joints is weathered, the stones become vulnerable to damage and material loss on stone surfaces are seen.

Permeability, porosity, density and other properties of mortar and stone must be recorded. When the mortar is less permeable and less porous than stone, it acts like a vapour barrier in the wall, causes a continuous vapour flow into the stone and prevents evaporation. A permanent dampness can occur in stone that is very harmful. Cement based mortars in contact with stone can introduce sodium or potassium sulphate (3) and must be avoided, not only in the preparation of mortar but also in every stage of repairs.

Re-pointing is an advanced type of work, and must be done by qualified workers. Flush filling will greatly increase the apparent width of the joint, and therefore great care must be taken to keep the layer of the new mortar within the original width.

- The original jointing profiles must be examined.
- The joints must be carefully cleaned before re-pointing.
- The width of the joints must not exceed the original joint width.
- Blunted points must be repaired by building stone profiles in mortar.
- The joint must not be projected from stone surface.

2.4. Plastering and Painting

Plastering: After grouting and re-pointing, plastering the external walls is necessary. All of the buildings in the area need plaster repairs, except the ones that have never been plastered. The properties of plaster must be compatible with former plaster and stone. If the plaster is more porous than stone it weakens quickly and if it is less porous it causes the deterioration of stone by transporting salts and vapour. The criteria for interior and exterior plasters do not change, while their composition is different due to the different conditions in and outside the buildings.

Painting: Painting is the last step of the maintenance of the walls. Besides the compatibility of properties of paint with the plasters and stones, colours have to be carefully selected for the harmony with the other paints in the district. Some of the plasters in the site are coloured with original colours extracted from plants and earth (indigo, madder, i.e.)

2.5. Timber Repair and Consolidation

Structural timber elements like floors and roofs more urgently need attention and must be solved immediately. The main works to be done for the maintenance of the timbers are;

- *Local or Total Replacements of Timber Elements with New Timber:*

Substitute timber must be the original type of wood and the moisture content of it must be limited in low percentages. New timber must be the treated with insecticides. Replacements must be limited within least possible amount.

- *Treatment of Infested or Infected Timbers:* Infested or infected timber elements must be treated against insects, dry rot or wet rot. Extraction of moisture from infected timber and providing adequate ventilation must be done before treating with fungicidal paste. Similarly, insecticidal pastes may be applied to infested timbers.
- *Application of Timber Preservatives:* For improving the strength and the resistance of timber elements against external conditions, they must be applied proper kind of preservatives, paints, insecticidal/ fungicidal pastes after various studies and researches on them.

2.6. Metal Repairs

The traditional method is painting for preventing metals from corrosion; however, there are other works to be done before painting

- After inspecting the thickness of corrosion layers, and densities on metal elements, manual preparation (removal of rust, loosening mill scales and soluble corrosion salts) of metal surfaces by using various mechanical and chemical methods considering "not to lose details on surfaces of metals".
- After the application of a primary paint coat with anti-corrosive properties, intermediate and finishing coats of paint must be applied, taking care not to harm or change its properties.

2.7. Roof Repairs

Roofs: The structural timber elements must be repaired, by considering the important points mentioned for timber repairs. Replacement of the broken and missing tiles must be done with same type of roof tiles.

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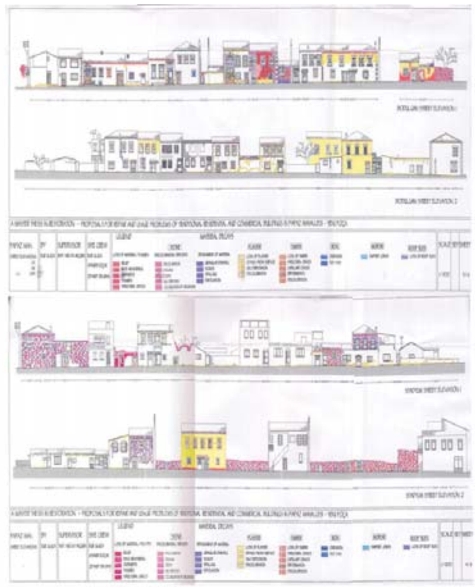

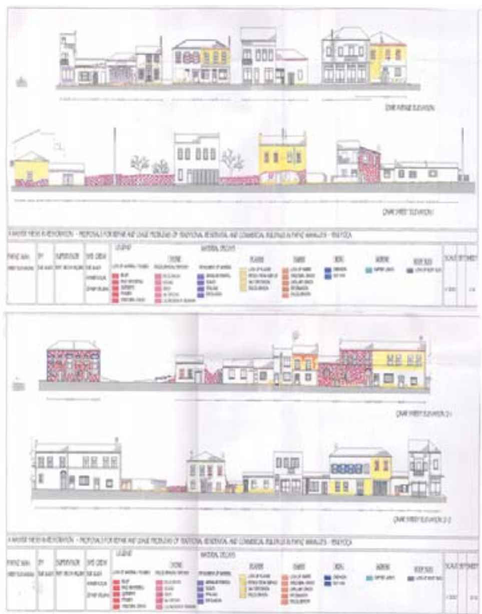

Traditional Construction Techniques Revaluation of «Good Practice Rule» for Sustainable Construction

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Introduction

The Mediterranean area has been characterised, since ancient times, by technical knowledge and stylistic exchange influences. Migrations, conquests, commercial links allowed more advanced constructional cultures to spread, in different historical periods, even at relevant geographic distance and beyond the Basin itself. During European Middle Ages, as instance, the weight of Roman art on Romanesque architecture in France, Byzantine influence on figurative and decorative arts in Germany, France and Italy, Islamic art rule in Southern Spain and Southern Italy can be cited. Multicultural contact European territories like Southern Spain and Italy were interesting demonstrative laboratories of imported techniques adoption and combination, as well as of styles amalgamation (*mudejar art*). In such contexts, foreign good technical rules have been locally assumed by adapting materials and accustomed practice. Such variations can be seen as the consequence of a process of optimisation of material and economic resources which entails what we could presently call "improvement of sustainability performances".

Since the Renaissance, and more systematically since XVIII century, the habit began to classify architecture constructional and formal rules in treaties and manuals. The *Grand Tour*, the *Grand Prix of Rome*[1] and afterwards more frequent and southwards travels in the Basin, had permitted direct observation, study and representation of Mediterranean buildings in *Voyage Carnets*. They were drafted in detail and hypothetically reconstructed by scholars and *Beaux Arts academy students*[2] interested in ancient Greek and Roman construction issues but also in vernacular examples.

Manuals and treaties contain a precious structured repertoire of information on common traditional techniques in the Mediterranean basin. Up to the I World War, French and Italian textbooks - the present study refers to some of them, - endorsed architectonic identity of local examples that were directly surveyed with reference to analogues applications in ancient well known buildings. Local idiom were codified in these "illustrated dictionaries of construction art", where classical universal rule is taken into account too. Furthermore they give details on durability and quality of different materials and techniques and put-into-work practices, references to cost and material depletion and use optimisation. At any rate transportation, material availability, recycling and recovering concerns were always dealt with in pre-modern building contracts and documents.

The paper investigates some issues of "sustainability" which were implicit in traditional techniques of construction by taking into account prescriptions in manuals and existent case studies. Local traditional rules, only partially deducible from manuals, are to be integrated, in fact, by data coming from direct survey in order to verify local variations, efficacy and related durability performances.

Good practice Rule and Sustainability Principles in Mediterranean Construction

Stone Masonry

Stone for structural walls - almost 70% material in a traditional masonry construction, - was accurately chosen. For minor constructions and vernacular architecture adoption of undressed stone available on site, rejected or coarse roughly dressed stone consented to save more precious quarried stone for ashlars.

Rubbles were picked up from closest plots of land and selected according to dimension and weight. They were proportional to mason's strength (25-30 kg) and easy to handle (35-40 cm). They were afterwards arranged in the building yard into five separate piles of stones, for rational and ergonomic putting into work. Undressed stones might have different origin, hardness and permeability: cold volcanic or metamorphic, quarry offset, live splinters from crushing, irregular fragments picked up below rock faces. Reuse materials frequently came from ramparts or more ancient existing constructions.

In the traditional building site nothing had to be spoilt and discharged: inert wastes were used to form thin walls at upper levels (15-35 cm) and infill. The stuffed wall, where the core between the two external masonry workform walls was filled with mortar and stone rubble, belonged to Mediterranean tradition since ancient Rome (II century b.C.). It has spread in Mediterranean humble or minor constructions until XIX century, assuring quickness and economy when put into work.

Roofs and floors

Manuals classify pitched roofs secondary timber frame according to kind of support of roof covering: Steep battens roof (*piemontese* style); horizontal counter batten roof; timber-decking board, terracotta flat tiles or stone slabs. All the systems preview maintenance and partial replacement of timber components, that were pre-squared, prefabricated and ready to be assembled on site. Carpenters used to mark them to facilitate their putting into work. Type and dimensions of secondary roof frame differ according to countries and resources availability.

In the *piemontese* roof, span between battens is proportional to minimum tile width (generally almost 20 cm) and curvature. Manuals recommend this system as it is particularly light but also easy to put into work, to maintain, to replace, even if it requires a false ceiling when covering living spaces. Larger tiles with greater curvature permit reducing tiles number for square meter so getting wider span between battens, fewer pieces and lower wood consumption. In some countries dressed wood battens (generally 3x4; 5x7 cm) are replaced by chestnut timber half-poles.
Horizontal counterbattens system requires a moulding finishing in the tile backside, thus more expensive and fragile. Some manuals specify that necessity for a relevant timber amount make this system more appropriate and more common in Northern countries.
The timber-decking board is frequently substituted by other locally available materials, also appraised as more durable. In Mediterranean countries dressed timber often had to be hauled long distances and was very expensive as a result. Local practice can replace timber planks and rafters by mats of reeds, chestnut poles, undressed branches (i.e. laurel), dried palm leaves. Otherwise, for secondary timberwork and minor primary frame, local manuals advise adopting soft timber (i.e. fir, cypress) instead of harder, more resistant and durable but expensive and rarer species (chestnut and oak). Manual also specify soft timbers are preferable owing to their fast growth. Nowadays we would say: "extremely renewable".
Screed in traditional floors was also made by waste inert materials from demolition like crushed calcareous, broken terracotta debris, animal bones. Moreover, common practice has always reused tiles from roof covering disassembling, permitting a 35% recover.

Internal partitions

Vertical partitions pre-modern construction technique was basically derived by one principle: a resistant frame (generally timber) with an infill made of the most available resources. Load-bearing elements were prefabricated. The infill was generally handmade and no specialised skills were required.
Pan de bois (with squared timber) and *colombage* (with irregular timber) are widely used in vernacular architecture not only in Northern Europe (Normandy, Alsace, Switzerland) but also in Portugal and Turkey. The timber frame was filled with coarse stone, rubble or irregular blocks of calcareous or brick masonry mixed up with ordinary mortar. The whole element was finished with a coat of plaster that was applied onto a nailed on timber lattice.
In *Wattle and daub* partitions the infill was organic. They consist of interwoven staves and twigs used, as well, to fill a panel in a timber frame, providing a backing for a finish of daub (clay, dung, or mud) or plaster (usually on straw or hair). Wattle, as secondary timberwork, could also be made of sea-grape, strawberry or cabbage wood. The whole system was then lime-washed. When the timber frame was in evidence it was protected by beef blood (rich of iron oxide) and pinecone infusion. Certainly diffused in Europe since Middle Ages, this system was traditional in Middle and Far East but also in Africa. Vitruvius mentions it in his *Ten Books of Architecture*, also explaining its technical limits.
As a variation of the previous techniques, *reed partitions* were either woven as an infill organic panel or nailed directly, singly or double, onto the timber frame. The rendering coat was then applied directly onto the reed mat since it provides excellent key, either to clay, lime or gypsum plasters. Organic cord was usually used to tie dried reed battens. Reeds must have been cut since a year at least. Cavity could be filled with rubble. Nowadays modern reed mats or boards are commercialised, complete of up-dated cutting and fixing prescriptions. Reeds are highly renewable, easily transportable and widely available. Reeds mats could also be utilised for false vaults and ceilings, with aesthetic but also insulating and aerating functions. They were supported by a timber frame made of coupled boards inserted in the structural masonry. Superior side is generally lime-washed and inferior one plastered with gypsum.

Conclusions

We can then synthesise the following aspects of sustainability in traditional Mediterranean construction:

- Integrated choice of construction products and processes, according to availability and supply of resources, - the production, transformation, assemblage rules being empirically known.
- Expected service life of the building: minimising costs implied optimising durability of components and maintenance to delay service life.
- Deconstruction/recovery/recycling/final disposal: traditional techniques previewed repairing, disassembling and replacing of some parts rather than demolition and complete redoing of elements (carpentry, roof covering and some wall masonry structures). In the traditional building yard, pre-existent elements were reused as well as wastes (tiles, bricks, stones and wood). Traditional mechanic assemblages were often reversible, so allowing recycling and reuse.
- Lack of COV sources like synthetic varnishes and glues or wood treatments. Wood was seasoned in order to give it mechanical, physical and chemical resistance. Ancient glues were derived from vegetal or animal substances (casein).

Nowadays new manuals supply catalogues of suitable examples to insert pre-modern technological culture into nowadays production, organizational and economic environment.
Survey and interpretation of recurring element types and pathologies are estimated as necessary to put into force a compatible renovation with respect to the original construction principles.
Respect of original conception, as far as possible, is considered essential to any refurbishment and renovation classifiable as sustainable, especially when adopting traditional materials and techniques.
A compared analysis of literature with real examples could aid this interpretation work.

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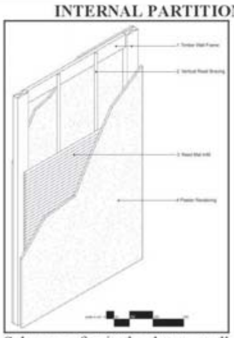
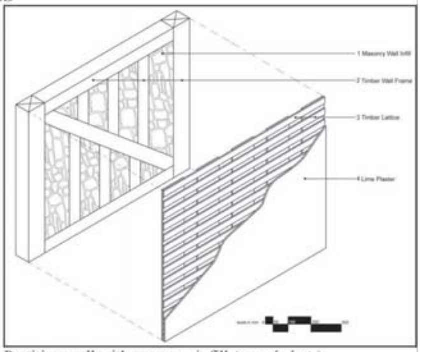
INTERNAL PARTITIONS

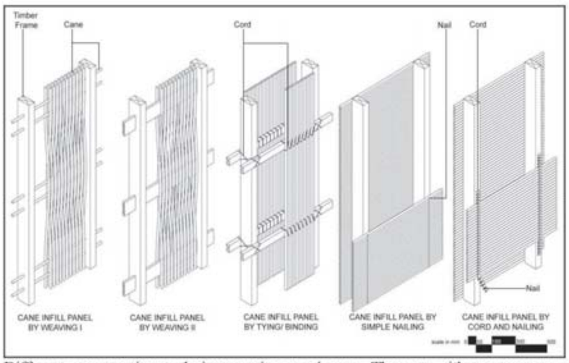
Reed mats forming internal partitions.
Single layer partition in a XIX century building at Poggioreale (Sicily, Italy) and the same technique by Vitruvius: *Les cloisons légères des Romains, étaient composées de montants d'huisserie et de travers en bois équarris. Les intervalles étaient remplis avec des cannes grecques attachées avec des clous (comme des lattes) recouvertes par enduits de mortier et stuc.* (in Rondelet J.B., Paris1817)



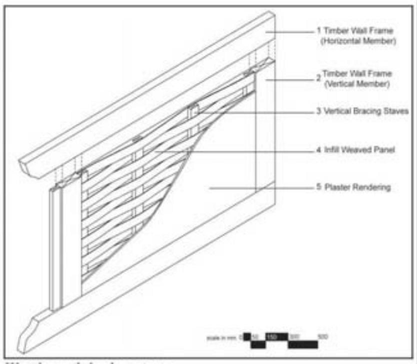
Scheme of single layer wall partition:
The reed mat was nailed at close intervals to additional vertical reed elements for further stiffening and bracing



Partition wall with masonry infill (*pan de bois*)
Timber frame : oak, chestnut
Key for plaster coat: timber lattice
Infill : irregular block of calcareous

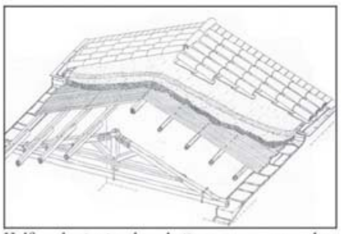


Different construction techniques using *reed mats*. They are either woven as an infill organic panel or nailed directly, singly or double, onto the timber frame

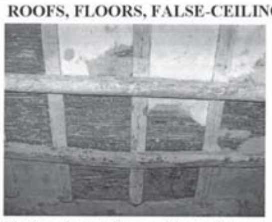


Wattle and daub system

ROOFS, FLOORS, FALSE-CEILINGS



Half chestnut-pole battens as secondary framework roof support.
Marconi P., *Manuale del recupero del centro storico di Palermo, 1997.*



Timber frame floor with reed mats support (Sicily, Italy), widely diffused in the Mediterranean area.
(see Corpus- *Architecture traditionnelle méditerranéenne*)

False-vault with reed mat support.
Main church of Poggioreale (Sicily, Italy) damaged by 1968 earthquake.

Present and Future of Solar Control with Photovoltaic Components in Mediterranean Architecture in Turkey

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1. Introduction:

Buildings are constructed to be a shelter for people. They have to provide comfort conditions for the people as well as being a shelter. This is due to the fact that human beings are not well protected against environmental and climatic factors. Some animals have fur and this fur protects them from cold weather. But human beings are not as lucky as those animals. They have to provide these conditions on the buildings that they design, construct and live in. Therefore these buildings should be a shelter that protects them from cold weather in the winter and from hot weather in the summer.

Sun is the source of life and we cannot live without it. But especially in some places, it becomes unbearable in the summer time because of the hot weather. Therefore, people developed some strategies to overcome this effect of sun on their buildings. These rules have become traditional in time and they are still being used.

One of these strategies is the "Solar Control". Solar control has been used for thousands of years by human beings for creating comfort conditions in building interiors. Especially Mediterranean architecture uses solar control a lot because Mediterranean countries have more sunlight than they need and this more energy is not wanted in the interior places. Therefore we need to create spaces that will keep us warm in the winter and calm in the summer. By the use of the solar control devices, this is possible because the aim of the solar control is to balance the solar energy which enters a building through its windows. Nowadays, it is possible to change this unwanted solar energy into desired electrical energy by the use of "Photovoltaic Components" as solar control devices, because PV components are devices that produce electrical energy from solar radiation directly. It is also possible to integrate them into existing buildings as shading devices with only a little effort economically because the shading elements' mounting systems already exist on some of the buildings and only the cladding panel should be replaced by new photovoltaic panels. For the ones that do not have any shading system, only the mounting system should be added and then the photovoltaic panels can be placed on them. This is not an uneconomical process due to the fact that new shading system will make the interior more comfortable than its present situation and also will reduce its energy need considerably. Therefore, the aim of this study is to examine the use of solar control systems and to make a proposal for using photovoltaic components for solar control in the Turkish Mediterranean architecture. This will be done by examining solar control in traditional Turkish architecture in Alacati-Izmir as case study and use of photovoltaic (PV) panels for solar control, and by proposing a new method for Turkish Mediterranean architecture for the future.

2. Solar Control in the Traditional Turkish Architecture in Izmir

Solar energy is desired in the houses in the winter, but it is not wanted in the summer. Therefore windows have to be designed very carefully in order to avoid overheating in the summer while getting the maximum solar energy in the winter. Especially solar shading elements are being used for that purpose. These shall be curtains, sun louvers, Venetian blinds, etc... These all have the same purpose: to protect the window, therefore the interior of the building from excess sunlight. But the ones that are used inside are not as efficient as the ones that are used outside due to the fact that they stop the solar rays after entering the building. Therefore these rays still make interior hot because of the greenhouse effect of the window-glasses: the solar rays which lose their energy after entering the interior and hitting the solar control device inside cannot get out through the glass again and they begin to heat the interior. Therefore shading elements that are used outside the building are more efficient.

Shading elements should be designed very carefully. If the windows are protected with them so strictly, interior cannot be heated with solar energy in the winter. But if they do not protect the windows much, then they are not used efficiently. Therefore, there should be a very careful designed balance when they are being used. For this purpose, masks and sun-path-diagrams are being used.

The climate has a very important role in designing houses. Izmir has Mediterranean architecture. The summers in Izmir are hot and dry, and winters are warm and rainy. Due to the fact that the weather is very hot in the summer, all the streets and roads are placed perpendicular to the sea. Therefore all the houses can have the summer breeze, especially the desired local wind of Izmir "imbat" is taken easily to the inner parts of the houses easily. The entrance (bottom) floor of the houses is generally constructed with stone and these walls are thick and massive with low ceilings. These floors are generally called as "winter floor". Upper floor of the houses is constructed with light materials like wood and the walls are thin with high ceilings. These floors are generally called as "summer floor"[1]. Besides these, solar control has an important role in traditional architecture in Izmir.

As seen in these pictures 1 and 2, buildings are not declined outwards; in spite they are declined inside. That cannot be seen from these pictures but there is a courtyard at the backside, inside the house. This courtyard helps to protect people from excess solar energy by providing shades for them and let them spend most of their time outside the house. Courtyards are climate control spaces. They form spaces that are designed according to wind, sun, hot and cold. They provide shade when necessary, and they provide solar energy when needed.

Another strategy is to make north facing walls as thick as possible and to open as less and small windows as possible. That is due to the fact that these walls are the coldest walls of houses in winter and heat can escape from these walls easily. As similar, west facing walls of houses are designed and constructed as narrow as possible.

Another strategy is using long eaves if there is no opportunity to provide a courtyard. These long eaves protect the building from excess solar radiation and also from rain. As similar, shading elements are also used in front of the windows in order to prevent excess solar radiation enter the building.

3. A Proposal for Using PV Components for Solar Control in Traditional Architecture in Izmir

Shading elements are used in the Mediterranean architecture a lot because of the excess solar energy in the summer. This is unwanted solar energy in the summer. If shading devices are composed of PV components, then this unwanted solar energy can be turned into desired electrical energy. This is economical due to the fact that no money is paid for the energy source. And if the mounting system is ready, then it is more economic due to the fact that PV panels can easily be mounted on this system.

In the traditional Turkish architecture, it is easy to integrate PV components into the buildings with only a little effort because the shading elements' mounting systems already exist on some of the buildings and only the cladding panel should be replaced by new PV panels. For the ones that do not have any shading system, only the mounting system should be added and then the photovoltaic panels can be placed on them. This is not an uneconomical process due to the fact that new shading system will make the interior more comfortable than its present situation and also will reduce its energy need considerably.

When "PV - Sun - Radiation - Building" words are thought together, the forming of buildings with the help of passive design system principles according to the sun is recognized. That is due to the fact that climatic comfort conditions could be achieved in the interior by the use of the differences in the angles of the sun-rays. If PV elements are going to be used instead of roof or wall cladding elements or shading devices, they are going to take the solar radiation instead of them, but in spite, they are going to use most of this solar radiation to produce electricity. (Some part of the solar radiation will heat the PV panel and this heat will be carried to the interior by conduction. Thus, not all, but most of the solar radiation will be used to produce electricity.) Therefore, the sustainability of the traditional Turkish architecture in Izmir would be achieved because of the fact that these houses would be more comfortable and in addition they would lower the energy need with the energy they produce by using unwanted solar radiation[2].

4. Conclusion

It is important to provide comfort conditions in the buildings. It is also important to provide the sustainability of traditional architecture with the use of new technologies. This can be done by integrating PV components as shading devices to the traditional architecture in Izmir as well as all around Turkey. This will provide comfort conditions and also will help lowering the energy requirement of houses. Therefore it will help the traditional Turkish architecture live longer in time.

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Reproduction of hydraulic lime mortars based on the traditional production technology of ancient mortars from Cyprus

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Introduction

Until the beginning of the 19^{th} century, mud, air hardening lime, hydraulic lime and lime mixed with natural or artificial pozzolanas (e.g. crushed brick) were the most popular binders and renders used in the construction of buildings. After the discovery of Portland cement in 1824, the latter and its derivatives became the dominant binding and rendering materials in the building industry, mostly due to the standardisation of their production [1]. As a result, during the last century, there has been a gradual replacement of traditional mortars by highly hydraulic cement-based mortars.

The uncontrolled use of cement-based mortars for restoration purposes resulted, in many cases, in extensive damage to cultural heritage, mainly because of their incompatibility with the traditional material [2-8]. Cement is hard, rigid and impermeable. It also contains significant amounts of soluble salts which can be harmful to historic buildings. These salts not only produce non-aesthetic efflorescences upon crystallisation on the façade of a building, but they can also develop large damaging pressures when they crystallise behind the surfaces of masonry materials.

Reported damage cases, together with the principle of "authenticity", defined in the ICOMOS Venice Charter [9], resulted in a renewed interest in the use of (hydraulic) lime mortars in the field of restoration.

In the research study described in this paper, a physicochemical characterisation of ancient mortar samples from Cyprus was undertaken in order to find out the provenance of their raw materials and to determine their composition and properties. An experimental study was also carried out to design compatible mortars for restoration and conservation purposes.

Materials and Methods

Mortar sampling was performed on excavations, monuments and traditional buildings. Part of each sample was ground and used for X-ray diffraction (XRD) and X-ray florescence (XRF) analyses to identify mineral constituents and to determine quantitatively the major oxides present in the mortars. A slice was used for the preparation of a thin section which was used for petrographic examination of the mortars. A scanning electron microscope (SEM), equipped with an Energy Dispersive X-ray (EDX) microanalyser, was also used to examine the microstructure and texture of the mortars, while a significant group of 15 samples underwent thermal analyses (DTA/TG) to determine their hydraulicity. The most important physical properties of the ancient mortars (i.e. vacuum saturation porosity and capillary absorption coefficient) were also measured using water as the wetting liquid.

The analytical study of ancient mortar samples was followed by the laboratory preparation and testing of experimental mortars with similar compositions. The laboratory mixes were prepared using a water/binder (w/b) ratio enabling the mortar to achieve a constant flow of 165 ± 10 mm. The proportion of binder (lime and ceramic powder) to aggregates was equal to 1:3 w/w. This was selected as the proper mixture ratio for restoration syntheses since it is matching with technologies of homologous mortars found in ancient monuments of the wider Mediterranean area [6, 10-11].

In all experimental samples, the aggregates comprised siliceous and calcareous sands. The mixing of the aggregates and binder with tap water was mechanical and always uniform. Compaction of the samples was carried out in accordance to EN 196-1:1995 [12]. It was considered critical to use the same batch preparation for all specimens to avoid any differences which might occur from batch to batch. Such differences have been shown to exist for hydraulic mortars in previous studies [13].

The samples were prepared using standardised prismatic steel moulds of dimensions 40 x 40 x 160 mm. After casting, the moulds containing the specimens were covered with a glass plate to prevent loss of water by evaporation. Specimens were removed from the moulds after 7 days and they were kept covered with a wet burlap until testing. The performance efficiency of the experimental mortars was evaluated by a series of tests designed to measure their physical and mechanical properties.

Results and Discussion

Characterisation of ancient mortars

Laboratory examination of the ancient mortars under a stereoscope revealed in most samples the presence of small (angular, sub-angular and rounded) reddish inclusions in a compact (fine-grained) matrix (Fig. 1). These inclusions were identified by SEM/EDX analysis as regions of silica-alumina composition (i.e. clay brick ceramic).

Petrographic observations provided evidence that the mortars mostly consisted of fine to medium aggregates of quartz, feldspars, pyroxene and plagioclase. Carbonate compounds and broken shells were also observed in some samples.

Microscopic observations also provided ample evidence of products of boundary reactions. Reaction rims were observed at the interface between the binding matrix and the ceramic fragments. These were dispersed in the form of veins along the matrix, filling the vacancies and

discontinuities of its structure. The presence of hydration rims around individual hydraulic phases is indicative of the existence of a strong cohesion between the constituent elements of the mortars [14].
The results of the mineralogical (XRD) analysis showed that the binding material of the ancient samples was almost exclusively calcitic. The presence of quartz and other accessory minerals was also evidenced in all samples. Salt crystallisation was observed in some cases where halite and/or gypsum were present. Gehlenite was also evidenced in some of the ancient mortars. This is characteristic of the use of natural hydraulic lime burnt at low temperatures (<1200 oC) [15] and/or ceramic fired at 800-1060 oC. The use of the latter is also confirmed by the presence of anorthite in some samples [16-17].
The hydraulicity of the ancient samples was determined using the results of the thermal analyses (Table 1). Weight losses at temperatures below 120°C are attributed to the loss of physically adsorbed water. The loss of water due to hydrated salts is measured at temperatures between 120-200 °C, while the loss of chemically bound (hydraulic) water is measured at temperatures between 200-600 °C. The loss of CO2, following the decomposition of carbonates, is evidenced at temperatures exceeding 600 °C.

Sample	**Weight loss per temperature range (%)**				
	<120 °C	120-200 °C	200-600 °C [A]	>600 °C [B]	[B]/[A]
A.15	1.59	1.64	4.61	7.28	1.58
A.17	1.13	0.93	5.36	30.44	5.68
A.20	3.25	1.68	6.46	27.37	4.24
AD.5	2.77	2.46	4.75	15.12	3.18
AD.18	2.30	1.39	5.91	25.59	4.33
AD.27	2.51	2.30	3.96	16.30	4.12
AG.4	1.48	1.66	3.51	11.52	3.28
EP.1	1.73	2.03	3.91	20.78	5.31
HST.3	2.83	1.94	2.98	9.79	3.29
HT.1	3.06	2.18	4.56	15.71	3.45
KK.1	4.96	3.52	4.85	15.04	3.10
KT.26B	1.86	1.00	2.39	21.65	9.06
M.8B	1.60	2.04	4.16	18.95	4.56
M.20B	1.15	1.45	3.29	22.63	6.88
MV.3	1.57	1.05	3.74	28.12	7.52

Table 1: TG analysis results for 15 samples.

According to Maravelaki-Kalaitzaki et al [8], the results of the thermal analyses permit the classification of mortars into typical lime (aerial), hydraulic and crushed brick-lime and pozzolanic. The typical lime mortars correspond to less than 1.5% structurally bound water to hydraulic components, while the hydraulic lime and crushed brick-lime mortars have hydraulic water contents up to 5%. The pozzolanic mortars have a hydraulic water content exceeding 7%. The latter present the most advanced hydraulic character. Based on this classification, one may deduce that the majority of the tested ancient mortars were moderately hydraulic.
Further evidence of the hydraulicity of ancient mortars is given by the ratio of CO2/H2O (hydraulic water), also shown in Table 1. This ratio, in relation to the CO_2 content (Fig. 2), inversely expresses the hydraulic character of the mortars [6, 18]. The mortars with the most advanced hydraulic character are concentrated at the bottom of the curve, while those in which there is a reduced presence of hydraulic binder are found at the upper right. Intermediate CO_2/H_2O ratios ($2.5 \le CO_2/H_2O \le 7.5$) and CO_2 contents (10-32%) correspond to moderately hydraulic mortars (i.e. crushed brick-lime mortars) [14].
The hydraulic character of the ancient mortars is attributed partially to hydraulic compounds deriving from crushed brick-lime interactions and partially to raw materials, like marly limestones with clay inclusions, employed to produce hydraulic lime [6, 15]. The specific "pozzolanic" character of the crushed brick-lime mortars is attributed to the adhesion reactions occurring at the ceramic-matrix interface [15, 18-19]. These reactions may, in turn, be attributed to calcium aluminosilicate formations at the interface along the brick fragments, acting as the silicate source and membrane, and lime, which makes the interfacial surface alkaline and causes the chemical reaction. The penetration of lime into the ceramic and the consequent reaction transforms the microstructure of the mortar by reducing the size of the pore radii and augmenting the apparent density. The transformation of the pore size distribution confirms the hydraulic character of the mortar matrix, imparting to the mortar high physico-chemical resistance to polluted and marine atmosphere, as well as high strength.
The results of the XRF and SEM/EDX analyses revealed high contents of silicon and calcium oxides and relatively high contents of aluminium and iron oxides in most of the samples. The presence of high quantities of aluminium, silicon and iron oxides in some samples can be attributed to the addition of clay (ceramic) material during the preparation of the mortars. Silica content was highest in mortars of more advanced hydraulicity, while the weak hydraulic and lime mortars showed lower values. In contrast, the calcium oxide content was higher in typical lime and weakly hydraulic mortars. The inverse relationship between silicon and calcium oxides is shown in Fig. 3.
Examination of the physical properties of the ancient mortars revealed porosity values between 30-50% and capillary absorption coefficients in the range 3.5-25.5 mg/cm2s1/2. However, due to the very small size and friable nature of the samples, no valid conclusions can be drawn regarding these properties.

Experimental mortars

From the results (Table 2) of the experimental study that was carried out in order to design suitable mortars for restoration purposes, it is clear that the type and degree of fineness of the ceramic powder play the most important role in strength development. This observation entirely agrees with evidence found in the literature [10, 14, 20] stating that the grain and fragments size of the crushed brick influences directly its hydraulic reactivity and, consequently, the physico-mechanical properties of crushed brick-lime mortars. The results suggest that the ceramic powder is active when its particle size is less than 150 μm. With a reduction in its size below 45 μm, the powder became very active and the compressive strength (Fc) exceeded 5 MPa in 28 days.
The experimental results also indicated that compressive strength of crushed brick-lime mortars increases significantly over time. The addition of surplus water in the mix reduced the strength radically. The flexural (F_t) and compressive (F_c) strengths of the samples generally showed the same trends, irrespective of age [21].
The porosities (P) of the experimental mortars (Table 2) were around 35%. This could be taken as an indication of a weak hydraulic to aerial character. The air-hardening lime mortar (B.2) showed a slightly lower porosity value than most of the crushed brick-lime mortars, possibly owing to the

Sample	Ceramic Powder	w/b	Fc (MPa)			Ft (MPa)			P (%)	S (mg/cm2s1/2)
			28d	90d	180d	28d	90d	180d		
B.2	n/a	0.8	1.0	1.6	1.3	0.5	0.6	0.5	34.8	26.41
B.4	CB3 (0-150)	0.9	3.0	4.0	4.8	1.1	1.9	1.9	36.9	14.01
B.7	CB11 (0-150)	0.9	0.5	1.0	2.0	0.2	0.5	0.9	37.1	22.33
B.8	CB12 (0-150)	0.9	0.6	1.6	3.3	0.2	0.8	1.1	37.3	14.06
B.9	CB2 (0-150)	0.9	0.6	1.4	3.5	0.3	0.7	1.4	36.5	19.47
B.10	CB14 (0-150)	0.9	1.2	2.9	4.1	0.5	1.4	1.0	37.8	21.68
B.11	CB31 (0-150)	1.0	0.9	2.7	3.1	0.4	1.2	0.5	37.5	25.88
B.12	CB31 (0-150)	0.8	2.4	4.6	4.9	1.2	1.7	1.0	35.8	19.69
B.14	CB31 (0-150)	0.9	2.9	3.0	3.6	0.7	0.6	0.9	37.3	19.74
S.10	CB2 (0-75)	0.8	3.4	6.2	6.4	1.3	2.6		30.6	16.45
S.15	CB2 (0-45)	0.8	5.4	7.5		1.7	2.7		29.1	8.55
S.16	CB2 (75-150)	0.8	2.6	4.6		1.4	1.9		29.9	10.64
S.20	CB2 (150-500)	0.8	1.2	1.7		0.5	0.6		34.8	21.10
S.21	CB3 (0-75)	0.8	7.0	7.7		1.7	2.4		32.3	15.07
S.25	CB3 (0-150)	0.8	5.0			1.4			31.0	13.05

Table 2: Experimental results.

presence of a dense carbonated rim on the surface of the sample which prevented moisture from reaching the interior of the mortar [1].
The experimental results confirmed the close relationship between compressive strength and porosity. Fig. 4 shows that the compressive strength of the experimental crushed brick-lime samples increased with decreasing porosity. The relationship between these two fundamental mortar properties may be described analytically as follows [22]:

$$S = S_0 (1=P)^n \qquad (1)$$

where S is the strength of mortar, S_0 the theoretical strength at zero porosity, P the porosity and n a constant.
The capillary absorption tests (Table 2) showed that the coefficient of water absorption (S) is dependent on the microstructural characteristics of the mortar and, in particular, its porosity [23]. Mortars with lower porosities and higher mechanical strengths (i.e. mortars with finer ceramic powder), generally showed lower capillary water absorption values, as would be expected from denser materials [13]. The results also showed differences between the aerial and the weak hydraulic mortars. The latter exhibited lower capillary water absorption coefficients.
The evaluation of the physico-mechanical characteristics of the experimental mortars should be carried out bearing in mind their compatibility with old masonry [23]. Low mechanical resistance (~ 5.5 MPa) and high porosity (35-40%) characterise one of the main building stones (i.e. the calcareous sandstone of the Nicosia-Athalassa formation) found on ancient monuments in Cyprus. The experimental mortars exhibit lower strengths than the original stone and similar porosities. Therefore, one may assume that they are compatible with the units of historic buildings and can be used for re-pointing and re-rendering.

Conclusions

Following the physico-chemical characterisation of ancient mortars from Cyprus, and adopting a "reverse" engineering" process, it became possible to prepare restoration mixtures having characteristics compatible with the traditional masonry structure. The repair mortars consisted of raw materials locally available.
Examination of the physico-mechanical characteristics of the experimental mortars indicated the main parameters which determine their strength, workability and durability. These are the binding system and the water content.

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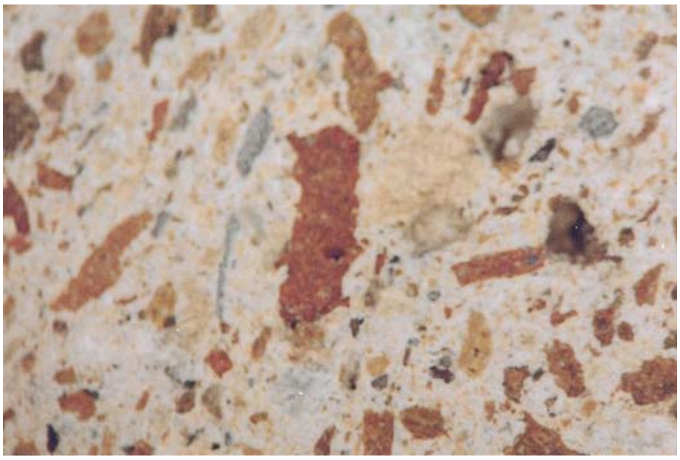
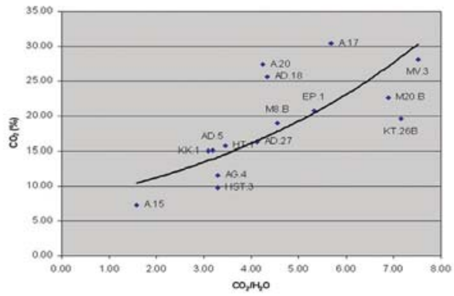
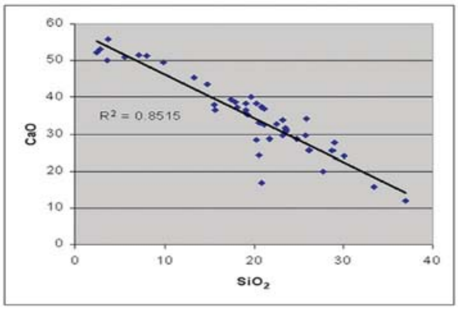


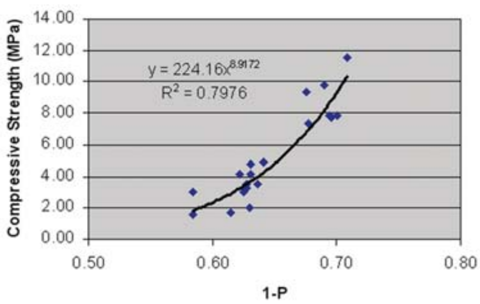
1: Evidence of reddish inclusions in sample KT.26B.



2: CO2 (%) versus ratio of CO2/H2O for ancient mortars.



3: Inverse relationship between silicon and calcium oxides.



4: Correlation of porosity with compressive strength for the experimental mortars.

Hacia un sistema-mortero para intervención en restauración

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1 Introducción

Desde siempre el conglomerante universal ha sido la cal, hasta la aparición del cemento portland. El cemento portland y los cementos en general son la consecuencia de la evolución en una determinada dirección tecnológica de la producción de la cal.
Resulta muy interesante viajar por los textos clásicos (los "tratados de construcción") para constatar que, con el paso de los siglos, el discurso no ha variado substancialmente en lo referente a la cal. Las instrucciones "vitruvianas" se repiten aconsejando un producto a partir de la piedras lo más puras posible [1].
Sin embargo, las técnicas de producción preindustrial de cal no permiten asegurar un producto de máxima pureza en óxido de calcio [2]. Debemos pensar que casi nunca se conseguía un producto exento completamente de propiedades hidráulicas y de elementos no calcinados. La naturaleza de las materias primas disponibles cercanas a las obras, la dificultad en el transporte, la heterogeneidad en la distribución de la temperatura en el horno, etc. necesariamente son causas de una producción de baja pureza en CaO libre.
El largo proceso de apagado por inmersión en balsa generaba un producto compuesto por hidróxido cálcico y carga mineral inerte. Otras formas de apagado con menor cantidad de agua, materias primas con mayores contenidos de arcillas y superiores temperaturas de cocción proporcionaban productos de cal con propiedades hidráulicas que actualmente conocemos como cales hidráulicas naturales.
El conglomerante con propiedades hidráulicas es aquel que comporta en si mismo elementos capaces de reaccionar entre si en presencia de agua para formar nuevos compuestos resistentes. Así pues, existe una cierta continuidad desde las cales aéreas puras a los conglomerantes modernos con fraguados mayoritariamente hidráulicos.
El conocimiento "clásico" ya distinguía entre diversas utilizaciones de los morteros de cal, donde eran necesarias determinadas prestaciones. Realmente, aquello que se convertía en un producto con propiedades de resistencia inicial elevada, o con capacidad de fraguado en ambientes saturados, etc., era el propio mortero. Estas propiedades se conseguían a partir de dosificaciones con materiales con puzolanidad latente, como puzolanas naturales o chamota.

Las modernas técnicas instrumentales de análisis de materiales [3] han permitido constatar en multitud de edificios patrimoniales la realidad de los morteros históricos realizados con materiales de actividad puzolánica.
Otra cuestión es ¿con que morteros intervenimos actualmente en estas obras?
La cotidianidad de las obras de restauración [4] nos muestra una realidad muy preocupante. La industria del cemento y las preferencias de los operarios han ido arrinconando el uso de la cal, por muy diversas causas. La cultura actual de las obras (y de los proyectos) es la del cemento y el hormigón.
Si en una determinada obra de restauración se prescribe el uso de cal como conglomerante, se puede conseguir realmente, como mal menor, la confección de un mortero bastardo de cal y cemento. Aunque seguramente sería más correcto definirlo como un mortero de cemento adicionado con cal cálcica, dadas las proporciones de ambos conglomerantes.
Incluso determinados morteros industrializados, comercializados como "morteros de cal", son realmente morteros mixtos cemento-cal con proporciones en peso 2 a 1, respectivamente.
No es ahora el momento de relatar pormenorizadamente los distintos problemas que comporta el uso de cemento portland en estas obras [5].

Resumidamente:

- Incompatibilidad con otros materiales presentes en la obra, con la consiguiente formación de nuevos compuestos, generalmente expansivos.
- Formación de sales solubles que generan eflorescencias o criptoeflorescencias.
- Aumento del módulo de deformación del mortero con los consecuentes cambios de rigidez de partes del monumento.
- Cambios de permeabilidad al vapor en la red porosa, etc.

2 Planteamiento

Entroncando con la tradición de los morteros romanos, de los medievales y los posteriores hasta los de cal hidráulica, se plantea desarrollar nuevos morteros de cal con capacidades puzolánicas (controlando estas características) a partir de productos específicos, de alta pureza y constancia, concebidos como un mortero para obras de restauración.
Justamente por el hecho de tratarse de este tipo de obras se puede pensar de manera algo distinta a las obras nuevas, dadas las siguientes características:

- El período de estudio del objeto arquitectónico es más largo y pluridisciplinar. En particular, generalmente, se identificarán los materiales presentes y los procesos patológicos existentes, lo que posibilitará definir condiciones generales para los "nuevos" materiales.
- Las empresas constructoras serán especialistas. Por tanto, con experiencia en este tipo de obras y disponiendo de mano de obra cualificada en los distintos oficios.
- Los períodos de ejecución serán, generalmente, más dilatados y el presupuesto se regirá por parámetros distintos a los de la obra

nueva.

- En muchos casos, el uso (simultáneo, parcial,...) del monumento condicionará el proceso.

Así, es posible plantear para cada caso la utilización de un mortero determinado considerando distintos parámetros de diseño del material como:

- compatibilidad con otros materiales existentes
- rigidizaciones de los elementos constructivos o de la estructura en general
- prestaciones mecánicas demandadas a corto, medio y largo plazo
- funciones de protección respecto de otros materiales, o de sacrificio
- aspecto final de la intervención a corto, medio y largo plazo,
- ambiente en que se encuentra el monumento, período en el que se desarrolla la obra, medios disponibles y tiempos de utilización de estos, etc.

En la medida de lo posible, se persigue desarrollar una cierta base común para todos estos morteros que de por sí resuelva un buen número de situaciones, o bien que facilite el desarrollo de morteros específicos para determinados casos.

3 Propuesta

Se piensa en un producto a medio camino entre el producto industrial y el artesanal, es decir, un mortero moderno preparado industrialmente, pero con una parte de la dosificación que deberá de finalizarse en la obra. Aquella que resulta más determinante en el aspecto final, es decir, el árido de mayor tamaño y el colorante.

Se parte del conglomerante generalmente aceptado para estas obras, la cal aérea, por razones de compatibilidad[6].

Se cuanta también con elementos capaces de incorporar al sistema sílice reactiva para desarrollar funciones puzolánicas y conseguir mayores resistencias mecánicas y rigideces iniciales. Pensamos en elementos de tamaño de partícula muy pequeño, de gran superficie específica (hasta 100 m^2/g.)[7,8,9].

La utilización de tantas partículas pequeñas comporta una gran demanda de agua y, por tanto, condiciona la retracción en el proceso de secado. Será necesario incorporar un aditivo reductor de agua.

También debemos considerar las funciones diversas que desarrollan los áridos en los morteros[10]:

- Intervienen decisivamente en la reología del mortero.
- Condicionan la porosidad del material.
- Colaboran en el proceso de germinación de los primeros cristales del conglomerante (germinación).

De todo el conjunto de la curva granulométrica, la parte más relevante en los aspectos anteriores es la de las partículas menores (< 200 µm), por tanto, deberá de conllevar una cierta curva de finos.

La parte de áridos de mayor tamaño se incorporará en obra y condicionará el aspecto del mortero. Estos deberán ser "limpios" de elementos potencialmente nocivos para el monumento, es decir, lavados bajo agua y tamizados por 200 µm, despreciando la parte que pasa.

Los colorantes minerales para conseguir el color deseado, y naturalmente, el agua "que pida".

Finalmente, en tanto que el mortero es un elemento de unión o de revestimiento, puede resultar un magnífico testigo, aparentemente invisible, de datación de las intervenciones. El sistema-mortero que se propone conlleva un elemento inerte cuya única función es la de trazador imborrable de la intervención.

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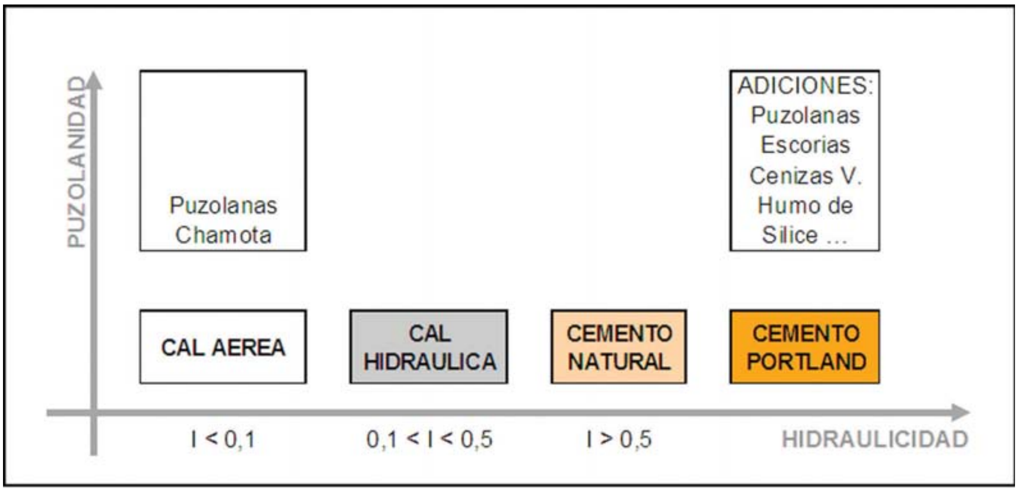

SISTEMA MORTERO

Componentes dosificacos industrialmente				
	Sílice reactiva			
Cal aérea	React. Rápida	React. Lenta	Aridos < 0,2 mm.	Aditivos
Cal cálcica CL-90	Metakaolín Humo de Sílice …….	Puzolana Natural Chamota Diatomeas …….	Granulometría controlada, secos, de forma adecuada….	Reologia Sistema poroso

Componentes dosificados en obra		
Aridos > 0,2 mm.	Colorante	Agua
Condicionados por el aspecto buscado en el monumento		Condicionada por la técnica de aplicación

Newsandstone versus Montjuïc. ¿Hermanas Gemelas?

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1. ANTECEDENTES

Comparamos dos rocas, separadas geográficamente, de orígenes geológicos diferentes, pero de composición química y propiedades físicas similares.
Una roca es la utilizada en Barcelona, y conocida como piedra de Montjuïc. Sus canteras o están agotadas o han sido cerradas. Es la piedra emblemática de Barcelona.
La otra roca proviene de Escocia, en concreto de Moray, con varios frentes de cantera abiertos actualmente, y con buenas reservas de material a explotar. En su lugar de origen se conoce con el nombre de Clashach sandstone. Se ha utilizado en multitud de edificios, destacando el Museo de Scotland (1998), Scottish Widows Fund and Life Assurance Society (1997), y en reparaciones del castillo de Edimburgo (1978)[1].
Consideramos óptimo que las piedras de substitución deben envejecer de forma similar a las piedras originales, con la finalidad que no se produzcan variaciones de cromatismo y textura muy diferenciados, para que así no se tenga que recurrir a la aplicación de recubrimientos que impidan la lectura de estos elementos nobles: las piedras de construcción.

2. CARACTERIZACIÓN

Dada la imposibilidad de finalizar a tiempo la caracterización de la piedra Clashach en nuestro Laboratorio, los datos aquí presentados de esta roca han sido facilitados por el British Geological Survey, a excepción de los datos de resistencia a compresión y flexión que sí se han podido realizar en este Laboratorio.
En cuanto a la caracterización de la piedra de Montjuïc, los datos aquí expuestos son experimentales de este Laboratorio, y cotejados con los publicados por Esbert, R.M. et al[2]. Para caracterizar esta roca se ha realizado el correspondiente estudio geológico, petrofísico, y se ha envejecido aceleradamente.
Actualmente se está llevando a cabo una caracterización de seis tipos diferentes de la piedra de Clashach, diferenciados principalmente por su contenido en óxidos de hierro.

2.1. Caracterización geológica

Arenisca de Montjuïc
La arenisca de Montjuïc se formó como un depósito sedimentario detrítico en un ambiente deltáico. Esta roca ha sufrido importantes modificaciones (principalmente una extensa silicificación, por circulación intersticial de aguas ácidas a baja temperatura) que han conducido a la desaparición del cemento carbonatado originario y su matriz arcillosa (hasta un 50-55 %del volumen original), así como a la argilización (o neoformación de adularia) a expensas de los feldespatos y fragmentos líticos (San Miguel y Masriera 1970[3] , Gómez Gras et al. 2000[4], 2001[1], Parcerisa et al. 2001[6], Parcerisa 2002[7]).
Su composición es en un 96% de cuarzo y el resto son feldespatos y fragmentos de roca silícea. El cemento de esta roca principalmente es silícico, aunque hay zonas donde existe un cemento ferruginoso.
Su coloración varia entre gris (variedad blancatxe, con cemento silícico) y rojo (variedad rebuig, con cemento ferruginoso), aunque la más utilizada en construcción es la de coloración grisácea, que en algunas zonas puede tener cementos ferruginosos.
Es una roca de edad miocénica, concretamente del Serravalliense (Gómez Gras et al. 2000, 2001).

Arenisca de Clashach
La arenisca de Clashach se formó en un proceso sedimentario de tipo eólico (dunas del desierto). Presenta una mejor selección granulométrica y mineralógica que la anterior arenisca.
Esta roca también fue afectada por un proceso diagenético (cementación) desarrollado tras su deposición, menos intenso que en el caso de la arenisca de Montjuïc, pero suficientemente importante como para darle características mineralógicas similares.
El estudio petrográfico de la arenisca escocesa muestra tanto el carácter eólico como, en general, una menor cementación silícica. Su composición es en un 96% de cuarzo y el resto son feldespatos y fragmentos de roca silícea. También tiene los dos tipos de cemento: silícico y ferruginoso, y por tanto se pueden encontrar desde variedades de color grisáceas hasta rojizas, existiendo sus puntos intermedios.
Es una roca del Pérmico superior[1].

2.2. Caracterización petrofísica y envejecimiento acelerado

En la siguiente tabla se recogen los resultados de algunas propiedades físicas de estas dos rocas, así como la pérdida de material que sufren tras el envejecimiento artificial acelerado mediante cristalización de sales y de hielo deshielo.

TIPOS	ρo	no	Ws	Rc	Rf	Δm sal	Δm hielo
Clashach	2.08	21.40	6.90	65.20	7.60	-0.8	-0.08
Montjuïc	2.13	24.00	8.34	60.16	7.20	-0.1	-0.07

ρ_o: densidad aparente (g/cm^3); n_o: porosidad abierta (%); W_s: contenido de agua en saturación (%);
Rc: resistencia a la compresión uniaxial (MPa); R_f: resistencia a la

flexotracción (MPa),
Δm sal: incremento de masa tras envejecimiento por cristalización de sales (%).
Δm hielo: incremento de masa tras envejecimiento por hielo deshielo (%).

Dado que el principal agente de alteración de la arenisca de Montjuïc, a excepción de las actuaciones realizadas por la mano del hombre, es la cristalización se sales solubles, se ha creído conveniente observar el envejecimiento de los dos tipos de roca, bajo este agente alterológico. Por ahora, se ha comprobado que presentan una pérdida de masa insignificante al finalizar los ciclos normalizados, y que no se observan formas de alteración relevantes, a excepción de una subida de los tonos rojizos en aquellas muestras que presentan una concentración de óxidos de hierro importante.
También se ha realizado el envejecimento artificial acelerado mediante hielo deshielo. No se ha observado ningún síntoma de alteración de estas dos rocas bajo este agente alterológico.

3. CONCLUSIONES
Como se ha podido comprobar, las características petrológicas y petrofísicas de estos dos tipos de piedra son muy similares. Su envejecimiento es muy similar, tanto en valores de pérdida de masa como de su forma de alteración.
Así pues, la arenisca Clashach se perfila como una verdadera substituta de la arenisca de Montjuïc
El comportamiento de estas piedras frente al envejecimiento artificial acelerado ensayado nos indica que no se alteran excesivamente, tal y como se puede comprobar en la realidad, en los edificios construidos, y que envejecen como si de dos hermanas gemelas se tratara.
Así pues, tenemos la posibilidad de garantizar que los edificios construidos con piedra de Montjuïc sigan teniendo el mismo aspecto, aún con la actuación del paso del tiempo y de los agentes alterológicos.
En este estudio no se ha pretendido menospreciar las piedras que en la actualidad se están utilizando como substitutas de Montjuïc (piedra de Vinaixa, La Floresta, etc). Tan solo pretendemos justificar que, si es posible, siempre es mejor sustituir con piedras de similar características que con otras que sólo se asimilan a las originales en el color inicial.
A la vista está el comportamiento diferencial de las piedras ya substituidas respecto a las originales.

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Sagrada Familia de Barcelona. Piedra de Montjuïc

Exterior del Museo Nacional de Escocia. Piedra de Clashach

Traditional Building Techniques from 1850 to 1950: The case of northern Jordan

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Introduction

The past human activities had always left traces on the landscape as the thread on canvas (Ashmore and Knapp, 1999). On of these traces is architecture embodied in building and structures which reflects in a way the interaction of the social systems with the surrounding environment (Sozen and Gedik, 2007), geography (Doeppers, 1990) and politics (Swenson, 2007). It has long been known that architecture indirectly serves as a metaphor for the people's social and behavioral attitudes and consequently the culture (Al-zoabi, 2004). All of these components were not divorced from the cultural exchange which most of the time enriches the traditional buildings and structures, and provides a special essence for them. Taking a very important time span of the history of Jordan (1850-1950), this study focuses on the various attributes of the traditional buildings in Jordan, an issue that remain not very well researched until recently.

Before 1921 and during the Ottoman era (1520-1920AD), the area comprising modern Jordan was divided among a number of continuously changing administrative provinces which comprised Bilad al-Sham (the area consisting of Syria, Jordan, Lebanon, and Palestine) (Salibi,1993, Fradric,1958). Being a passage for the pilgrimage to Mecca, Jordan received a special attention by the Ottoman authority, which constructed the Hijaz Railroad in 1900 (Fraddric, 1934; Ochsenwald, 1980). The Ottoman heavy taxes altered the development of settled life as much as the raids of Bedouin tribes (Daher, 1988; Abujaber, 1989).

Consequently, Jordanian peasants fled to caves; then numerous villages were constructed on the mountains representing several stages of architectural development through trial and error to suite the environment and the community (Khammash, 1986). Each village adapted to several cultural and environmental changes through time as being located near historical sites (Khammash, 1986; Knauf, 1986). The villages' architecture reflects the social traditions and the prevailed socio-economic patterns; the subsistence economy was mainly agriculture and pastoralism (Khammash, 1986) and the construction materials were stone, mud, wood, and reeds (Mahadine, 1997). The establishment of Transjordan encouraged the development of a settled life. Therefore, a considerable progress was achieved in the construction development. The emerg¬ing state acted as a magnet which attracted immigrants bringing with them new construction methods (Al-rifaa'i and Kan'aan, 1987; Salibi, 1993), such as Circassians and Chechens in the late 19th century (Al-rifaa'i and Kan'aan, 1987; Ochsenwald, 1980; Abujaber, 1989).

The north of Jordan received series of immigrants from Syria and Palestine. These new developments created an immediate need for new buildings in Amman and the other major towns of Jordan. Interesting new structures, which incorporated imported design features and construction methods, were built during the next few decades (Al-asad, 1997). These buildings included train stations, which were built along the Hijaz Railroad. The stations spread new building materials such as steel beams that were used in the construction of roofs. Previously, the roofs in the area were constructed using stone vaulting, which is complicated, and costly (Zou'bi and Shahab, 1995). The other method of roofing comprised the use of wooden beams or tree trunks that spanned a maximum length of about 3 meters and covered with thatch and mud. This method is not durable; it needed frequent maintenance and depended on the availability of wood which is very scarce in the region (Bushnaq, 1997, Al-rifaa'i and Kan'aan, 1987).

Before the establishment of Transjordan, few important structures other than those of the Hijaz Railroad were built, especially in the major cities by master builders from Bilad al-Sham. These structures incorporated Western architectural features alongside local traditional ones, and showed a remarkable use of stone for construction and decorative purposes (Al-asad, 1997). The traditional buildings can be classified as rural and urban, the traditional urban buildings were affected by the already existing patterns of rural architecture (Bushnaq, 1997).

Rural Dwelling plans:

The first type of the rural houses was the peasant house (Fellahi House); this type of houses has been existed as early as the beginning of sedentary life (Nourissier, et al., 2002). It's simple in form and building technique with a rectangular plan and double skin stone walls. This type was a single or multi-purpose space. These houses can be entered from one door; they have small openings for natural lighting and ventilation (Khammash, 1986, Nahhas, 1987; Faqih, 1991) (fig.1).

The second type of rural houses was the Yard house (Housh), which was almost a development of the previous type (Fakhoury, 1993; Khammash, 1986). This type dominated over the other types in Jordanian villages due to its compatibility with the environment and daily activities. The rooms were grouped around a large open space, while the rest of the space is defined by the use of high walls built in the property line (Al-rifaa'i and Kan'aan, 1988; Faqih, et al., 1989) (Fig.2)

Urban Dwelling plans:

Riwaq type was brought by Circassians and Chechens immigrants. This type consists of a number of rooms placed side by side. They are connected together through doors opened in a front arcade (shaded space functioned as a foreground and summer living) (fig.3).This type was found in Amman, Jarash and Swaileh (Khammash, 1986).

The other type of urban dwelling(in most of the urban buildings) followed a tripartite arrangement. The middle section contains an entrance and a major living room. The side sections contain sleeping and service areas. One of the corner rooms is usually located next to the entrance; it may have been used as a reception. This arrange¬ment was originally a traditional courtyard house one, but here the central section of the house replaced the courtyard. The prototypes for these houses are built in the urban centers of Bilad al-Sham during the early 20th century. During the 1940s, this traditional arrangement was changed to a more western one in which the bedrooms are grouped together and separated from the living, dining, and family rooms (Zou'bi and Shahab, 1995; Al-asad, 1997; Bushnaq, 1997) (Fig.4).

Foundation system:

In the mountain areas where the topsoil is shallow, Jordanians built their houses directly into the rocks either on a slope or step systems. In the clay soil they usually dig a trench about one meter in width and down to the bed rock (Zou'bi and Shahab, 1995). The foundation trench was filled with stone boulders mixed with mud. The mud was replaced by concrete in later periods (Al-asad, 1997).

Walling system:

The load-bearing walls were made of rubble stones held together by mud and mixed with thatch making them thick. Rough-textured stone blocks provided the major exterior surface mater¬ial for the houses. Smooth-textured stone blocks were also used, but less frequently than the former ones since they require additional chisel¬ing by stone masons and therefore being relatively expensive (Al-asad, 1997).

Roofing system:

The flat roof was the common roofing system in traditional buildings having very weak slopes to evacuate water, which required permanent maintenance (Nourissier, et al, 2002). Jordanians experienced different roofing techniques; mostly not domestic. Barrel vaults and cross vaults made of limestone were the most common. Arched walls that divided the house space were also used to shorten the distance between the wooden beams. In Jordan valley, these techniques were not applied due to availability of wood. Tree trunks were used as a main beam and reeds as a second beam. After 1912 Steel I-beams, which were closely spaced at intervals of about one meter, were generally used to support the roofs. By the end of the 1930s, the roofs were mostly of reinforced concrete mesh (Al-asad, 1997, Bushnaq, 1997).

Flooring:

In rural areas, earlier type of flooring technique was the compact soil finished with lime wash. The other type of flooring was executed by paving the floor with stones covered by sand mixed with lime but lately replaced by a thin layer of concrete. In urban areas, tiles brought form Palestine and Syria were used. Terrazzo floor tiles were used for the interior and exte¬rior areas. These tiles were often colored and had vegetal or geometric patterns (Zou'bi and Shahab, 1995, Al-asad, 1997).

Opening System:

The windows of these houses were usually narrow and long. Flat and arched lintels were common for windows and doors. The vertical orientation of windows bridged the horizontal span of the window openings, while the overall area of each window allowed a sufficient amount of light to enter. Wood frames and glass panes were used for the windows. Wrought iron grillwork incorporating a range of patterns pro¬vided protection for window openings from burglary. Stone carving was used selectively for elements such as the frames surrounding openings, columns, cor¬bels, and balustrades (Al-asad, 1997; Zou'bi and Shahab, 1995).

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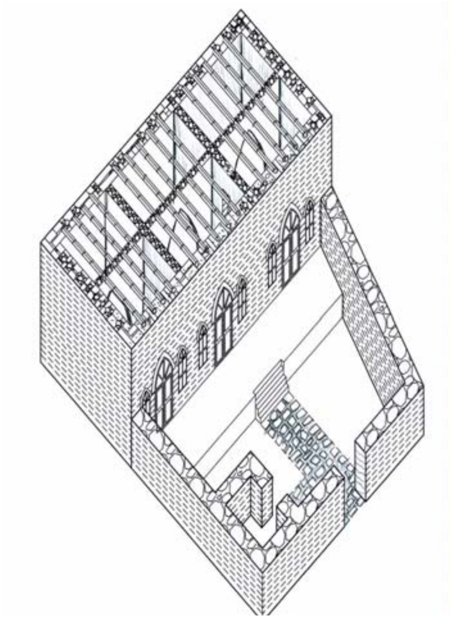
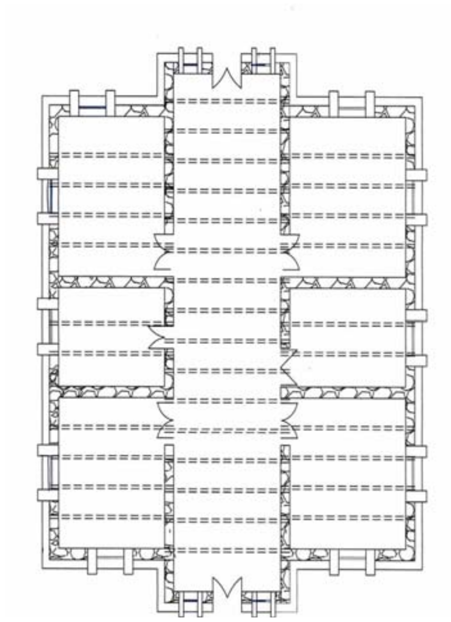
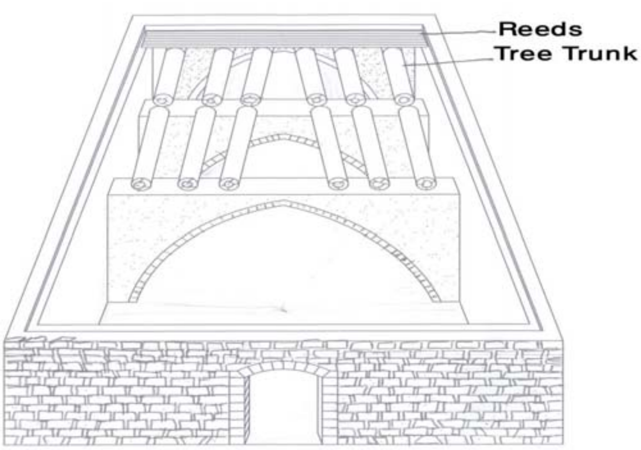


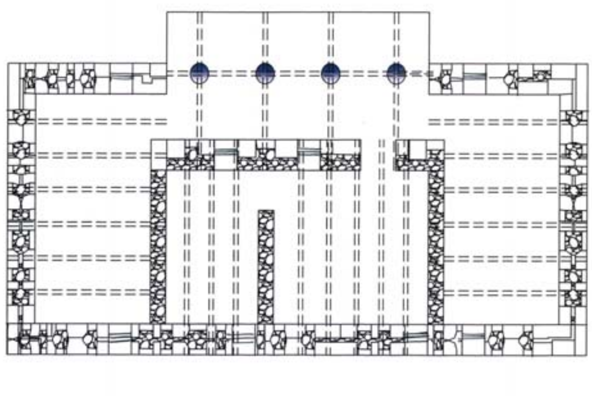
Yard House



Courtyard house



Peasant house



Riwaq house

La intervención en la cimentación de la construcción tradicional

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La intervención en una cimentación existente es un tipo de actuación que conlleva una problemática diferente a otras actuaciones dentro del campo de la rehabilitación. El caso de intervenir en el Patrimonio Tradicional, por sus características intrínsecas, tanto funcionales, como constructivas es particular.

La configuración constructiva de la cimentación ha variado a lo largo de la historia y de la localización geográfica. Lo más común es que sean elementos con una gran homogeneidad con los materiales de la estructura sobre rasante.

Podemos hallar casos apoyados en terrenos blandos, como aluviales, o zonas arenosas, con problemas propiciados por la presencia de agua. Pero no solamente este tipo de terrenos pueden provocar problemas geotécnicos.

Una afección diferente es la asociada a la actividad humana, que modifican las características geotécnicas del terreno pudiendo afectar a la cimentación.

Dos aspectos son fundamentales, a la hora de analizar este tipo de intervención, y que influyen a la hora de seleccionar el tipo de técnica a aplicar. Son por un lado el aspecto técnico, y por otro el económico.

Desde el punto de vista económico, son intervenciones de gran volumen económico, que literalmente va a ser enterrado, y por ello la aparición de dudas sobre la necesidad de su ejecución.

Desde el punto de vista técnico, son intervenciones complejas, con técnicas no habituales en el proceso constructivo, que obligan, al técnico que interviene, a estudiar de un modo minucioso cada situación, cada técnica tiene sus aplicaciones y sus inconvenientes.

Particularidades específicas en la Construcción Tradicional

Cuando se interviene en un edificio de carácter tradicional, existen particularidades que condicionarán la selección del sistema, así como su proceso de puesta en obra:

Derivados de ser una actuación bajo rasante

- Necesidad de movimientos de tierras afecta a los edificios del entorno y servicios subterráneos, produciendo movimientos diferenciales.
- Invisibilidad del presupuesto invertido. Solamente serán apreciables los movimientos de maquinaria durante la ejecución de las obras.

Derivados "de la edad del edificio"

- El valor de la configuración del elemento construido, puede impedir su alteración, siquiera de forma provisional.
- Es frecuente que los materiales sean de baja calidad, y su alteración implique afectación al conjunto.
- La existencia de alteraciones importantes, agrava la complejidad constructiva.
- Circunstancias de los edificios colindantes, lo que implica la necesidad de medidas de precaución en lo referente a movimientos en ellos.

Derivados de aspectos constructivos y estructurales

- Las cimentaciones pueden ser deficientes para su correcto comportamiento, estar realizadas con fábricas de baja calidad, o estar degradadas.
- Los sistemas constructivos pueden haber adquirido gran complejidad. El tiempo puede producir la integración de unos materiales en otros.
- Potenciales asientos sufridos en función del tipo de terreno donde se apoye. Esto plantea la imposibilidad de asumir movimientos añadidos, y se deberán adoptar sistemas dirigidos a tal fin.
- Posibles condiciones de inestabilidad estructural previos, que pueden ser la causa de la intervención.
- Necesidad de no modificar el comportamiento estructural del elemento original.
- Obligado control de asientos, como sistema de garantizar que no se producen movimientos incontrolados.

Derivados de la organización de la obra
- Será necesario adoptar medidas especiales para conseguir movimientos nulos.
- Limitación de gálibos para uso de la maquinaria.
- Conocer las anomalías que se produzcan, durante la ejecución, realizando las correcciones adecuadas.

Metodología de aplicación en la selección de la técnica a adoptar

Es necesario saber mirar, "produce una inmensa tristeza observar como la naturaleza habla, mientras que el ser humano no escucha" (Víctor Hugo) y utilizando el símil médico, la terapia debe estar basada en un buen diagnóstico, que no se encuentra sino se busca.

La selección del sistema de intervención debe ser como consecuencia de una metodología que principalmente debe tratar:

- Realización y análisis de los estudios previos.

- Búsqueda y determinación del problema e hipótesis de causas.
- Selección del sistema de actuación y problemática a resolver.

Los criterios de selección serán fundamentalmente técnicos y económicos, aunque hay otra serie de factores:

- Viabilidad y rapidez de ejecución
- Peligrosidad durante la ejecución.
- Comodidad para la Propiedad, evitar desalojos.

Todo esto sería valido para cualquier actuación de recalce, independientemente del tipo de suelo. Cada edificio debe tratarse como caso único, irrepetible y con un estudio específico de sus circunstancias.

Tipologías a aplicar.
Una clasificación ajustada a la problemática, sería diferenciar entre las técnicas que interfieren en el elemento construido, modificando su comportamiento estructural, y las que sin actuar directamente en el elemento construido mejoran las características geotécnicas del terreno.

Sistemas que actuan sobre la cimentación existente
En estas soluciones es imprescindible una conexión con la cimentación original. Fundamental es tener claro cómo funciona estructuralmente el nuevo conjunto de cimentación.

- Micropilotes. Son elementos de gran esbeltez, pequeño diámetro y gran longitud. Son de gran aplicación por su cierta versatilidad, sobre todo trabajando como conjunto (“Pali Radice”). El fallo más común es un deficiente dimensionado y/o ejecución de su conexión con la cimentación, que puede provocar la nula conexión. Se debe tener en cuenta el estado de la cimentación original ya que en caso de optar por perforarla y estar en mal estado podría producir su deterioro.
- Recalces superficiales, que profundizan el estrato de apoyo, necesitan una puesta en carga correctamente ejecutada, ya que pueden producir asientos bruscos en la estructura superior, de forma diferencial. Son fundamentales las medidas auxiliares.

Sistemas que actuan sobre el terreno de apoyo del edificio
En estas soluciones se trata de sistemas que varían las características geotécnicas adecuándolas a las necesidades del edificio. La implicación de estos sistemas está en el propio proceso de ejecución.

- El Jet-Grouting, crea columnas de terreno tratado, mediante un “batido” de este con cemento, a altas presiones. Estos sistemas implican que en su zona superior no se produzca un contacto directo con la cimentación, ya que debido a las altas presiones se podrían producir movimientos considerables no controlables.
- Las inyecciones de posible aplicación son múltiples en función del parámetro que se desee modificar. De este modo en el caso de querer dotar de un carácter impermeable, se deberían utilizar inyecciones de impregnación a muy baja presión y con lechadas muy fluidas de carácter químico.
- En el caso de rellenar cavidades se pueden utilizar inyecciones de baja movilidad, con presiones bajas a medias, con la utilización de morteros muy plásticos.
- Las inyecciones expansivas, en capas próximas a la cimentación, de material con alta capacidad de aumentar de volumen, aumentan la cohesión del terreno, pero implican movimientos no compatibles o admisibles con la estructura superior.
- La técnica de mayor aplicación en el campo de los recalces, es la inyección armada, con tubo manguito, que crean franjas de terreno tratado, modificando los parámetros geotécnicos aumentado la cohesión y el ángulo de rozamiento interno. Son inyecciones a baja presión, y con una gran capacidad de control. La puesta en carga es progresiva conforme se va produciendo la mejora del terreno y no implica variaciones bruscas en el comportamiento estructural de la edificación existente. Esta progresividad en la ejecución permite incluso la ejecución de recalces parciales, mediante la utilización de zonas de transición entre la zona recalzada y sin recalzar.

Conclusión
Como se ha observado, y dada la gran variedad de circunstancias que pueden presentarse no se pueden presentar soluciones generales, siendo de gran importancia la metodología aplicada, que lleven a un diagnóstico completo y a solucionar la técnica concreta de aplicación.
Para poder seleccionar, diseñar y poner en marcha cualquier solución es necesaria la preparación científica y técnica, por parte de los técnicos, que puedan prever las acciones derivadas de cada solución, y no se condicionen las obras a decisiones proveniente de carácter comercial.
Es de gran importancia la visión interdisciplinar, tener en cuenta opiniones desde los diferentes puntos de vista que intervienen. Para la Universidad de Alcalá y desde su Grupo de Investigación: “Intervención en el Patrimonio y Arquitectura Sostenible” este es uno de sus objetivos.
materiales presentes y los procesos patológicos existentes, lo que posibilitará definir condiciones generales para los “nuevos” materiales.

- Las empresas constructoras serán especialistas. Por tanto, con experiencia en este tipo de obras y disponiendo de mano de obra cualificada en los distintos oficios.
- Los períodos de ejecución serán, generalmente, más dilatados y el presupuesto se regirá por parámetros distintos a los de la obra

Utilización correcta de contraventanas para ahorro energético

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Cuando un arquitecto emprende la rehabilitación de un edificio, sobre todo si éste tiene interés arquitectónico por su carácter histórico y/o artístico, normalmente prestará atención a los aspectos formales del mismo, con la intención de conservar su carácter.

Esto conlleva la conservación del tamaño de los huecos y del color y aspecto exterior de las carpinterías, pero no siempre se presta igual interés a otros aspectos de las mismas, como la posición de dichas carpinterías en el espesor del muro, el material de que están hechas – independientemente de que formalmente se haya conservado un aspecto similar – y la protección climática de que se va a dotar al hueco, y estos aspectos son, sin embargo, fundamentales para minorar el gasto energético del edificio.

El primero de los aspectos – la posición de dicha carpintería en el grosor del muro – suele funcionar correctamente si se conserva la posición original de la misma, puesto que, tradicionalmente, se buscaba la captación solar en climas fríos – para lo que se instalaba la carpintería a haces exteriores del muro – y el apantallamiento en climas cálidos – para lo que se instalaba la carpintería a haces interiores, logrando mejorar la protección de dicha carpintería y evitar gran parte del efecto invernadero que de otra forma se produciría (de hecho nos encontramos con artificios tales como tejadillos adosados al muro encima de las ventanas (figura 1) que aumentan localmente el ancho del mismo, incrementando la entidad de la sombra, de forma que en verano, con el sol más vertical, no se introducen rayos solares en el edificio a través de las ventanas orientadas a sur) –. El desconocimiento de la utilidad de estos tejadillos hace que encontremos ocasionalmente este tipo de elementos ubicados en zonas de sombra (por ejemplo, bajo porches) donde son, evidentemente, inútiles.

Evidentemente, si las ventanas están orientadas a norte la posición de las carpinterías en el espesor del muro es indiferente (excepto en el aspecto de la protección de las mismas contra las inclemencias del tiempo), y si están orientadas a este u oeste tampoco afecta mucho dicha posición desde el punto de vista del ahorro energético, ya que a primera hora de la mañana y a última de la tarde, el sol estará demasiado bajo para que cualquier visera horizontal pueda producir sombra sobre la ventana, aunque sí la producirán parcialmente las jambas verticales. En estos casos habrá que recurrir al diseño de las contraventanas para paliar las ganancias energéticas.

El segundo aspecto a considerar es el material que se utiliza en dicha carpintería, ya que el coeficiente de transmisión térmica del mismo se toma siempre en consideración, pero no ocurre lo mismo con otros aspectos como su capacidad de almacenamiento de calor, que puede ocasionar elevaciones de la temperatura de la carpintería tan intensas como para llegar a causar quemaduras a los usuarios.

El efecto puede incrementarse considerablemente si se pigmenta dicha carpintería en colores "tradicionales", sin pensar que un color que no afecta en demasía a la temperatura de una carpintería de madera, puede suponer un aumento de temperatura insoportable para una carpintería metálica.

Como recomendación general, no deben utilizarse carpinterías metálicas de color oscuro en aquellos puntos en que puedan quedar expuestas al sol directo, puesto que, incluso en los climas más fríos de España, la temperatura alcanzada podría llegar a ser tan elevada, aunque sea por breves periodos al año, como para producir estas quemaduras.

Adicionalmente, estas carpinterías transportarían esa temperatura a la cara interna de la misma, actuando como un elemento radiante que modifica las condiciones climáticas interiores en gran medida, incluso en las carpinterías dotadas de rotura de puente térmico.

El tercer aspecto a considerar sería la utilización de contraventanas, estudiando su posición, su forma, su color y el material de que estén constituidas.

En cuanto al primer punto – su posición – podemos encontrar contraventanas prácticamente idénticas pero ubicadas respectivamente en el interior de la ventana y en el exterior de la misma.

Energéticamente, ambas funcionan de forma muy diferente, ya que la primera de ellas permite el paso de los rayos solares a través del cristal, de modo que la contraventana se calentará y la radiación infrarroja que una vez caliente emita tendrá una longitud de onda incapaz de atravesar nuevamente el cristal, por lo que el calor captado se quedará en el interior de la estancia.

Si la contraventana es de color oscuro, este efecto aumentará, ya que el porcentaje de energía solar absorbido será mucho mayor que el reflejado, mientras que si es de color claro el efecto será mucho menor debido al alto coeficiente de reflexión de esos colores.

También en este caso habrá que tener en cuenta el material de la contraventana, puesto que el metal – mejor conductor del calor – se calentará más deprisa y en mayor medida, radiando posteriormente dicho calor al interior del local, lo que le hace más deseable en climas fríos, mientras que materiales más inertes como la madera, captarán mucha menos energía solar lo que mejorará su comportamiento a nivel energético en climas caliente, aunque, evidentemente, lo mejor será siempre nunca instalar las contraventanas en el interior en climas cálidos.

La utilización de contraventanas opacas presenta ventajas en dos aspectos: la protección contra el frío, deseable en zonas con este tipo de clima, y la capacidad de oscurecimiento que las hace idóneas para locales específicos como los dormitorios. Sin embargo, en el área mediterránea, el problema no es usualmente la captación solar sino la tamización de los rayos solares y de la alta intensidad de la luz para que sólo se introduzcan en el interior de las viviendas cuando es necesario, permitiendo al mismo tiempo la percepción del exterior. Para ello, tradicionalmente, se ha recurrido a la utilización de contraventanas de tipo celosía, que igualmente pueden ubicase tanto interior como exteriormente. Lógicamente, si se usan preferentemente en climas cálidos su ubicación idónea será siempre en el exterior del acristalamiento, aunque puede considerarse su ubicación interior si el acristalamiento es practicable con la celosía cerrada, ya que el calor que ésta capte será así expulsado al exterior; esto suele recomendar la instalación de carpinterías con apertura de tipo oscilobatiente, y aún así es muy probable que el calor radiado por la contraventana penetre en gran medida al interior.

En cuanto al material, las celosías metálicas presentan el inconveniente ya mencionado de su rápida y elevada capacidad de calentamiento, evidentemente tanto más considerable cuanto más oscuro sea su color. Sin embargo, en esta ocasión esa disipación térmica se produce en el exterior del edificio, por lo que es menos perjudicial que con las contraventanas interiores.

Además, la utilización de contraventanas exteriores metálicas presenta la ventaja de constituir un cierre de seguridad contra intrusiones, además de una protección térmica, por lo que puede ser aceptable su utilización, siendo en estos casos deseable en el clima mediterráneo la elección de un color lo más claro posible para la misma y una circulación convectiva natural que evacue el calor captado lo más rápidamente posible.

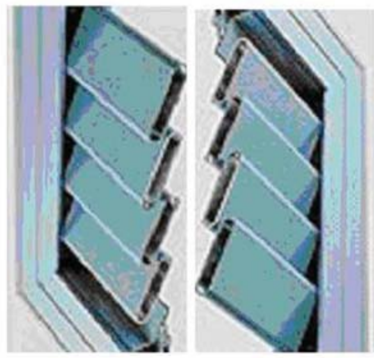
Las celosías de madera sólo presentan el inconveniente de su alta necesidad de mantenimiento, ya que a intemperie es un material que se deteriora rápidamente si no es protegido adecuadamente. El color recomendable de estas celosías es, asimismo, el más claro posible.

En cuanto a las lamas, podemos encontrar celosías de lamas horizontales y de lamas verticales, siendo siempre deseable que éstas sean móviles para que puedan abrirse con el fin de permitir la percepción del exterior y cerrarse para lograr el oscurecimiento del local.

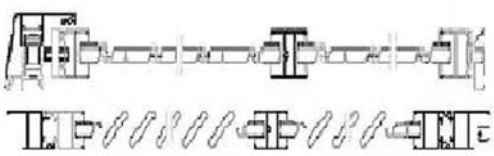
La elección de la inclinación de las lamas semiabiertas de las celosías horizontales dependerá de varios factores: la existencia de pluviometría abundante requerirá que su inclinación hacia abajo favorezca la evacuación de agua y la existencia de altos niveles de soleamiento directo del sur también recomendarán esta posición de las lamas, ya que es la más idónea para el apantallamiento solar con el sol en el cenit. Sin embargo, si la pluviometría es escasa y no existe exposición directa al sol del mediodía (por ejemplo por sombreamiento cvonseguido mediante la existencia de dinteles profundos), se favorecerá la evacuación del calor captado potenciando la convección natural al instalar la lamas abriéndose hacia arriba (segunda imagen de la figura 2). Si además estas lamas pueden abrirse en los momentos en que no les da el sol directo, la evacuación del calor será más rápida.

La ubicación de una celosía en una ventana ubicada al este o al oeste, deberá dar preferencia a las lamas verticales (figura 3), dado que el sol puede estar muy horizontal en cualquiera de estas orientaciones. Simplemente con esta actuación y manteniendo la ventana a haces interiores evitaremos gran cantidad de captación solar sin eliminar la posibilidad de la visión hacia el exterior.

1



2. Posición de las lamas horizontales en zona de alta y baja pluviometría



3 Sección horizontal de celosías de lamas verticaes, con lamas cerradas y abiertas, respectivamente.