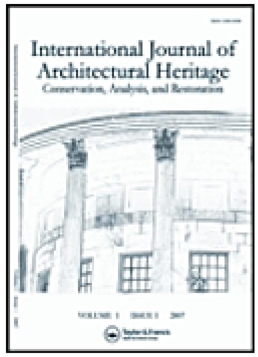

Revitalization of architectural and ethnological heritage: The recovery of vernacular building techniques in a nineteenth-century winery

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Complete List of Authors:	Garcia-Esparza, Juan A.; Universitat Jaume I
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Abstract

The research was aimed at the restoration of the facings and frames of the *Rósula* winery, which dates back to the nineteenth century. Its abandonment and subsequent state of disrepair offered a challenge in the preservation and revitalization of its vernacular techniques. The plan of action mainly concentrated on the preservation of its construction, unavoidably linked with its history and local character. The paper starts by analyzing the local character and environment in order to understand the current situation of this heritage and continue analyzing and searching for technical materials and solutions compatible with the structural deficiencies to allow a combination of aesthetic, functional, structural, and environmental aspects for highlighting the complexity of the recovery and treatment of traditional techniques, which have barely been developed by local builders. The final reflections suggest the suitability of the results and their feasibility in the socio-cultural context in which the vernacular building is found.

Keywords: Vernacular Building, Forensic Engineering, Historic Environments, Sustainable Management, Value Preservation.

1. Introduction

The neo-vernacular buildings in the Spanish Mediterranean basin area tend to adopt contemporary construction solutions which are not entirely suitable, and in most cases are both physically and chemically incompatible with the integrity and preservation of the traditional construction systems and materials. The results are interpreted as constructions of neo-rural aspirations, with a predominance of the social projection of the new imported elements and which aim to achieve better living standards outside the symbiotic, bioclimatic and construction values of traditional housing. These construction activities, which recreate a neo-local external appearance instead of respecting the traditional form of construction and structure, have become important for the livelihood of the local population.

However, up until now the special nature of the region and its relative neglect have helped conserve local character and the individual characteristics of its buildings. Despite all this, an extensive process of research and assessment of the traditional architecture of this enclave is required to ensure its survival in relation to the economic and social changes observed. This kind of inventory should affect the preservation interests of society as a whole and the interests of future generations, often placed above the rights of ownership and temporary property rights of individuals.

The building-specific research work on the complex changing panorama of traditional architecture is followed by a reflection on the possibilities of restoring traditional constructions with contemporary techniques that are physically, conceptually, and visually compatible with traditional materials and techniques.

The main aim of this research was the search for compatibility between the indispensable functional needs in housing and our desire to preserve traditional architecture. To do so, prior knowledge of the origin and historical function of a building is considered as the key factor for interventions adapting local constructions (Fig. 1a-1b).

The hope for long-term preservation of natural, cultural and social assets must include the potential for at least partial replacement as well as new evolutionary processes which help to secure diversity in a broad sense and allow for new development. The intelligent further development of existing assets thus follows when transmitting tangible and intangible values and reasonably long-term usage of the goods and artifacts already existing (Hassler, 2009).

2. Historical evolution of the winery

Throughout the second half of the nineteenth century, while phylloxera spread throughout countries like France or Algeria, conditions in the Spanish region of Alcalatén in Castellón were excellent for vine growing. A process of colonization and plowing had a profound impact on the territorial structure. Hence, between 1895 and 1906 vine-producing regions increased their production by more than 300%.

The high prices of wine (and liquor) remained constant until the late nineteenth century. The invasion of this territory by phylloxera took place around 1905, and in the years that followed vines had to be removed. Subsequently, olive and almond trees were planted, along with vines grafted onto American rootstock. Despite the transformation to which the viticultural activity was subjected, the vine-grape-wine cycle produced a wide range of ethnological tools and constructions which are still preserved in the region.

In order to understand the factors involved in the evolution of the area it is necessary to take into account the inevitable and legitimate social and cultural changes that have taken place in the last few decades. The progressive decline of a rural society based on farming and stockbreeding economies and the development of an industrial society have profoundly changed the aspirations of the local population. The ethnographical objects remain rooted to their past spatial position, with a free mental interpretation made tangible using knowledge, writings, and images which reach the senses and sensibilities of individuals (García-Esparza, 2011. 2). The rural culture linked to local land, landscape, and materials has progressively lost value against an urban cultural model which imports more immediate modern materials (concrete, aluminum, bare brick) as well as aspirations to functional, comfortable and easy access housing.

In addition, the progressively dwindling rural economy and the subsequent depopulation were reflected in the abandonment of buildings connected with rural dwelling patterns (buildings with stables and lofts for garnering food) and with local production (windmills, wine presses, wineries, lime and plaster kilns, bread ovens, etc.). This abandonment has been followed by a process of systematic replacement of traditional buildings that are increasingly obsolete in their function or left derelict through lack of use (Fig. 2).

The new constructions and replacements, which appeared from the decade of the sixties onwards and have increased over the last few years, represent a cultural, material, constructive, and compositional contrast in relation to the agrarian, or even urban, landscape of villages.

But thanks to a series of local development programs, specialized agrarian activity linked particularly to local products and the development of organic farming have been implemented. In addition, the promotion of local development in connection with rural tourism appears to have become increasingly fashionable among travelers fleeing from stressful urban culture, and this demands a neo-vernacular accommodation model linked to concepts stemming from what are perceived as exotic weekends far away from the city.

3. Nature of the construction and landscape

Stone has always constituted the main building material for the rural architecture of this region. Its superabundance and the need to free fields from anything that might hinder plowing have resulted in extensive use of this material. Its immediate relationship with the environment has brought about the integration of rural constructions into their natural tectonic surroundings.

The type of stone characteristic of the region is rough stone or *pedra de tap*, which is low density and normally used for secondary buildings connected with rural tasks, although it is possible to find some spots where homes have been built using this stone. Traditionally, the mortars used in the region were based on gypsum and lime and were sourced locally. According to Cavanilles, their patterns varied depending on the location of the gypsum or lime kilns, and the nature of the site, whether private or public.

The gypsum plaster obtained set so quickly that the rhythm of the building work had to adapt to the material or be combined with a product obtained from firing lime, a process which presented greater complications as it took longer than plaster to attain ideal conditions for construction. These binding materials, along with the local earth which was the most extensively-used material in most of the region's traditional construction, were sometimes combined with straw. Thus, most rural homes were built using rough stone masonry rendered with common clay that would eventually be mixed with a small amount of gypsum and lime.

The introduction of Portland cement mortar in the late nineteenth century meant the start of the progressive abandonment of gypsum, lime, or a combination of both as mortar binders. These were replaced by cement binding materials which provide the mortar with greater mechanical resistance and are more resistant to damp thanks to their hydraulic characteristics (Alejandre, 2002). Nevertheless, cement was probably not used as a binding material for rural constructions before the second half of the twentieth century in the area studied (Fig. 3).

Since gypsum and lime are natural materials, found plentifully in rock form, little energy is required to process them for the use in construction. The use of Portland cement, increasingly popular among professionals, put an end to traditional materials, techniques, and craftsmanship.

Tougher materials, which were also waterproof, but were probably no more durable than the older traditional ones, took over the market. Many of these coating materials restrict or impede air movement through the wall pores. For thermal reasons, when air is expelled, dissolved salts are expelled with it and salt levels are gradually reduced. After, when the temperatures decrease clean air will come in, and in the words of true craftsmen, “the wall is allowed to breathe”. Given their porous nature, little fragments of fired clay added to the mortars provide better permeability, which in turn results in better carbonated lime, and also in a pozzolanic reaction between clay fragments and hydrated lime.

New materials, such as Portland cement or those synthesized from petroleum residues, possess characteristics which allow them to form steam barriers, subsequently causing a concentration of soluble salts within the coatings. This results in the disintegration of the materials which become sandy or develop fissures (Fig. 4a-4b-4c).

4. Restoration methodology

The main source of research of our built cultural heritage continues to be the buildings themselves. Thus, their material preservation and adaptation are considered essential for the conservation of constructions, culture and history. The goal of preserving material data and their legibility has been achieved carrying out conservation work on the existing walls. The preservation of stratification has imposed criteria for the preservation of materials depending on their degree of deterioration, for building techniques (bonding, types of joints, etc.) and for visual aspects (color, texture, etc.).

The entire preservation of the walls with its pathology signals and its original gaps, and the preservation of original spaces, would determine the global physiognomy of the new project. In that sense, in order to provide continuity to the natural history of the building we chose to follow the traditional practice of adding spaces when the need arose for new spaces within the house. The building extension was carried out adding spaces in line with the size of traditional openings and volumes. These extensions sought compatibility with the traditional scale, respecting the original dimensions and appearance of the building and surrounding landscape, and enabling us to understand the original appearance of the winery within the spatial physiognomy of the current construction (Fig. 5a-5b).

4.1. Building pathologies

Depending on the nature of the original construction elements of these facings, the winery was built with walls thick enough to ensure their stability measuring between 50 and 80 cm. Despite the size, the building load-bearing walls were greatly deteriorated owing to its abandonment, which probably took place in the first third of the twentieth century.

The structural elements of the winery had a direct structural purpose. The ground floor was formed by masonry walls which were bonded to greater or lesser standards, and rendered with lime and gypsum mortar in a ratio of 1:1:3. The masonry walls of both façades appear to be structurally sound and show no signs of settlement or any other type of damage. However, the gradual effect of rain has resulted in the loss of most of the mortar that formed the joints of the stone in the more exposed parts. Owing to the building's age, the physical and chemical properties of the mortar, combined with local weather conditions, have caused the disintegration of the inside of the walls.

Other causes associated with the deterioration of the building, in addition to those determined by its specific geographical location, can be closely linked to the orientation of the facings, the effects of the sun or exposure to prevailing winds. The building's stability may also have been compromised by faults in the original construction such as low cohesion due to lack of binding material, incorrect quantities, insufficient water in the mix, or excessive use of mortar in relation to the stone; or mixes that were not designed for excessive loads, particularly if made up of unsuitable aggregates such as loamy sand or sandy clay (Gárate, 2002). (Fig. 6).

4.1.1. Characterization and damage

The process began with a general study of the characteristics of vernacular architecture that allowed us to understand its logical processes and its particular character so as to be able to respect and enhance these during the intervention process. The bulk of the characterization work was carried out using a non-metric digital single-lens reflex camera (Canon D30). This camera has been successfully tested for use in low-cost applications for low and medium precision surveys in archeology, architecture and cultural heritage (Cardenal et al, 2008). With camera calibration, wide angles and normal lenses and using CAD software support we were able to produce a representation of the seriously damaged ruins with one face nearing collapse after decades of abandonment.

After digital characterization, surfaces were visually examined looking for bulges in the wall, either thin or thick, and broken or continuous cracks. Verification was carried out using a small fiberglass bar; as a kind of screwdriver when is used to punch some timber frames looking for termits. Like an endoscopy, the fiberglass bar allowed us to check the depth and mortar disgregation in some cracks without making any additional holes.

The characterization allowed us to find two levels of facing damage: general damage located on all facings, and which corresponded to the loss of joint mortar, inner disgregation forming cavities, and the loss of the coatings. And specific damage, which depended on the facing, and was connected with the loss of some parts of the wall as a result of the detachment of stone through impacts or slumps, or connected with the loss of wall stability because of thrusts and collapse. All the damage and respective repairs will be listed in sections 4.3.1 and 4.3.2 (Fig. 7a-7b-7c).

4.2. Technical discussion

The intervention on the winery walls focused on the physical functions involved in supporting the walls, the chemical functions as regards how the walls' constitution and restoration materials affect the environment, and the rheological behavior of the building in its environment.

The material of the building stock is subject to ageing, depreciation and deterioration; this process can be slowed through constant intervention for value preservation and structural maintenance. A long-term preservation perspective can theoretically be made possible through processes of replacing capital assets (Pearce, 1992). But, the documented reasons for the relinquishment of buildings are less a matter of material ageing and problems of material preservation than the complex phenomenon of obsolescence (Hassler, 2009).

Therefore the main objectives of the work were the following:

- To consider different treatment options for improving the walls' structural behavior.
- To reflect on the suitability of traditional horizontal structures and the adaptation of new techniques to maintain the advantages of their traditionally-crafted status, while improving their resistance and the walls' capacity to withstand stress.
- To test the appropriate application (intensity, tone and texture) of limewash to allow the inside of the walls to breathe.
- To estimate the environmental influence on the thermal behavior of traditional walls in relation to current construction and usage requirements.

4.3. Structural recovery of the facings

Functionality requirements were associated with the building's new use as a single-family home and required a specific distribution of functions. However, it was possible to combine this distribution with the need to respect a historic location requiring guarantees in terms of levels of both physical wellbeing (damp, temperature, safety, etc.) and visual and sensory perception (suitable, presentable, clean, pleasant appearance, etc.).

In order to do so, the preservation of materials has been guaranteed at all times with different treatments according to the situation. The type of consolidation was chosen according to the type of material to be preserved (mortar, stone, etc.) and the project considerations relating to the building's functionality and appearance. As directed by Paolo Marconi, a lime mortar similar to the existing materials was used both for superficial consolidation -4.3.1- and for reinforcement treatments -4.3.2-.

At the end of the process, and following the analysis of the physical and mechanical characteristics of the mortars in the existing construction, the application of a mortar with a 1:3 ratio in its components was decided upon.

- 4 units of hydraulic lime	102 kg/m³
- 2 units of hydrated lime	357 kg/m³
- 12 units of fine sand	614, 90 kg/m³
- 6 units of medium aggregate	345, 88 kg/m³
- 4½ units of water	260 l/ m³*

* Depending on the correct storage of sand and medium aggregate because its humidity.

Lime mortars show faster water penetration than cement mortars but do not tend to retain water within the wall, and thus contribute to a faster drying of the substrate. The type of sand selected can also affect the presence of water. Although sands with a bit of clay can delay water penetration, they also delay the drying of the substrate, and can therefore be disadvantageous (Veiga, 2005).

The aggregate used to prepare the restoration mortar was extracted from a local quarry, while the stone was gathered on the land surrounding the building. The masonry walls of most façades appeared to be well-preserved and did not display any signs of settlement or damage of any other sort. However, it was necessary to strengthen the handmade mortar, at least its minor imperfections, as is explained in the text below.

4.3.1. Filling of facings

a) Deep filling

The filling of cavities, generally caused by the internal degradation of the wall and the disintegration and lack of cohesion of the traditional mortar, has been carried out on all the facings of the winery using the mortar described previously with the same dosage but without medium aggregate. Once these had been filled as described, the visual appearance of the facing was hopeful compared with its prior status (Fig. 8a-8b).

The intervention consisted firstly in moistening the facing walls prior to applying the repair grout. This was essential to ensure suitable adhesion and preserve the water present in the mortar composition, without taking any water from the mortar or transferring it to the wall. Once the facing had been moistened with normal water free of potentially harmful mineral charges, we proceeded to fill the existing cavities (derived from mechanical or erosive actions) in the walls, subsequently carrying out selective jointing in the voids of joints and layers, respecting the existing mortar of the joints.

The aim of these repairs was the geometric and mechanical recovery of the masonry's structural capacity by inserting fluid lime grouts without any sort of hydraulic component or filler to achieve a grout which, in the long term and with the occasional presence of inner humidity, provides the wall with a minimum content of water-soluble salts. The grouting was distributed from the base of the walls up to an approximate height of 2.50m. The grout was inserted into holes of variable diameters depending on the openings caused by the erosion of the original mortar, their depth and direction in relation to the cavity generated naturally by the erosion, and the internal disintegration of the mortar that joined the two leaves composing the stone facing structure.

Once the injected grouts hardened, the facings were cleaned with water to remove excess superficial mortar and to re-hydrate the masonry. The grout was applied at an environmental pressure of 1 atm, in order to avoid placing excessive pressure on the original mortar and stone, and to help these to recover cohesion and be hydrated so that some original lime particulates could carbonate again.

The need to ensure the deep filling is connected to the load-bearing capacity, given the presence of thicker and disintegrated mortar joints which cause a severe reduction of the compression resistance of the walls. When testing and graphically analyzing the cracks at the beginning of the intervention we took note of them and classified them in accordance with their depth and direction to survey the execution. To control an accurate execution non-destructive testing was carried out, and in some cases, this was done using two separate methods as a result of occasional leakages:

This was done manually, by introducing a long thin nail in a repaired crack, making a narrow hole in which a glassfiber bar was introduced to check whether the crack was hollow or had been filled in. When manual testing produced no clear results, sonic testing was used to verify the increase or decrease in sonic velocity, relating it to the highest or lowest quantity of grout (Porto et al. 2004) (Fig. 9).

b) Superficial filling

Although they did not endanger the stability of the constructions the existing grooves, with an average width of 5 to 10 cm and little depth, made the ensemble appear ruinous and weakened, at least to the naked eye. The filling of grooves was carried out mainly on the outer curves of the facings, using the same lime mortar as was used for the previous operation. Care was taken to leave the filling on the same level as the original mortar of the construction, that is, slightly sunk compared with the plane of the stone facing. The visual impression of the repaired facing changed completely, since the grooves were no longer seen as open wounds and were integrated into the facing as old dignified scars of its history.

4.3.2. Partial reconstruction and reinforcement treatments of existing facings

- Double-faced walls; *Opus Emplectum: Incertum*

In order to maintain a clear differentiation between the original body of the traditional construction and the new spaces added, the double-faced walls were preserved from the walls of the historic winery which had lost a major part of their volume. In order to do so the base of the wall from which the new building work would start was prepared by suitably cleaning the original mortar which was in bad condition (Fig. 10).

The repair of the existing walls was carried out with well-settled masonry faced with suitably-shaped stones, and rendered with the lime mortar mentioned earlier to refurbish areas that presented an irregular or broken up mesh. In any case, a large portion of the existing walls was repointed. In areas where the stone had come loose these were replaced with others in a similar size to avoid using other materials unsuitable for the traditional method, which could cause deficient structural settlement and collapse in the long term (Keefe, 2005).

Special attention was paid to reconstructing specific cracks, connected with slight collapse, provoked by occasional thrusts. The specific case of a south-west facing collapse showed a serious crack above which masonry walls were meant to be built up. After checking its stability and ensuring that the resulting mass center of the wall was within its base, we decided to preserve the collapse as a historical feature (Fig. 10a).

To start the volumetric recovery task, a fictitious edge was drawn to act as a guide. Existing wall surfaces that would be in contact with the new masonry walls were prepared. After cleaning them, the walls were intensively moistened to prevent them from absorbing water from the fresh mortar since this could lead to rapid hardening.
Next, we looked for good horizontal settling on which to support the first stones which were to act as the base for the remaining rows of stones in the new building unit (Fig. 10b).

To achieve suitable jointing between the cracks, and to reinforce the joints between old and new building units, some stone rows were fixed using stainless steel rods screwed into the existing mortar with micro-drillings and grout fillings. The new building unit was held together by the rods within the fresh mortar which pressed the rods once hardened. The collapsed wall was also reinforced with a peripheral ring as part of the first floor reinforcement, as the text explains below (Fig. 10c).

4.3.3. Total reconstruction of non-existent facings

Single-faced walls; *Opus Emplectum: Incertum-Testaceum*

In the areas with newly-built facings and additions to the old winery a wall composed of three leaves was used, first, an outer one in masonry to maintain the homogeneity of the built ensemble and the traditional building character in keeping with the landscape; the second internal one in solid brick, which offered advantages in terms of speed and cost for the execution of the work in comparison with stone; and the third which was to join the first two with lime concrete applied as repair mortar in the same dosage but using an aggregate with greater granulometry.

4.4. Distribution of stress on the walls

Traditional floors in the area are based on a supporting structure formed by wood joints laid out between the facings forming a horizontal plane with parallel elements in a single direction every 60 cm approximately. The free space between these elements is filled with small solid brick longitudinal vaults measuring 24 x 12 x 3 cm and rendered with gypsum mortar. Once the vaults are completed a smooth layer of gypsum and lime mortar with an approximate thickness of 4 cm is added to homogenize the surface.

When dealing with a deteriorated original facing this traditional technique provides the advantage of being light when it comes to distributing permanent stress on walls, but it is not a suitable bracing solution for the ensemble of the walls, for the distribution of stress, or for the behavior of the construction in the event of an earthquake.

Given the lack of traditional floors due to their loss or disappearance over time and the relative elasticity of the binding material of the facings, the new floor to be laid required a certain amount of isostaticity as well as improvements on the traditional solutions for the distribution of loads and bracing of the facings.

The solution was decided in order to preserve the supporting function of walls, with the goal of sharing new loads resulting from the floor, which involved additional vertical strain efforts for walls not designed to withstand these extra loads. The solution of the new floor meant weight could not be placed on walls with a hyperstatic floor with heavy concrete components or floors that distributed concentrated loads like the beams and joints of the traditional wood model.

The solution adopted was a reinterpretation of the traditional floor with a metallic structure anchored to the walls using a perimetral element to receive the end of the joints and anchored to all facings in order to optimize the distribution of the new stresses (García-Esparza, 2008) (Fig. 11a-11b).Although the innovative metallic structure was used, the ribbing of the floor followed the traditional technique still in use in the area, which had the advantage of being extremely light in comparison with any other modern solution.

4.4.1. Floor structural considerations

Solution analysis:

Usually, traditional floors are reinforced with a concrete layer over the existing frame.This solution was rejected as the effects on traditional techniques are far too drastic, specifically because of the addition of water to the existing gypsum vaults and to the wooden joists. In addition, the solution, far from helping the existing joist, resist its flex deformation, puts considerable weight on the frame. And, moreover, for this solution to be feasible, all facings have to be drilled to support the concrete layer.

Adopted solution:

The reason for adopting this kind of reinforcement was the need to preserve materials and old techniques, also in terms of appearance. The proposed intervention allowed us to respect this with the lower portion preserving the historical roof elements and all the original walls. The reinforcement was carried out using a specific longitudinal joist reinforcement to raise the transversal joist section considerably and to level the entire flexed joist horizontally.

A complementary reinforcement consisting of 3 cm plywood boards covered the entire floor. The need to connect all facings to provide greater cohesion between them was satisfied by anchoring metallic L-profiles to the whole perimeter where floors and facings met. In parallel joist facings, we made allowance for eventual flex movement using an isostatic anchoring in addition to the hyperstatic anchoring in perpendicular faces, just to reinforce the sharp effort in joist heads.

To calculate the stress and ultimate limits state produced for an average maximum span of 4m:

Floor self weight: 1.50 kN/m²

Need overload: 2.00 kN/m²

Security coefficient: 1.44 kN/m²

$$M= [(3.50 \times 4^2) / 8] \times 0.6 = 4.2 \text{ mkN}$$

$$\sigma_{m,d} = [(4.2 \times 10^3)/ 740] \times 1.44 = 8.17 \text{ N/mm}^2$$

Self weight: 1.50 x 0.6 = 0.90 kN/m

$$M= (0.90 \times 4^2)/8 = 1.8 \text{ mkN}$$

$$\sigma_{m,d} = (1.8 \times 10^3) / 740 = 2.43 \text{ N/mm}^2$$

Board weight: 0.50 kN/m²

Flooring and partition walls 1.00 kN/m²

Overload: 2.00 kN/m²

Each joist: (3.50 x 0.6) = 2.10 kN/m

$$M = (2.10 \times 4^2)/8 = 4.2 \text{ mkN}$$

Lower tension stress considering 15cm joist diameter:

$$\sigma_{m,d} = [(4.2 \times 10^3) / 70613] \times 15 = 0.89 \text{ N/mm}^2$$

The maximum stress of the joist with the reinforcement is:

$$\sigma_{m,d} = (2.43 + 0.89) \times 1.44 = 4.78 \text{ N/mm}^2$$

4.4.2. Structural considerations for walls

Once the stone resistance resulting from joint thickness and mortar composition is known, load-bearing resistance is estimated at 1/10 (Huerta, 2004) in relation to that of the stone. Suitable conditions for mortar after its consolidation through superficial and deep filling prevent cavities which could provoke cracks or differential settlements.

- Stone compression resistance: 30 Mpa – 293 kg/cm²
- Estimated load-bearing compression resistance: 293/10 = 29.3 kg/cm²

Considering the whole load:

Floor self weight:	1.50 kN/m²
Board weight:	0.50 kN/m²
Flooring and partition walls	1.00 kN/m²
Overload:	2.00 kN/m²
Total load:	5.00 kN/m²

- 8 support points (existing joists)

Considering the existing quadrangular frame of 4 m² and 8 joints to support it, we have 8 supports in a load-bearing wall for 8m².

TI = 5.00 kN/m² x 8m² = 40.00 kN / 8s = 5 kN/s
*s = Support

Joints

Considering the surface of each support to be 15 cm²:

JI = 5 / 15 = 0.33 kN/cm² = 33 kg/cm² *

*JI = Load in joint head

- 16 support points (existing joints and new anchors)

If the L-profile is placed with 8 more anchor points between joists, the load in joist heads will be divided by half; JI = 40kN / 16s = 2.5 kN

Joints

Considering the surface of each support to be 15 cm²:

JI = 2.5 / 15 = 0.16 kN/cm² = 16 kg/cm²

Anchors

Considering the surface of each support to be 10 cm²:

AI= 2.5 / 10 = 0.25 kN/cm² = 25 kg/cm² *

*AI = Load in anchors

* Still inside the boundaries of load-bearing compression resistance, an extended anchoring area is recommended to avoid high load concentrations.

4.5. Properties and preservation of old coatings

The project aims to maintain existing construction techniques and repair coating materials whenever necessary in accordance with tradition and using compatible modern materials (García-Esparza, 2011. 1). Throughout the region it is possible to observe recent interventions of exterior restorations of facings in other traditional constructions, consisting mainly in the systematic removal of layers of traditional covering or, in the best cases, a new rough-rendering with cement mortar which prevents old constructions from breathing properly, causing the appearance of Portland soluble salts when in contact with water.

The planned intervention maintained the external traditional gypsum and lime rendering in keeping with its original state. In the instances where the traditional plastering had been preserved a simple cleaning and consolidation operation was carried out, and wherever there had been losses or new additions, these were repaired using a mortar similar to the original. This type of intervention enabled façades to preserve their original transpirability and a whitish appearance from the lime and gypsum which in time would turn red because of the earth and rain transported by the wind.

Inside the building the wall surfaces presented varying degrees of preservation. Some renders were completely stripped without any sort of coating and no mortar between stones while others, in contrast, conserved the original coatings in their integrity. Two very different protection techniques were therefore used depending on the state of preservation.

4.5.1. Limewash on facing

In the case of the better-preserved facings, once filling had been carried out, a whitewash (1 part lime for 6-8 parts water) was sprayed on in three successive layers, letting each one dry before applying the next one. In this case limewash application had to be done in varying degrees depending on the base material, as the varying absorption and reactions of materials could be observed with subsequent differences in appearance once they had been treated. This superficial hydration of the facing favors the carbonation of the new lime particles provided to the surface of the original rough casting, encouraging a greater hardening of the support.

4.5.2. Rendering on facing

The same composition was used for rendering as for joining, restoring the surfaces, and filling and repairing cavities.

Once the work needed to ensure the smoothness of the render had been carried out this was applied in two successive layers: the first or base coat with a trowel and coarser aggregate, and the second rendered with a finer aggregate, pressing with the trowel to compress the mix into the render and obtain a smooth surface. Applying coatings in several thin layers is much more effective than one thick layer, as the ability to dry is greater and it delays water penetration (Veiga, 2005).

The need to coat the facings externally is closely tied to the protection of stone that is physically or chemically unstable from exposure to extremes of heat and cold, or the biological aggressions of micro and macro vegetation. The need for interior coatings on the facing is directly linked with the compacting action, a rapid and energetic application of layers of mortar to compact the facing by joining its components and reducing interstitial spaces (Gárate, 2002) (Fig. 12a-12b).

5. Environmental and economical reflection on the intervention

Finally, traditional masonry walls and new interventions in old buildings must take their materiality into account, as well as their optimal intervention as regards environmental and local social sustainability. In this respect intervention is proposed to counteract the high percentages of building energy consumption (Bloom, 2011), to reduce the energy use of all households which constitutes approximately 25% of the total annual energy use of the EU-25 countries (Eurostat, 2007). The global physiognomy of spaces and the presence or absence of gaps on façades will determine the bioclimatic conditions of the new building.

In terms of thermal inertia and insulation, new constructions of partitions consisting of brick walls with air chambers and insulation materials are replacing the traditional masonry-wall constructions following the neo-vernacular models explained at the beginning. Unlike what happens in cities, in rural areas thermal inertia becomes a key factor for buildings that are exposed to the elements. While the new facings work well as thermal insulation for short-term stays in these buildings, the thermal inertia of masonry walls is perfect for adjusting and maintaining the internal temperature of the building in the long term. While in summer solar radiation is not strong enough for the heat to reach the inside of the building, in winter the cold slowly penetrates until it counteracts the heat accumulated by the walls during the day.

Even so, the inside of very thick walls is not heated or cooled during a daily cycle. Only part of the wall stores heat since it usually has low conductivity (for instance, approximately five hours are needed for heat to pass through 20 cm of a masonry wall). Tests have shown that the most suitable materials are rock, concrete, and ceramic, in that order. The construction mass can therefore be used to store heat and regulate the fluctuations of the inside temperature. Thus, excessive thickness can reduce the performance of walls, since the heat accumulated causes temperature increases in the walls before being emitted into the atmosphere.

In this sense, the thickness of the walls carries out two different functions. The first of these is suited to the stress that the walls have to endure, and is within the acceptable range for resistance to eventual seismic movements in accordance with the low scale of exposure of this Spanish Mediterranean basin area. But the walls were not constructed for this specifically. In fact, in order to ensure that the vertical compression efforts from the vertical framework were evenly shared the thickness of the walls was in direct proportion with their height, the irregularity of the rough stone, and the low mechanical resistance of mortar.

The second function is directly connected to the local environment. Temperatures in the inland zones of the Mediterranean basin area range from -10ºC in winter to +40ºC in summer. Taking this range into account, the building ensures an inside balance between 0 and 5ºC for minimum temperatures and 20 and 25ºC for maximum (without artificial heating or cooling mechanisms). Liu (2011) studied summer temperature behavior in specific vernacular dwellings from Yaodong, where external walls, with a thickness ratio between 0.6m and 0.8m (like our winery) and variable external temperature between 18 and 40ºC (like our summer season), result in a constant inner temperature of 25ºC.

Thus, intervention criteria should aim at a suitable balance between the legacy of the past and new building usages that require better lighting inside the house. Accordingly, the size of the openings must take into account solar radiation on winter days, which allows walls to store high percentages of energy, slowly giving this off when the temperatures drop at night. This is a factor in the concept of autonomous houses introduced by Vale and Vale (2010) which establishes a parallel between house size and energy consumption. In fact the walls/openings ratio in facings is also involved in the optimum incidence of solar radiation for the provision of light and heat.

For this reason, the old winery was preserved with its traditional openings on the north and west faces for ventilation purposes and to ensure a summer space where the maximum temperatures do not exceed 25ºC on the hottest days, taking into consideration a proper understanding of how to ventilate and refresh the spaces. The added building, on its south side, was specifically designed with big openings to ensure the entrance of the low-level sunbeams for the winter season. In addition to this, the house electricity is provided by solar panels without any other support and the house is heated with radiant floors connected to the traditional fireplace. The house obtained an A energy rating (4,5 $KgCO_2$ /m² year) using Cerma, the software developed by the Universitat Politècnica de Valencia.

Conclusions

Following the restoration process, the former winery became a twenty-first century house. Given the stringent building regulations applied to housing of such great historic value, and in order to conserve and convert it from an old winery to comfortable housing, several compromises have to be made between the preservation of the existing vernacular techniques and the building's finishes. Despite the difficulties of the building program, weights, loads, stresses, as well as installations, openings, etc, the refurbishment which is currently being completed shows that it is in fact possible to preserve the vernacular techniques and architecture of the region, not only in the case of town centers or rural settlements, but also in the case of ethnological heritage, with more complex programs of needs and infrastructures.

In fact, the intervention on the facings and frames of the winery was not exclusively directed towards their preservation. The intervention was related to an attitude of respect and reverence for the site, thus the intention was also to program a pilot intervention which would raise awareness in the rural society and among local builders of the need to intervene with specific prior knowledge in favor of the physical integrity of the ethnological heritage, and of the economy and the environment in accordance with the choice of certain building systems. In this sense, Europe's cultural heritage is also a basic part of the daily surroundings of many people. In most cases it is necessary to resort to a creative approach in order to invert the trend of neglect, deterioration and destruction found in many regions, as well as to be able to pass this heritage on to future generations.

Accordingly, interventions for the preservation of ethnological construction needs to be valid social and culturally, must be economical to ensure that many people can get it, should ensure the preservation of the health of its occupants and there must be a minimum of maintenance over its life. Nowadays the latter values are largely ignored, and even misleading, for the population. Finally, the suitable consolidation of these traditional and minority buildings highlights the importance of raising awareness using techniques forgotten by some and unknown to others, this results in better training for builders and a more educated local population, and so encourages awareness in the face of the continuous erosion of the local identity (Fig. 13).

Acknowledgements

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The drawings for figures 1a-b were provided by students of Architecture at Universitat Politècnica de València.

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FIGURE CAPTIONS

Figure 1a. External appearance of former winery with direct access at upper level to pour the grapes into the wine vat.

1b. Interior of former winery housing a three-meter square wine vat (covering the entire right-hand side of the ground floor).

Figure 2. Inner face of the upper portion of the south-west wall, showing damage to both sides of the wall, the loss of mortar and stones and the loss of some parts of inner coatings.

Figure 3. Mineralogical analysis of a mortar sample using X-ray diffraction.

Figure 4a. Schematic drawing of masonry wall without coating.

4b. Schematic drawing of masonry wall with new external coating and old internal coating.

4c. Schematic drawing of masonry wall with external deterioration caused by soluble salts.

Figure 5a. Floor plan distribution of the former winery. Shaded walls were repaired and non shaded were rebuilt.

5b. Floor plan distribution of the new home showing the addition of no more than 20% of new walls compared to the original ones.

Figure 6. Metric survey of winery facings in their original condition.

Figure 7a. Upper section of north-east facing wall showing the double wall leaves, the irregular bonding, the lack of cohesion and the loss of j mortar from the joints.

7b. Masonry loss on upper section of north-west facing wall as a result of collapse. The wall conserves its original external coating.

7c. Partial collapse in join between south-east and south-west facing. Stone breakage of up to 10 cm.

Figure 8a. Open crack in south-east facing, given its superficial nature it is not particularly relevant. It was preserved as it was found.

8b. Repaired crack on inner side of joint between south-east and south-west facing. Original coatings were preserved from both facings.

Figure 9. Quantity of grout injected. Darker shaded areas show highest density grouting and lighter shaded areas show the existing joint mortars. Lines indicate sonic velocity.

Figure 10a. North-west facing showing the traditional building unit recovered for contemporary one.

10b. External volumetric recovery process for joint between south-east and south-west facing following collapse.

10c. Type of joint used between the original building unit and the contemporary one.

Figure 11a. 3D CAD drawing of the reinforcement solution adopted for the traditional frame of the winery.

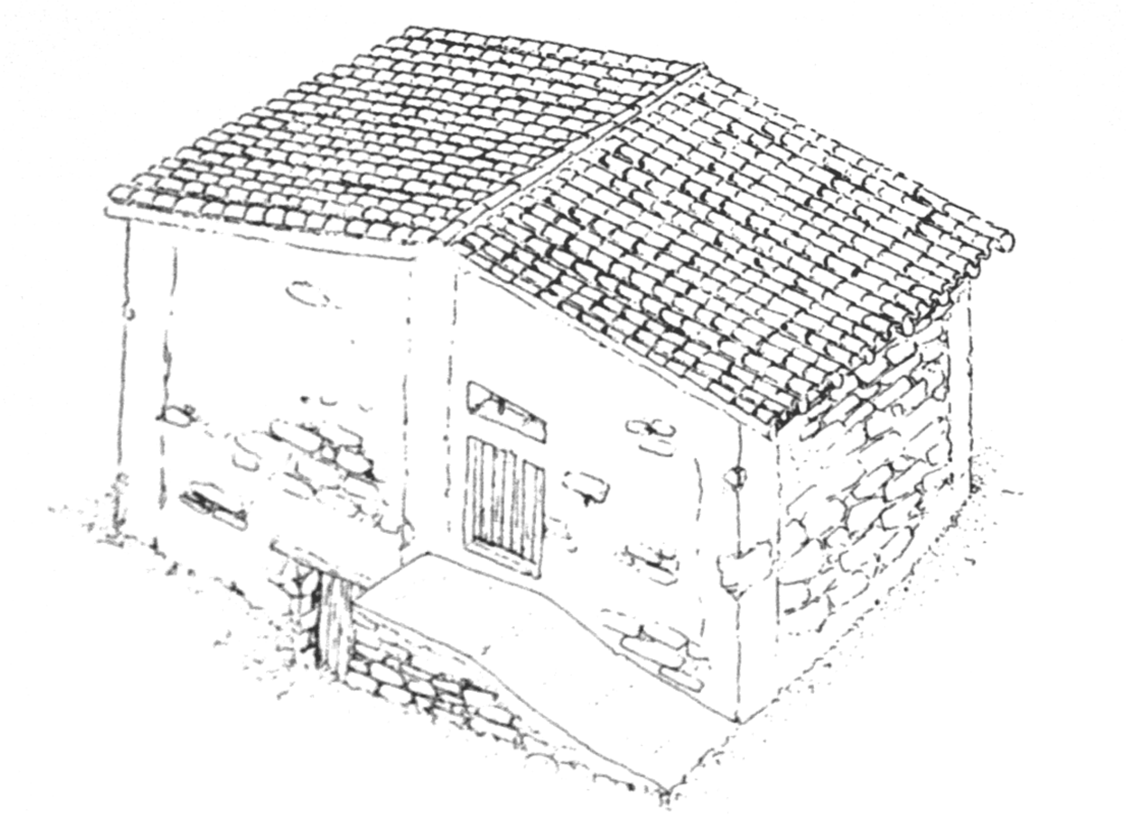
11b. Part of the reinforcement on the upper side of joist. Plywood and peripheral metallic rings are placed on top.

Figure 12a. Coatings of the former winery, testing new consolidations with different layers of limewash varying in density and color.

12b. Coatings of the former winery, cleaning and restoring those on the wine vat.

Figure 13. East face of the restored masonry of the winery, maintaining the original facings and the pitch of the original roof.

Figures



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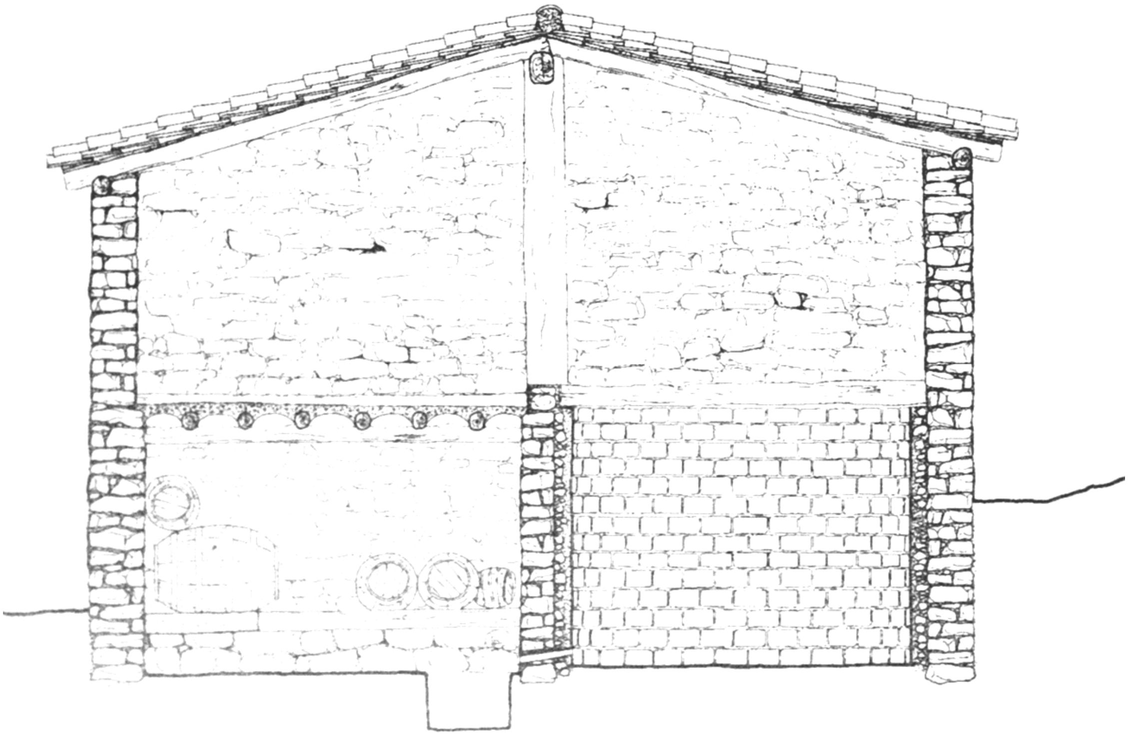

Figure 1b

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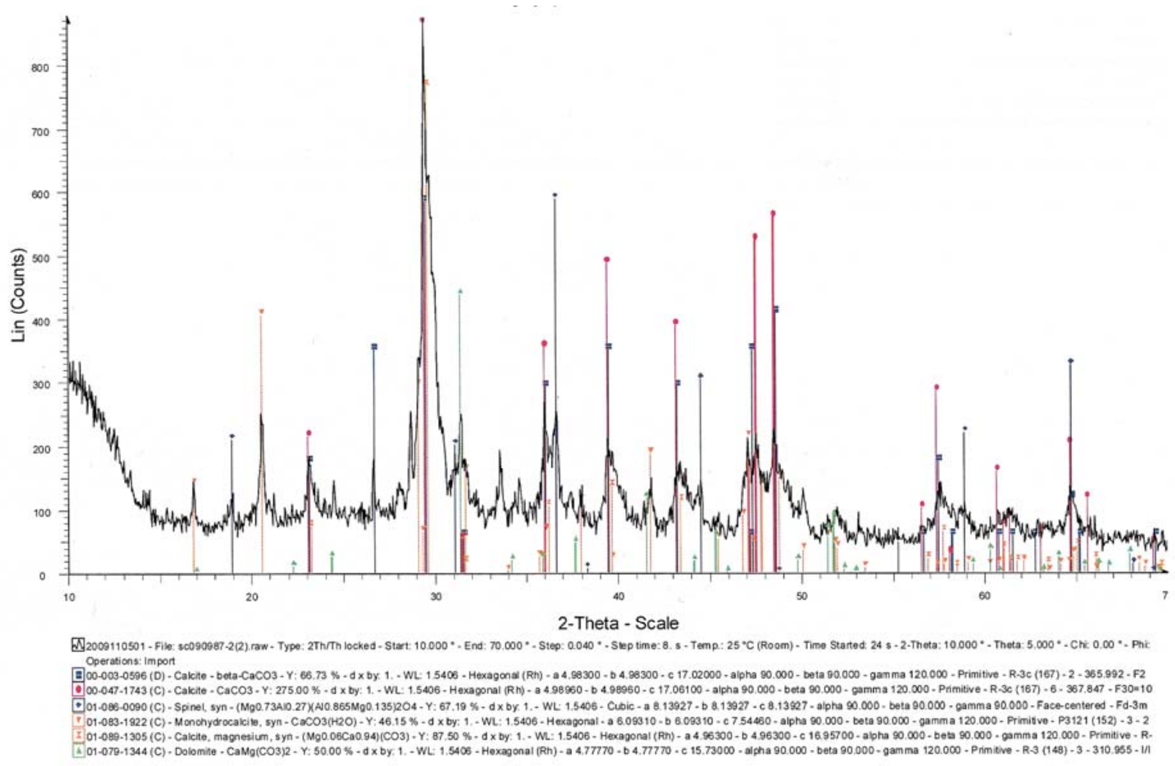
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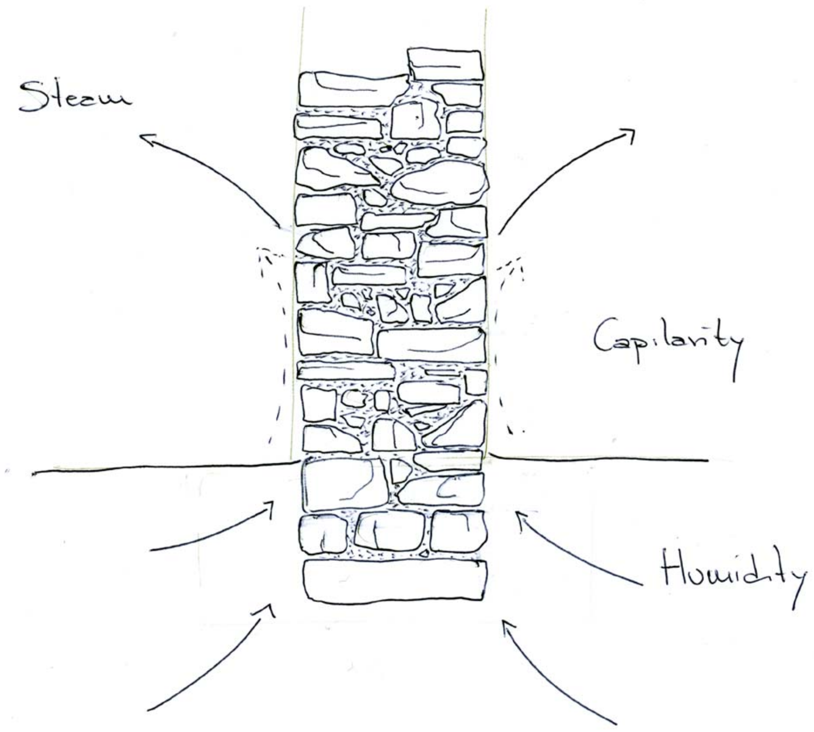
Figure 3.



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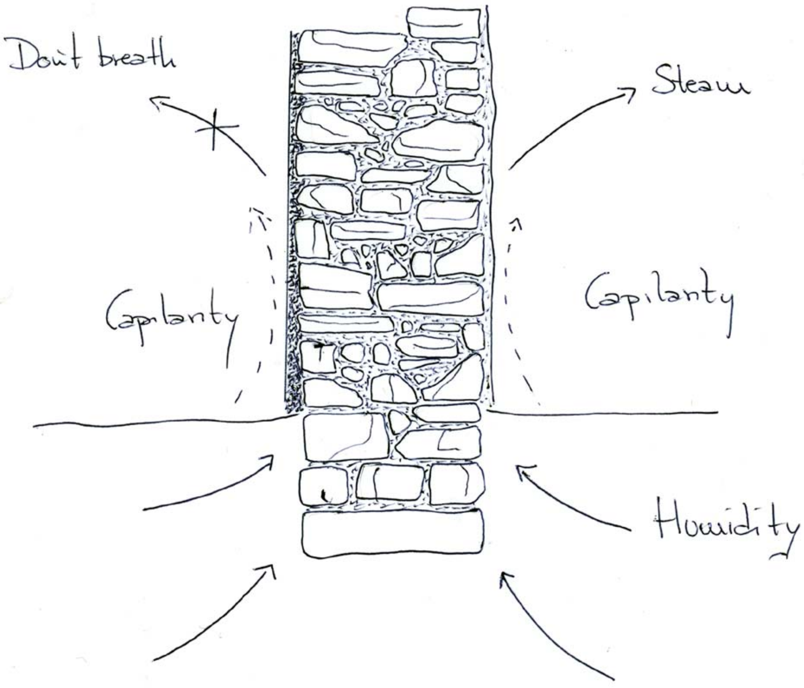

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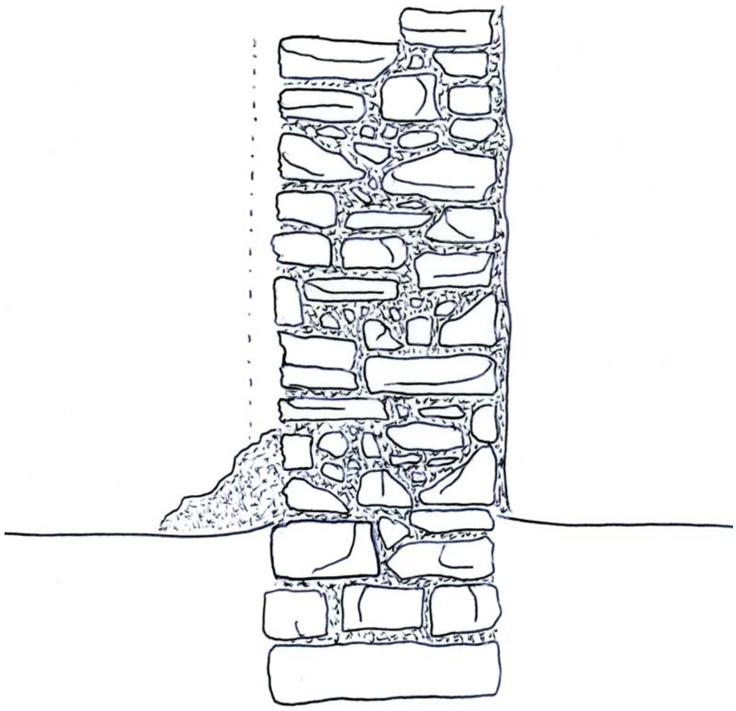

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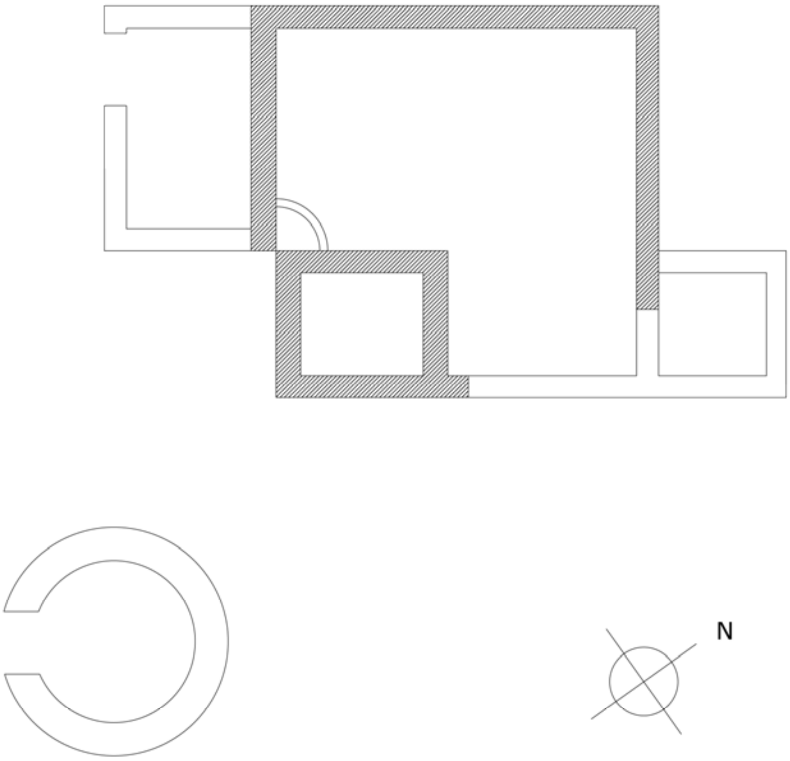

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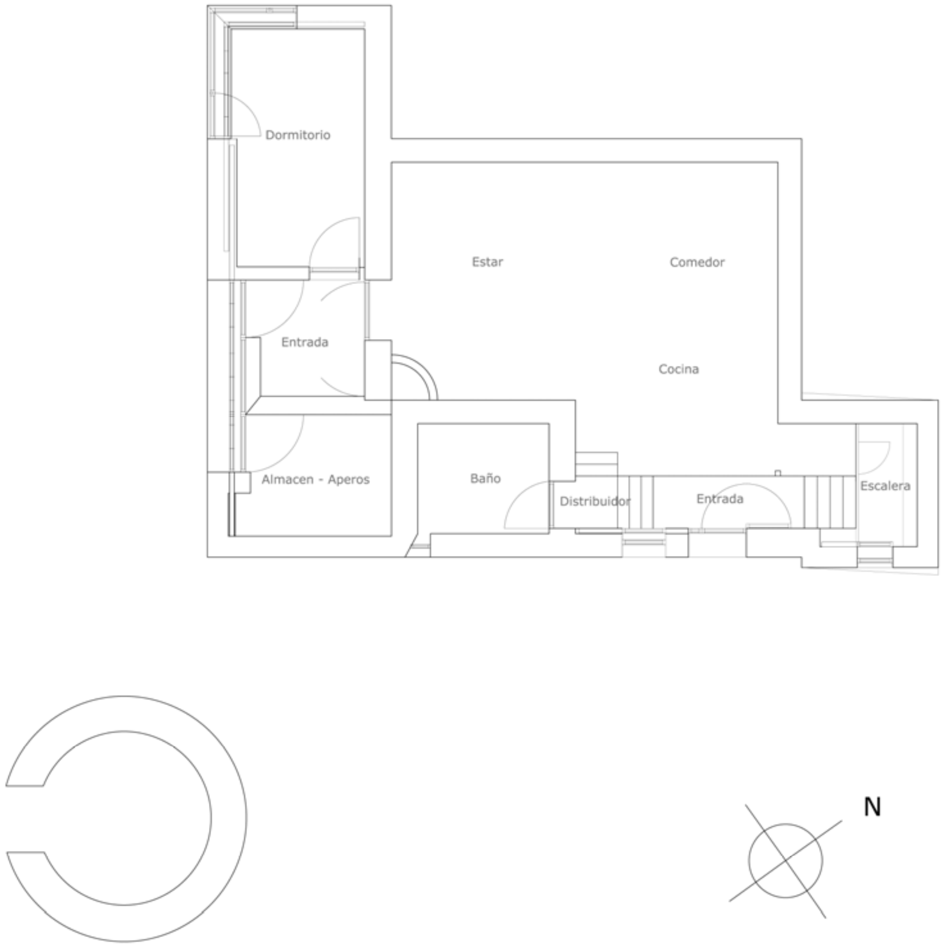
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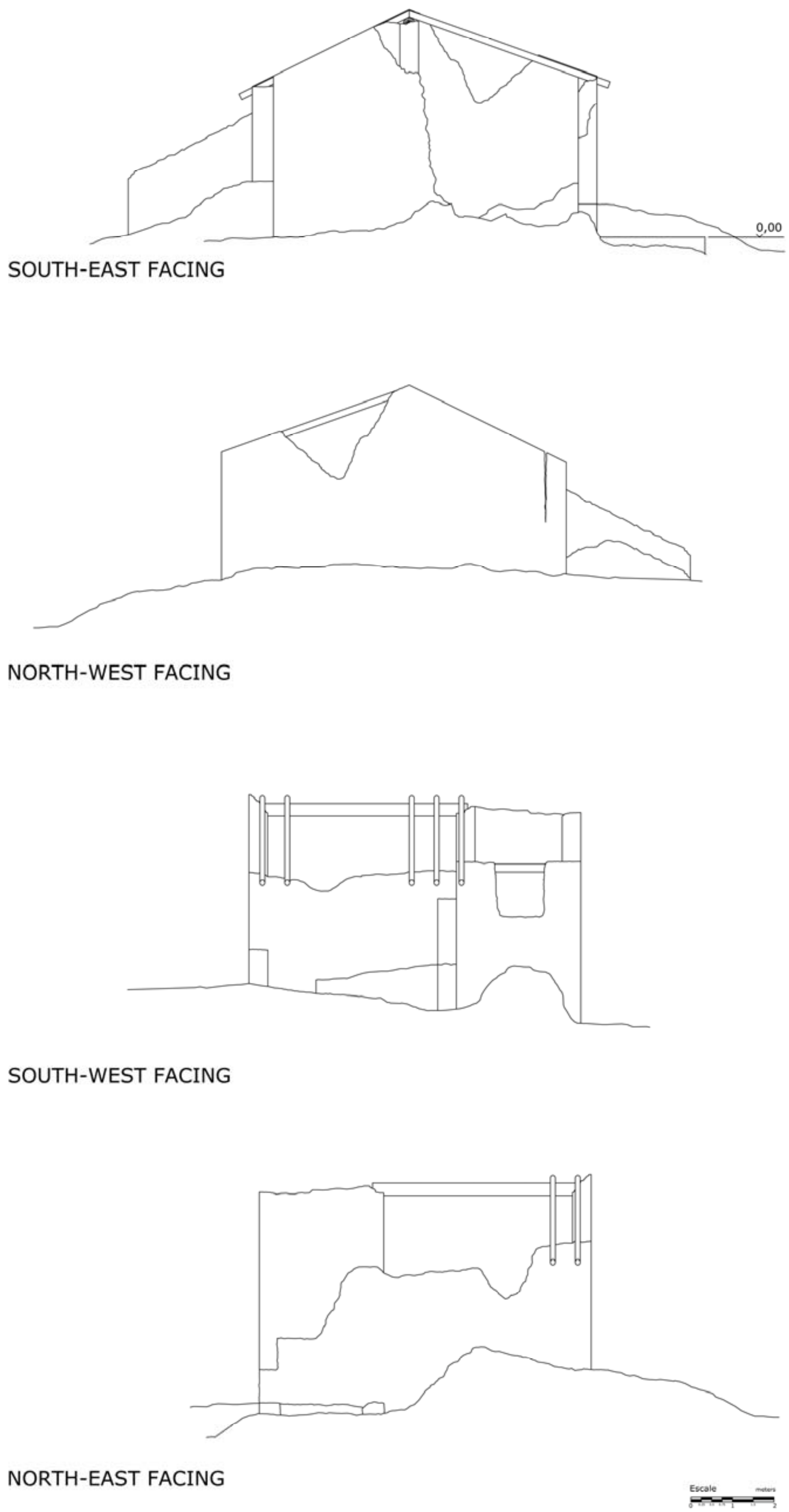
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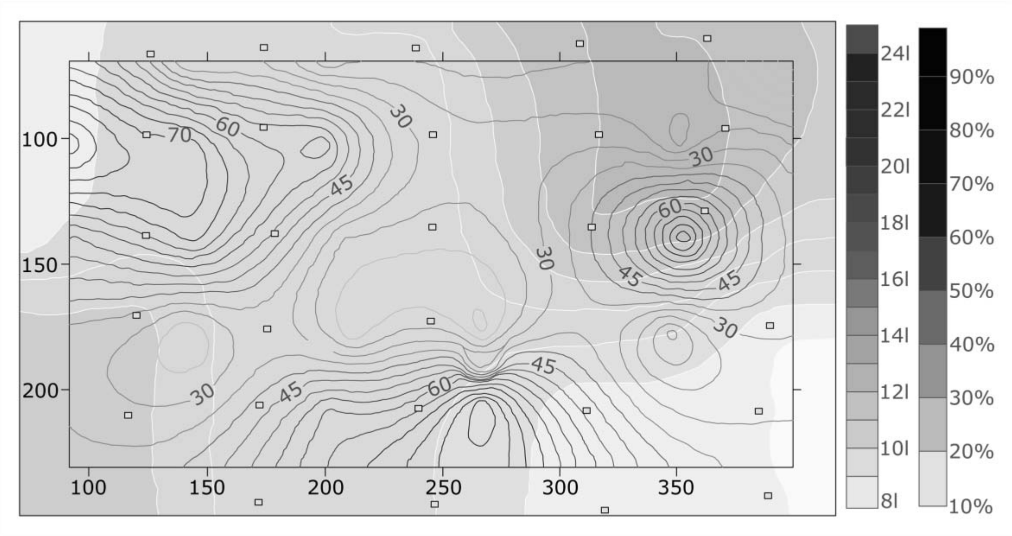
Figure 7c

Figure 8a

Figure 8b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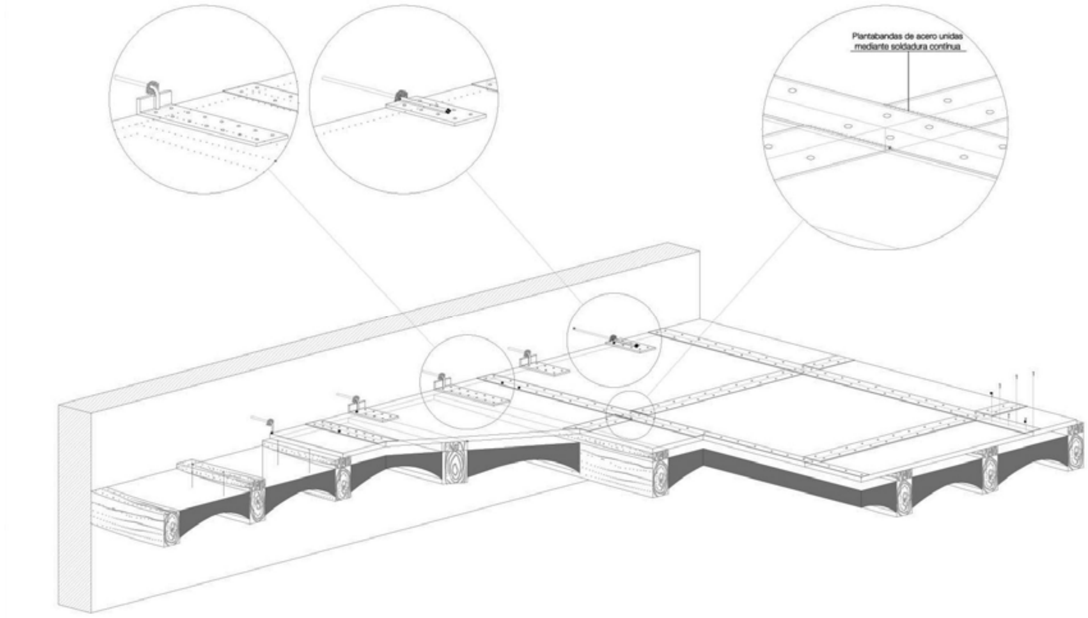
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Figure 11a

Figure 11b

Figure 12a

Figure 12b

Figure 13