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Original article

Chequered earth construction in south-western France

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ABSTRACT

Near the Pyrénées in France, there is a village called Castelnau-Magnoac where a very specific earthen construction technique exists. It consists of alternating adobe bricks and pebbles in staggered rows, resulting in an effect that gives the name of "chequered construction" to this special technique. Between two and three hundred houses and farmhouses built using this technique exist on an area close to a thousand square kilometres. The date of the construction of these buildings is estimated as the middle of the nineteenth century. In 2011, the municipality of Castelnau-Magnoac, owner of a chequered earth farmhouse, initiated the rehabilitation of this building so that it could house a physiotherapy practice. This was the opportunity for a group of researchers to study the specificities of the building from the point of view of both the construction methods and the characteristics of the materials used. The main results of this study are reported in this paper. The main construction specificities of this building are: the systematic alignment of vertical joints made without mortar, the lack of a ring beam combined with a high slenderness ratio, and a lack of protection against the rain. The special characteristics of the adobes used in this building are a very significant fineness combined with an exceptionally low limit of liquidity. These characteristics are outside the limits recommended by the French standard on earth bricks, yet the compressive strength of these adobe bricks is comparable to those of traditional adobe bricks reported in the literature and they have proved their efficiency over many decades, which calls the relevance of modern standards on earth bricks into question. It seems that the behaviour of these adobes is related to their mineralogical composition, which shows that the use of particle size distribution as the sole criterion of acceptability of a type of earth for the manufacture of adobe is not relevant. Although the study of this building was very instructive, many questions (technical, historical and societal) still remain and would merit further investigations on this type of buildings. The answers could be useful for modern reflection on the changes in choices that will be necessary to take account of environmental and social impacts in building practice.

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1. Introduction

Earth, with wood and stone, is probably the oldest building material known in the world. It has been used in many areas and by most of the civilizations in history, with the oldest recorded case of its use in the construction field dating back to Mesopotamia around 10,000 BC [1]. Building with earth is common in all hot-dry, subtropical and moderate climates, with a major expression in less developed countries where the majority of such constructions are located [2].

In advanced economies, earth was intensively used for construction until the end of the nineteenth century. After this date, cement was developed and preferred for construction. However, in the last 20 years, earth has been reconsidered as a pertinent material for construction in advanced economies, essentially because of its low impact on the environment and its capacity to regulate the hydrothermal conditions of the indoor climate.

France has a very rich heritage of ancient earthen constructions based on various techniques, which essentially depend on the geographic region. Rammed earth is mainly observed in the valley of the Rhone (neighbourhood of Lyon), cob in Normandy and adobe in south-western France (neighbourhood of Toulouse). In the village of Castelnau-Magnoac, near the Pyrenees, a very specific earthen

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Fig. 1. Overview of the building before its rehabilitation: southern wall and details of masonry.

construction technique can be found, which consists of alternating adobe bricks and pebbles in staggered rows. The resulting visual impression has given this technique the name of "chequered construction". It is difficult to evaluate the number of buildings based on this building method but it could range between two and three hundred houses and farm buildings on an area close to a thousand square kilometres. It is estimated that the construction of these buildings dates from the mid nineteenth century. In 2011, the municipality of Castelnau-Magnoac, owner of a chequered earth farmhouse, initiated the rehabilitation of this building to change it into a physiotherapy practice. This was the opportunity for a group of researchers to study the specific construction aspects of this building and the characteristics of the materials used.

This paper is separated into two parts. In the first, the building under study is described and its construction specificities are presented. In the second part, the mineralogical, physical and mechanical characteristics of the adobe bricks used in the building are studied.

2. Description of the building and presentation of the specificities of its construction

2.1. Description of the building

The southern, eastern and northern walls were built with adobe (Fig. 1). The western wall was built of stone blocks bound together with lime mortar. The southern wall was 8.50 m high and 8 m long. No coating was applied to the outer surface of the walls. The floor area of the building was approximately 150 m^2.

It was originally a farm building. The date of construction of this building is difficult to estimate but it could be the late nineteenth century. The timber structure was rebuilt in 1976 and it became the property of the village of Castelnau-Magnoac in 1981. The municipality of Castelnau-Magnoac initiated the rehabilitation of the building in 2011 to make it suitable for a physiotherapy practice. The work was completed in the summer of 2012 (Fig. 2).

In the original building, some existing openings were surrounded by fired bricks bound together with lime mortar. These fired bricks were produced using an extruder, which means they were manufactured after the First World War. They may have been introduced recently, during a previous rehabilitation of the building, and thus cannot add valid information on the date of construction. Other openings, probably older than the previous ones, were surrounded by wooden pieces.

It was noted that the foundations were much deeper than in current practice: the report of the geologist established the foundation depth to be 1.20 m, which nearly corresponded to the depth needed to find resistant soil according to the digger. These foundations had the same width as the wall and were composed of pebbles bound with lime mortar. However, such deep foundations seem surprising for a farm building and one can wonder if the existing building was built on a much older base, made for an old building at least as massive as this one.

The base of the walls was composed of limestone and pebbles bound with lime mortar. The lime mortar was made with sand having grains larger than 5 mm. This sand certainly came from the "Gers", a river about a kilometre away. The height of the base ranged from 0.30 m to about 0.60 m depending on the state of the natural soil.

2.2. Adobes

There were different types of adobe in this building (various colours of earth, various proportions of plant fibres and various

Fig. 2. South-eastern and north-eastern views of the building after its rehabilitation (May 2013).

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