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La Vera´s vernacular architecture. Structural design and climate protection in timber frame wall houses using constructive systems and local materials.

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Topic: T1.3. Studies of traditional techniques and materials.

Abstract
La Vera is a region in the west of Extremadura in Spain, on the southern slope of the Sierra de Gredos. Its architecture was designed for a rural way of life about to disappear. Three municipalities declared Historic and Artistic Sites were studied to define and explain their design and construction systems. A wooden frame structure is typical in the region, which uses sun-dried bricks in the infills and leaves the wooden structure visible from the outside. Its composite materials, clay and wood, subject to water and sun damage, are made resistant to weather via an extremely intelligent, skilled combination of wood, clay, pigments, lime mortars and paint. Verata´s wood frame structure is explained in detail, with every element named and how it works. Unique to these structures is the use of different elements as counterweights, which is considered a safety measure. Foundations built on granite and clay transfer moisture up the walls which results in the way in which paint and mortars are found. They have a clay or lime base, combined with pigments. The mixtures and application techniques have been documented from oral transmission. The selection of the base material of paint and mortars depends on their ventilation capacity and which waterproof or disinfection properties are required. Pigments are used as additives to increase these properties while obtaining the colour required. Nowadays, facilities to allow ventilation and sunlight are needed. This makes us question how all the applied knowledge developed over centuries can be preserved. This symbiosis of technique, design, structural knowledge, and close material use is the essence of Verata´s architecture.

Keywords: *timber frame wall; wood structure rehabilitation; climate protection; lime and clay paintings.*

1. Introduction

The region of La Vera is formed by nineteen municipalities situated south of the Sierra de Gredos in western Extremadura. There is a clear typology of building in these villages that is a consequence of geographic conditions, material availability and local knowledge. Verata architecture is also representative of a way of living that is disappearing and causes the demolition of some of its buildings.

This complex and varied typology, usually on three floors, is associated with the rural way of living described in "*Arquitectura popular de La Vera*" (Chanes & Vicente, 1975). The ground floor might have a portico (Fig.1) before stepping into the hallway. This hall leads to the stairs and to a lower level (40 to 100cms below) with the wine cellar, the henhouse or the stable. Wooden stairs take us to the first floor with small bedrooms and the *vasar* (room where fine china is exhibited).

Fig. 1. Porticos. Valverde de La Vera (Source: Elena Franco, 2020)

The third floor has the kitchen and small rooms. The kitchen has a fireplace on a stone slab and an outside long balcony called *solana* where fruits are dried. The roof structure can be seen above. The smoke from the fire is not conducted and fills the whole room, to smoke certain products such as peppers. Grains are also kept on this floor, ham and sausages are processed and wet clothes dried.

Drying products, smoking, and keeping animals in the same place where people live was possible because the house was permanently ventilated. An air current was necessary to dry and let the smoke out, but also helped the house to dry its walls. It is difficult to imagine how it felt to live in those houses in the traditional way. Life has changed and people demand dry, sunny conditioned houses to stay inside for long periods of time.

A group of experts was formed in 2021 to analyse the construction systems and discuss how to restore these buildings with new facilities and uses. Construction faces countless problems that define the processes which solve them (Nuere, Franco & Fernandez, 2019). On this idea, investigation was done to fully understand the techniques used, why they were chosen, and consider using them in future rehabilitation so that the essence of this architecture is not lost. A natural evolution of Verata architecture is possible and necessary to allow it to survive.

1.1. Objectives

The objective of this paper is to describe the main characteristics of the buildings studied, in order to understand the basic definition of La Vera´s vernacular architecture. The most frequent problems found in these houses will be exposed. An outline of further investigation required to match regulations and rehabilitation will be given.

Sixty-eight houses were studied in three municipalities declared Historic and Artistic Sites: 17 in Garganta la Olla, 30 in Villanueva de La Vera and 21 in Valverde de La Vera. The main architectural constructive and structural systems are described from these studies.

2. Foundations and masonry

The three villages studied are located on hill slopes; therefore, streets are perpendicular to the slopes and houses have walls with foundations on different levels. These villages have their foundations on granite soils, although Garganta la Olla has also clay soils. The ground floor has masonry walls to protect the wooden structure from water. Granite ashlars strengthen the corners, as well as jambs and lintels. Masonry is disposed (Fig.3) with bigger stones on the lower part, alternating with medium and small stones, with a dry-stone wall technique.

There are two main problems in rehabilitation processes affecting the foundations. The first problem affects building walls, which are wet because they are half buried by the slope. Damp is not seen in masonry walls if they have the henhouse or stable inside and the house is well ventilated, but when this semi buried ground floor is rehabilitated, capillary damp patches on walls appear as the natural ventilation system. Ventilated air cavities on the floor and the use of permeable mortars would help to drive the moisture out. Further investigation on formulae of mortars and capillary damp measurement in foundations and walls is needed considering the new methodologies already stated. (Gil & Lasheras, 2017).

Sometimes the lower level of the house extends across to the entire ground floor. The second most frequent problem occurs when the building´s wall on the upper street is left with no foundations, causing cracks.

3. Half-timbered structures

3.1. Wood structure

The vertical structure is formed by facades and an inner structure. The facades, from the first floor upwards, are built with timber framed structures. The wooden elements (Fig.2) have been described by various authors (del Río, 1991; Nuere, 2000). Wooden frames in La Vera are usually infilled with sun-dried bricks, although some differently dated bricks are also found.

Fig. 2. Facade in Garganta la Olla (Elena Franco, 2021)

Astorqui and del Rio explain that the loads are transmitted mainly through the infills in the case of a wall filled with plaster rubble (Astorqui & del Rio, 2014). Nuere and Cabeza consider that wood structures are always isostatic, and the balance of the whole wooden structure must be preserved when restoring these buildings (Nuere & Cabeza, 2021). In La Vera buildings have been conceived as carefully balanced wood structures. Sun dried bricks are not rigid enough to stop deformations. The structural design is sometimes organized with a main structure with main posts and beams and a secondary structure in order to stabilize the infills.

Fig.3. Facade. Villanueva de La Vera (Source: Elena Franco, 2020)

A house in Villanueva de La Vera is analysed (Fig.3). On the first-floor façade there are main posts with a wider section, and thinner wall posts. The inner beams lay on the wall plate on the ground floor wall and so do the main posts, while the upper beams lay on those main posts transmitting the load. The *riostras* and *virotillos* and secondary posts are used to avoid deformations caused by horizontal movements and to help during the constructive process of the frame.

The inner structure follows a slightly different pattern. On the ground floor, masonry at the base of frames is sometimes found on the inner walls, but it is also common to see high posts that reach the ground floor on a stone base that protects the wood from damp. These posts will hold a big inner beam on which the upper structure will lay.

The floors, both inside and outside, are made of a wooden structure. Joists are laid on the main beams and finished in two different ways. One way is to use wood planking with underneath laths to help dust from falling on the floor beneath. The other way is to put the planking on a good layer of sand, to level the tile floor held by a clay mortar. The sand layer not only levels the surface, but also helps the tiles from breaking in a house with a very isostatic structure that will frequently move. Many Verata houses are designed with an increasing surface area on each floor, as the

house grows up. The main beams will come out of the façade supporting the next floor and façade wall. (Fig.4)

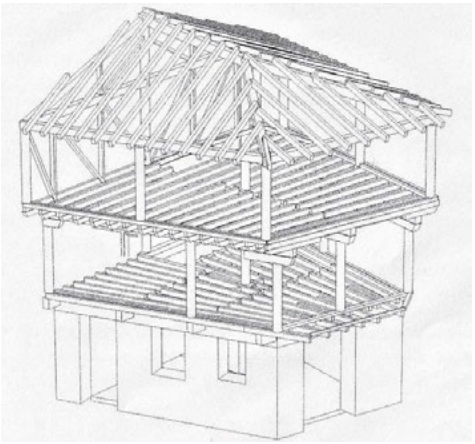

Fig.4. House structure in Garganta la Olla. (Source: Bujalance, 2019)

The construction system is very efficient. The cantilever supports weight at the ends helping main beams decrease its flexion. The upper floors protect the wood and sun-dried bricks from the rain and sun. Living surfaces are increased and create shade that will cool the streets during the hot summers. These structures were built with large chestnut trunks and other high-quality woods.

3.2. Porticos, balconies and corridors

In La Vera, the façade, and therefore, the main structure, comes in and out of the vertical giving way to different solutions depending on how the house is distributed.

Porticos with the function of an outside *zaguán* are sometimes used as an outside living room. When this happens, the upper floors rest on wood posts or stone columns. (Fig.1)

Balconies can be associated with one or several windows that are sometimes inside the *zaguán*. Balconies also form the upper corridor called *solana* connected to the kitchen floor. They are constructed with different designs and complexity levels.

Sometimes they are supported by the main horizontal structure while other times they have their own beams inserted into the main structure. (Fig.3, Fig.4). If balconies or corridors are designed to support weight, they might have a complex structure (Fig.5) using decorated carpentry solutions.

Fig. 5. Balcony in Valverde de La Vera (Source: Franco, 2020)

No double-layer façade buildings like the one described for the Posada del Peine, in Madrid were seen in this research. (González-Redondo, 2019).

3.3. Roofs

Roofs follow the same structural design as the rest of the structure. Wall plates on top of façades are the first and last beams. Several parallel beams and a ridge beam support the rafters on which the roof lays. This type of roof structure can work without tie beams because they are light, and the main beams are supported by posts organized in short distances, around two or three metres. The planking lays on the rafters, and the roof tiles are laid on top, sometimes with a clay mortar in between. When covering the kitchen, the planks are separated, and the tiles are laid on top with no mortar so that the smoke of the kitchen can slowly come out (Fig.7). Some roofs have been structured so that the beams are separated the width of a curved roof tile that is directly laid on them with no planking or mortar in between. (Fig.6)

Fig. 6. Roof in Valverde de La Vera (Source: Franco, 2020)

Fig. 7. Roof in Garganta la Olla (Source: Franco, 2020)

The smoking of pepper was done in the kitchens, on a wooden floor set on the base of the roof level, called *doblao* (Fig.8). The fire was below, on a back hearth, and skills in handling fire was required to get smoke or flame when needed. The smoke would go up to the *doblao* and finally come out between the roof tiles.

Fig. 8. Kitchen and doblao (Source: Bujalance, 2017)

3.4. Balance

The structural understanding that is behind Verata architecture shows us how the building was understood as a balanced whole. The weight of materials is very often used as a counterbalance. This is the case of cantilevers in upper floors which, in the secondary direction, will use a structure balanced by the house floor (Fig.2, Fig.4). It is interesting to see how the *riostras* are used to prevent horizontal movements in the structure. They were also used to stabilize the structure during its construction as well as to direct weight in a particular direction. This can be seen in the façade in Garganta la Olla (fig 9), where one post and two *codales,* receive the corresponding façade, floor and roof weight. The granite stone used as the post base has been carved to drain water away from the wood.

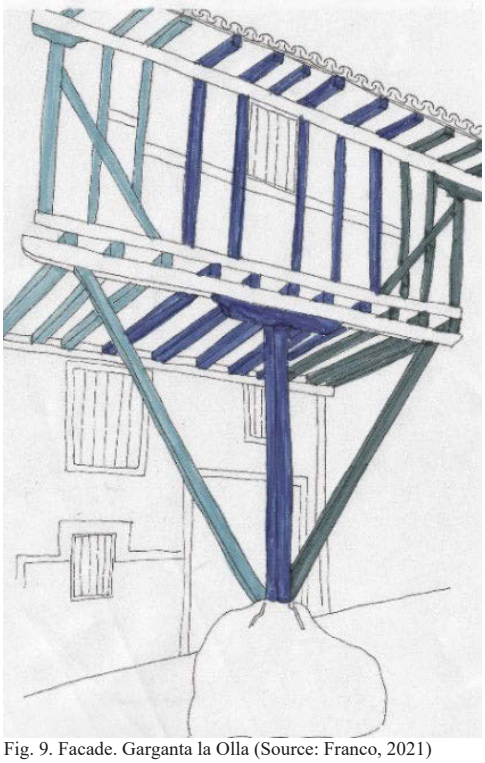

Fig. 9. Facade. Garganta la Olla (Source: Franco, 2021)

This balancing way of thinking is behind Verata construction and should be considered carefully when restoring because demolishing walls, floors, or even inner walls, might destabilize the whole building. These houses, when restored, will also need careful structural analysis, considering the new use they will have. It is compulsory to have an architectural project when rehabilitating and, in La Vera, it is recommended not to do any demolishing without a technical survey. It is common to see solutions where inner walls are used as a counterbalance for big balconies (Fig.10).

Fig. 10. Plankings. Valverde de La Vera (Source: Franco, 2020)

3.5. Wood and infills protection

There is plenty of wood on the outside of Verata architecture that is exposed to sun and water, as is the sun-dried brick infill of the walls. Popular strategies are used to protect them both. The most unique one is its design. Houses follow horizontal growth as they rise to the upper levels. This protects the facades below, but there are other systems helping to protect facades. Weather boarding is very common in La Vera. Wood planking is not used in main facades, and it is always placed on the upper levels. The planks are disposed by pouring water on the lower plank, and they are nailed to the posts. The wood is preserved because it is ventilated. It also protects the sun-dried brick wall (Fig.10).

It is very common to see decorated corbels, but it is an extended detail in La Vera to stripe the wood beam facing the street. This does not prevent the beam from moistening but helps it to dry more quickly. Different carved striped designs are finished in oblique, leading water to a drip. (Fig.11, Fig.12)

Fig 11 Corbel decorations. Valverde de La Vera (Source: Franco, 2020)

Fig. 12. Corbel decorations. Garganta la Olla (Source: Franco, 2020)

Beam faces are also protected with fretted boards which will be replaced when they get damaged. (Fig.1) Fretted boards have turned out to be a decoration motive typical in La Vera. They are also used as balcony posts. (Fig.11) Roofs always come out from the façade line by a distance allowed by the outcoming structure or by corbels. Roof tiles will stick out several centimetres more. Party walls sometimes also have their roof standing out of the vertical, when the house´s roof is higher than the neighbour´s.

In Garganta la Olla, we have seen some slightly burned wood house structures that are covered with oil. It is quite common to see roofs blackened from smoke throughout La Vera, so a sort of Shou sugi ban protective treatment could have been locally used.

4. Mortars and paintings

There are various mortars and paintings for each use. The main traditional mortar used to be made from a compacted clay and straw mixture that was laid on sun dried bricks. A variation of this mortar was used when it was applied on ground-level outer walls. This variation which includes cow excrements, in order to provide waterproofing properties. Lime was not used very much in La Vera as the soil did not contain it. It was brought from lime zones, and the application techniques were not as developed as they were in other places. Whitewashing was used. This technique is described in “Guía Práctica de la cal y el Estuco”, (Martín Sisi, García & Azcónegui, 1998). Local recipes have been found where hydrate lime was used immediately after hydration. This is not a correct procedure for a long-lasting finish, but it was enough for disinfection. The straw and clay mortars were

painted. Paint was applied with a paintbrush called *brocha extremeña*, which was similar to Portuguese brushes. It was a good quality round brush, with a wooden handle and strong, vegetable hair, perfect to press the paint in a process called *repretar* (Gárate, 1993) necessary for the lime´s properties to be achieved.

The upper house levels, which were more difficult to reach, were usually painted with a fine clay and water-based paint. Garganta la Olla has a beautiful ochre coloured clay. This upper paint was applied with the *escobillo* once a year, to protect the walls (Fig.13).

Fig. 13. Jesus mother´s escobillo (Source: Bujalance, 2017)

Other mixtures were used to get new colours for a specific purpose. The fireplace walls were painted in black (Fig.8). Black paint was made with charcoal, *negro de humo,* mixed with clay or sometimes charcoal mixed with lime. This last mixture turns into a black or grey coloured finish that was also used in outside wall bases. This black paint could easily hide splashes, but also, the lime and charcoal mixture would help transpiration, letting the inner wall dry. This finish also needed maintenance and was regularly applied.

Unfortunately, this is one of the paints that is almost lost, having been substituted with all kinds of materials on the bases. There is another paint used in La Vera composed of brown lime, an impure lime with clay and hydraulic properties. This paint is only occasionally seen in ground floor inner walls.

Women used to paint the inner walls with the *escobillos*. They relate how they used it first to take off the spider webs on every corner, as well as in the joint between walls and wood. Then they painted these areas with colour. These paints can still be seen nowadays, sometimes just clay paint, with no maintenance, still stuck to the wood (Fig.14).

Fig. 14. Ochre painting (Source: Bujalance, 2017)

Plaster is not usually seen, but some estuco is found on modern applications.

The techniques shown conform the traditional decoration in symbiosis with construction knowledge, the use of nearby materials and the slow introduction of lime. Coloured paints; white, ochre, black and red; were applied on clean surfaces ending in wide curves following the structure, the base or the stairs.

One of the most common errors found in the studied restorations, is the use of waterproof materials to avoid capillary damp on the walls. Ancient walls have always had their foundations in the ground, and capillary damp is and will be inside the wall. Ventilation has always been the strategy to let this humidity out, avoiding damp patches or, at least, improving them. The use of waterproof materials such as cement or tiles in the outer bases won´t allow damp out, leading it directly to the inner rooms, with the opposite effect to the one desired.

Outside mortars did not cover the wood structure. They were used just on the infills. Using rope around wood to stick the mortar on, is probably a late and uncommon practice which is hardly seen, and full of cracks. There is plenty of paint protecting wood on doors, windows and structures, probably made with flour, linseed oil and

ochres, greens and blues, with excellent adherence to wood, that would need further investigation.

5. Conclusions

The image of the three studied historical and artistic sites of La Vera is related to urbanism and geography, but also to a traditional way of living attending to rural needs. Houses were built with materials found nearby, such as wood and clay, although lime was also used.

The use of these buildings has changed, and a natural evolution of vernacular architecture needs to be found to maintain the essence and knowledge of these villages. This paper is the result of an investigation of construction techniques as a basis for this process.

The structural conception of Verata´s wood framed structures is leading weight to the wood structure. This was understood by builders who designed balanced structures using counterbalance weights and triangles to stabilize horizontal efforts or relieve below structures. This complex understanding has to be technically considered before rehabilitations or partial demolitions, to avoid loss or damage.

The design of houses is the clue to understanding how wood, clay mortars and sun-dried bricks could resist atmospheric damage. Houses increase in surface area as they get higher is the main strategy to protect facades. However, other strategies were used for this purpose: painting to protect infills and wood, ventilated wood planking or light burning were used. Every technique was developed based on the detail, increasing ventilation surfaces with corbel striped decorations and water drips, water drains or by the use of sacrifice fretted boards.

Painting and mortar techniques were developed on sun-dried bricks, wood and stone supports. Different mixtures of clay and lime with different pigments and substances were achieved obtaining different characteristics. There was an intention to improve hydraulic or waterproof qualities. Construction, a traditional use of architecture, design, structural conception, protection strategies and decoration, are the main elements of knowledge and image to be preserved in these villages. This is the essence of Verata´s architecture.

This knowledge acquired and the questions raised that require further investigation are the basis from which to define correct rehabilitation projects in order to maintain this essence that goes beyond an image.

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