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# Farmhouse interior restoration in bioconstruction

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***Abstract***
*The presented project deals with the interior design in bioconstruction of a family home, being a third part of the surface of an agricultural farmhouse named "Ca l'Amell", in the municipality of Premiá de Mar, in Barcelona. Founded in 1848, it is classified as a cultural asset of local interest by the Catalog of the Environmental and Historical Architectural Heritage. The purchase of the entire farmhouse has been carried out by three families through a "micro co-housing" process: they split the cost of the purchase of the entire property and then divided it into three independent units.The object of this work is the interior design of one of the 3 housing (U3), that has been carried out by recovering traditional construction techniques and materials, respecting the original character of the vernacular architecture of the agricultural farmhouses in the area. To achieve this objective the project is based on using natural and highly breathable materials (instead of synthetics) like hydraulic lime plasters, clay plasters, silicate mineral paints, recycled cotton fiber as internal walls insulation, natural waxes. Construction solutions and finishes respond to the need to control the excess of indoor relative humidity and the transfer coefficient in exterior walls, achieving a comfortable environment and taking advantage of the great qualities of the thermal mass inertia of the old vernacular constructions. At the same time, the aim was to use non-synthetic materials with a content of volatile organic compounds (VOCs)as low as possible. In the interior design project, aspects of habitat psychology have been considered too (study of color tones appropriate to the image of the farm and in accordance with the nature of the environments) responding to the need to maintain the interior warmth of the original construction.*

***Keywords**: restoration, bioconstruction, clay, lime*

## 1. Introduction

The purpose of this project is the restoration in bioconstruction of a part of an existing agricultural farmhouse located in the municipality of Premiá de Mar (30 Km north of Barcelona, in Catalonia, Spain), listed as a cultural asset of local interest by the "Catalogue of Environmental and Historical Architectural Heritage". The farmhouse was built in the mid-19th century and it was used for agricultural purposes and for cultivation of flowers. The building has a rectangular shape, with a total constructed area of 570,30 m² and it consists of a main unit in the center and two adjacent warehouses on each side. The main house is developed on two floors, and the two warehouses are developed only on ground floor, with a double height space. The main house has a gabled roof, and the sides have a single slope roof. The main facade of the farmhouse is oriented to the southeast. The building is surrounded by a garden; the whole plot of land has a total area of 1.682m².
The purchase of the property has been carried out through a "micro-cohousing" operation, by three families, who together have adquired the whole farm and took responsibility of the cost to

reform common elements. Then the property was divided into 3 units (one for each family) called U1, U2 and U3.
Once the common elements were refurbished, each family commissioned the interior design of their own unit: my professional assignment and object of this work has been the development of the interior design project of Unit 3, on the east side of the farm. My task as interior designer was to detail the layout of interior spaces and quality of the finishes of Unit 3, choosing all the materials and planning for construction techniques. From the first sketch, the interior design project respects the vernacular character of the original construction (Fig.1): by my own criteria it was very logical to start proposing the use of natural materials (clay and lime plaster, stone, mud, brickwork, untreated wood), due to the intrinsic characteristics of the construction and with the goal to defend its rural and agricultural physionomy.

Fig. 1. Historical picture (Source: "Premià de Mar Historical Architectural Environmental Heritage Catalogue", 2010)

From the very beginning I proposed to introduce bio-construction criteria for the finishes, considering that the use of natural materials and traditional construction techniques is the best way to keep alive the vernacular aspect of the building I was going to renovate. For the owners (a young family with their daughter) it was very important to maintain an intimate connection between the farm and its surrounding nature.

Fig. 2. Original state of the property: interior of the main house in U3, with the wood gabled roof (Source: Li Puma, 2021)


Fig. 3. Original status of the property, with the division in 3 units: U1, U2 and U3 (Source: Li Puma, 2021)

## 2. Project contents

### 2.1 Location, layout and requirements

Unit 3 is located on the east side of the building (Fig.3) and developed in two clearly identifiable parts: the old barn (on the left side, rectangular in shape and 5x10m in plan dimensions) and the peasant house, on the right side (6x14m). The area of the barn is articulated on two levels and is volumetrically included in the main body of the property, sharing a gable roof with the other units; the peasant house is on a single level and is therefore lower than the rest of the building, and it has only a single-pitched roof. (Fig.4)

Fig. 4. The Unit 3 project: ground floor, first floor, main façade, longitudinal section. On the left side of the building: the barn. On the right, the peasant house. (Source: Li Puma, 2021)

The new interior layout of the house is composed by common areas on the ground floor (entrance hall, staircase, living-dining room, kitchen), master bedroom with integrated bathroom, dressing room, toilet; on the first floor there are two single bedrooms with bathroom, separated by a hall. The main access to the house is on the east façade. In the entrance hall, in front of the door, there is the staircase leading to the upper floor. All the main rooms, due to good orientation, benefit from very favourable lighting and natural cross ventilation conditions.

The interior design proposal responds to the family's need for large and fluid meeting spaces, a few intimate corners, a generous and well connected kitchen, small work-study areas and a fireplace that will undoubtedly be the heart of the home: organic, warm and welcoming, with the possibility of sitting close to the fire and the floor. The use of warm and tactile materials, neutral tones and natural finishes like clay, lime, terracotta and wood create continuity with the original materials. At the same time, the physical properties of those materials have been checked (consulting their commercial data sheets), to guarantee the performance required by the current Spanish regulations and to ensure that all the constructive solutions will comply with optimal thermal and hygrometric values. The proposed finishes are summarised below:

- Floors in the living/dining room area: terracotta tiles. The use of underfloor heating has prompted the decision to use a handmade terracotta floor laid with pure NHL5 lime mortar, to enhance the effect of radiant heat;

-Floors in kitchen and bathrooms: ceramic tiles

-Floors in bedrooms, corridors and dressing rooms: three-layer oak parquet (natural unvarnished finish);

-Inner insulation in recycled cotton, replacing the rock wool originally planned;

-Interior wall finish: natural calcic lime mortar, clay plaster, gypsum fibre panels, silicate paint. In the living room area and in one bedroom we have left some parts of the original stone wall without cladding, in memory of the original building structure;

-Coverings in wet areas in bathrooms and kitchen: ceramic/glazed tiles;

-Fireproofing of all wooden elements with low VOC emissions ("A" label products);

-Furniture is largely re-used.

### 2.2 Project narrative

#### 2.2.1 Walls and partitions

The choice of using natural materials is due to the need to preserve the house from high levels of humidity, guaranteeing a high level of breathability of the original old stone. We have treated the existing walls differently, depending on whether they were inside the building or on the façade. The stone walls inside the farm have been restored and covered with two layers of calcic lime mortar, as Sarrau Orús (2015) explains, and then leaving a few portions of exposed stone wall in the living room and in one bedroom, by applying a pure silicate consolidating treatment. We decided not to cover the walls with ordinary plaster to guarantee the stability of the cladding against the high percentage of humidity and to establish continuity with the building's construction technique. In order to maintain the irregularity of the cladding typical of the building period, the final lime finish is hand-trowelled. All the exterior brick walls will be clad on the interior

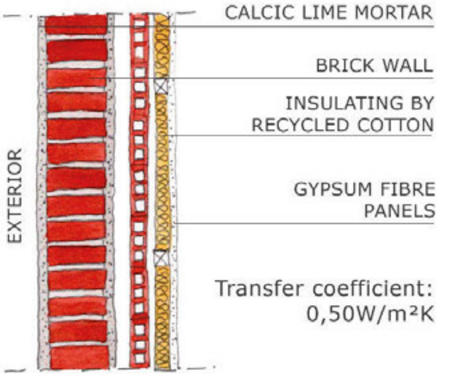


Fig. 5. Exterior brick walls details, section (Source: Li Puma, 2021)

side with a 12,5 mm.-width layer of gypsum fibre panels (a highly breathable, all-natural material) with the addition of 5 cm-width thermal insulation made of recycled cotton (Fig. 5). This material provides a 0.036W/mK thermal conductivity which is similar to that of synthetic or mineral insulation and has less polluting characteristics due to its organic origin. Thermal calculations formulas, based on Neila González (2004), demonstrate that the construction solutions guarantees a significant improvement in transfer coefficient, going from the original value of the brick (1.46W/m²K) to the current value of 0.50W/m²K. Hygrometric calculations (Corominas, 2012) that have been carried out on the new composition of the walls reveal that this solution (with initial values of 55% relative humidity, valid for home interiors) guarantees a minimum interstitial vapour production, approximately 0.4 kg/m², which is considered an acceptable quantity due to the fact that the insulating material can absorb a certain amount of water vapour without losing its insulating qualities. Any residual excess of humidity (due to the microclimate and the proximity of the sea) will be reduced by wireless electro-osmosis dehumidification and air conditioning/ventilation systems, thus ensuring optimum synergy between passive and active systems. The final finish of these walls will be two coats of pure silicate paint, maintaining the objective of the wall's breathability and stability against humidity, with 0% VOCs emissions.

Fig. 6. Cover of interior stone walls, made by calcic lime mortar, leaving parts of uncovered walls (Source: Li Puma, 2021)

Fig. 7. Detail of interior stone walls, made by calcic lime mortar, leaving parts of uncovered walls (Source: Li Puma, 2021)

In the main bedroom a different solution will be used: the final interior finish will be a 2.5cm-width layer of natural clay plaster, without painting. The use of clay in vernacular buildings is very popular, and in this very construction, during the general reinforcement works of the structure in Unit 2, some structural clay walls have been found. The choice of using clay in the main bedroom is based on health criteria (Schneider & Schneider, 2019): the earth plaster walls breath by absorbing moisture and humidity, they help to control the interior climate and air quality. Not only do they regulate temperatures during hot and cold times, they also prevent mold and bacteria to grow. Aesthetics criteria like continuity with the existing building, warmth, organic texture are considered too. As Balliu Castanyer (2020) explains, the clay mortar shall be applied in several layers of diferent thickness, one by one when the product is still fresh. The first layer shall be approximately 15-20 mm thick, the second layer 6 mm thick and the fine finish layer shall have a final thickness of 3 mm. The clay shall be locally sourced and pre-mixed by a specialised expert, in order to guarantee the optimum granulometry of the final product. This part of the work will be carried out in a workshop by an expert advice, with the participation of the owner's family too. All partitions walls in the rest of the house are made by gypsum fibre panels and filled with insulation made by recycled cotton.

Fig. 8. Insulating by recycled cotton and radiant heat, kitchen area (Source: Li Puma, 2021)

### 2.2.2 Floors

In the living/dining room handmade terracotta tiles are placed. The tiles measure 15x30 cm, with a generous thickness of 1.5 cm, and represent an optimal complement to the radiant heating system (Fig.9): as Neila González (2004) argued, the high natural thermal effusivity of clay (1.806-2.210 s½ *Wm²*C) and its heat distribution capacity make it work very efficiently in heating the house. We have chosen very tick tiles to increase their thermal inertia. The radiant heating system is well suited to a cold building like this, where it is very important to maintain the heat of the internal elements, and clay is an optimal and very fast distributor of heat. The mass of constructive elements (interior walls and partitions, floor slabs) helps to accumulate heat too. Terracotta tile was laid on a 0.5 cm layer of pure calcic lime, a natural product with zero VOCs emissions and no concrete. The final treatment of the tile involves the application of two coats of natural beeswax, to prevent absorption of dirt and grease. The use of terracotta has been reserved for the most intimate and warmest area of the house, near the fireplace and the dining room, also for its organic appearance and tactile properties, and its proximity to "warm" elements of the house such as the fireplace.

Fig. 9. Radiant heat and clay tiles, detail (Source: "Maestri del Cotto" catalogue, 2021)

Fig. 10. Clay tiles already placed in living room, waiting for minimum 25 days complete drying (Source: Li Puma, 2021)

The rest of the common areas of the house (hall, kitchen, bathrooms) will be finished with traditional ceramic tiles, more resistant to meet the requirements of impact and footsteps. The choice of the ceramic tiles (hall, kitchen and corridors in ground floor) is a tribute to the old house, which is located on land dedicated to flower growing. To remember and pay homage to the old house, we choose a delicate floral composition in very faint colours, forming a mosaic (Fig.11). In bedrooms and dressing rooms, three-layer natural wood parquet flooring in oak has been chosen. The flooring will be laid without varnish or paint treatments, with a natural water-based finish.

Fig. 11. Ceramic and clay tiles, between living room and kitchen (Source: LiPuma, 2021)

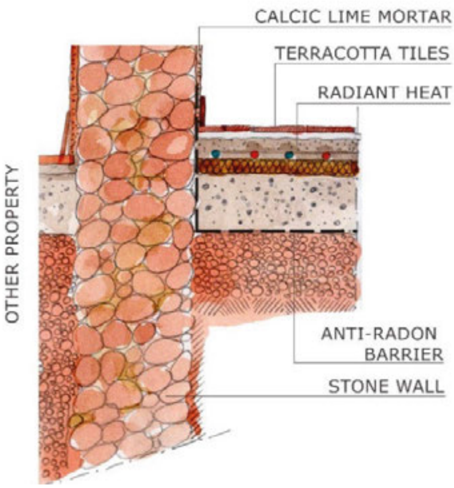


Fig. 12. Stone walls and terracotta: detail (Li-Puma, 2021)

Olive wood will be used for new furnitures in the living room; this type of wood, with its very irregular aspect, has been chosen to make some singular pieces (bookshelves, benches to sit next to fireplace side). The shape and organic aspect of the raw material will determine the final appearance of most important furniture elements.

Fig.13. Parquet pavement (Source: "Escomadera" catalogue, 2021)

Fig. 14. Olive wood for hand-maid furniture (Source: "Yevea Mediterranea" catalogue, 2021)

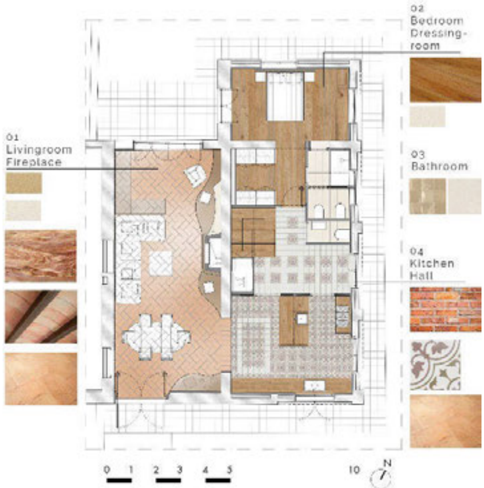


Fig. 15. Ground floor, final lay-out (Source: .Li Puma, 2021)

Fig. 16. Final render of the living room, with the organic fireplace: perspective and ground floor (Source: LiPuma, 2021)

### 2.2.3 Facilities and indoor environment

Mechanical ventilation and natural cross ventilation together, guarantee an optimal level of air quality and a healthy indoor environment at all times. The main problem of the house were the high levels of humidity and coldness, troubles that have been solved by the combined use of traditional and modern techniques. The radiant system powered by aerothermal energy works in conjunction with the terracotta tiles to achieve effective and pleasant heating, taking advantage of the high thermal inertia of the construction. Dehumidification systems are complemented by the great breathability of the walls. The use of materials such as calcic lime, clay, wood, ensure continuity with the existing construction in full agreement with traditional building techniques. At the same time, they contribute to the creation of a healthy indoor environment (Schneider & Schneider, 2019). To further improve the indoor environment, measurements to detect the presence of radon gas have been carried out (Sentmenat Bertrand, 2019). A protective barrier has been placed on the ground floor, to defend the house from unacceptable contamination: during 14 days of measurement, was detected aproximately an average value of 121Bq/m². This value, although it does not exceed the Spanish regulatory limits, represents a very high amount and we consider that the precautionary principle should be applied, in accordance with the SBM-2015 protocol (Standard der Baubiologischen Messtechnik) by “Institut für Baubiologie+Nachhaltigkeit” (Haumann, 2019).

### 2.2.4 Garden and outdoor spaces

For theoretical purposes only, I made a proposal by reconstructing the continuity of the garden on its north side, completely eliminating the rear concrete slab and remodelling the topography instead of just land excavation. The main motive is to restore the natural permeability of the soil, by re-naturalising the northern front, now partially sealed by the slab. We will restore the main drainage function to the soil, essential in this garden as the plot is at a lower level than the street, which can potentially cause rainwater to accumulate. The presence of an ancient and majestic cypress tree in the west corner of U3 prevents us from completely eliminating the current slope and makes it necessary to maintain a certain amount of fill around the base of the tree. Far from being a difficulty, the presence of existing trees at the edge of the plot suggests keeping the land where necessary, reconnecting the ends of the old pond with a series of landscaped "terraces", stepping the land progressively down to the level of the house. Soil excavated from the side strips will be reused to fill in the central area. The terraces are developed on 4 different levels (from +0.25m up to +1.00m) of natural stone laid in gravel, forming a layout of sinuous curves, with different species of plants. Species typical of Mediterranean climate will be chosen, with low watering requirements, placed according to the variable sunlight throughout the year (succulents, wild plants and ground cover in areas with more sunlight; aromatic and small flowering shrubs in areas with more prolonged shade, close to the building). The back wall will be covered with creepers and climbers (ivy, bouganvilles, jasmine). The lower level, close to the house, will be paved with clay tiles suitable for outdoor use as a passage and rest area.

Fig. 17. Sketch of the garden proposal (Source: LiPuma, 2021)

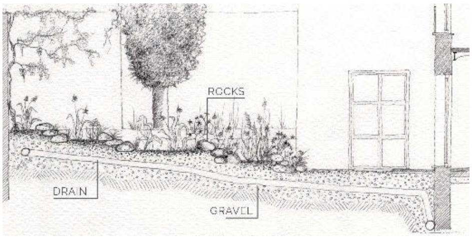


Fig. 18. Cross section of garden proposal (V. LiPuma, 2021)

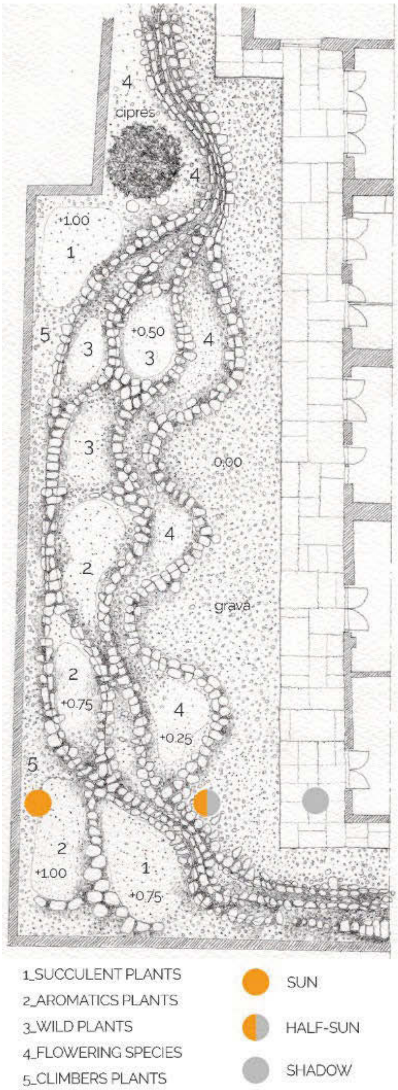


Fig. 19. Sketch of the garden proposal (LiPuma, 2021)

No lawn is planned, to minimise irrigation: as in the rest of the existing garden, small pebble gravel will be used. Underneath the paved area, the drainage will be reinforced with gravel or expanded clay, in order to defend the walls from the humidity coming from the ground.

## 3. Conclusions

I consider this professional task to be a great opportunity to experiment with processes and investigate with materials to an extent that might not have been possible in a more conventional situation. In this project I had the chance to test the behaviour of traditional materials by current calculation tools, demonstrating that the constructive solutions of vernacular architecture are still valid and can be recommended today. Moreover, I have been able to reconcile these solutions with very efficient installations, implementing their effectiveness and allowing them to work closely together in conditioning the house. This means that modernity and tradition are not incompatible, if the character of each material is respected and used in a way that is suitable with its physical properties. It has been very important to me investigating traditional construction techniques and finally discovering their capability to solve modern problems. Finally, the lesson I have learned from this experience is that the role of the architect cannot be limited to pure technical practice, worrying about proposing a "correct" design to the client and checking that everything is executed in the best possible way. I believe that our work has a human side that must take into account aspects of each client's psychology that make us design "houses" and not simply "living machines", as our ancestors did in the past.

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