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Study of thermal environment inside rural houses of Navapalos (Spain): The advantages of reuse buildings of high thermal inertia

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ABSTRACT

The main purpose of a residential building is to provide a comfortable environment for human activities. Nowadays this objective is the responsible for the consumption of more than 40% of total energy demand in European Union. The construction sector in Spain has been in rapid growth in the last decades, yet there exists many abandoned buildings in rural areas. In this article we try to analyze the environmental advantages of reuse abandoned rural buildings. Due to their thick exterior walls of high thermal inertia, the indoor environment inside them can be comfortable with less energy consumption than new buildings. Here we show the monitoring results of three different houses, two traditional and one modern building, constructed of different building materials. The aim of this work is to analyze and compare the thermal behaviour of existing constructive solutions in a Spanish district, not to improve them. The field test results show better indoor conditions inside the traditional houses. In summer, thermal comfort is achieved with no energy supply inside traditional houses but not inside the modern one. In winter, the indoor environment is more stable inside the traditional houses, however none of them were able to provide thermal comfort naturally. In the case studied, the only inhabitant of a small village lives in a prefabricated wooden house, and it is demonstrated that the indoor conditions of traditional houses in the same location are of higher quality.

1. Introduction

The energy consumption of the construction sector is estimated at more than 40% of the total final energy demand in European Union [1]. Therefore, the reduction of energy use in the air conditioning of buildings is an issue of increasing interest in which various research works have been developed [2–5]. The first regulation about thermal insulation of housings in Spain was created in 1979 [6]. The concern about energy use in buildings has led the Spanish Government to prepare a new regulation for the reduction of building energy consumption which has been introduced as a part of the new Technical Building Code [7].

The operating energy during the life cycle of a building is much greater than the energy consumed during the construction phase (embodied energy). There is a great potential for energy savings and reduction of environmental impact through the implementation of energy efficiency in the construction sector.

Due to the fast growth of construction sector in the last decades, in Spain there are many rural areas which have been abandoned, and many of the rural buildings are vacant and without use. From the department of construction and rural roads the possibilities of the reuse of abandoned rural buildings are analyzed. We think that the reuse of abandoned buildings has other advantages besides those commonly outlined as: keep the vernacular architecture up, reactivate the social fabric and preserve rural landscapes. This process can be seen as a mechanism to save energy in the framework of the energy supply sector. Thanks to a research project funded by the Ministry of Education and Culture of Spain, a lot of work of inventory and cataloguing of rural buildings in the province of Soria (province in the interior area of Spain) has been carried out. The village of Navapalos is located in a district from Soria, whose area is 2450 km^2 and the population is 13,884 people with a marked agrarian character and undergoing a process of depopulation [8]. The area is characterized by a continental climate (hot summers and cold winters) with high temperature oscillations. Navapalos is placed on the banks of Duero River, with an altitude above the sea level of 800 m (see Fig. 1). The village was abandoned due to the rural exodus in the fifties. In 1984 the "Centro Navapalos" was set-up as a private institute for the research and experimentation of traditional building materials and constructive techniques, with a particular interest in the use of earth as a building material [9]. In 1996 it created the "Navapalos Foundation" for the investigation and teaching in matters related to sustainable development, architectural heritage and earthen constructions. At present only one person from the Navapalos

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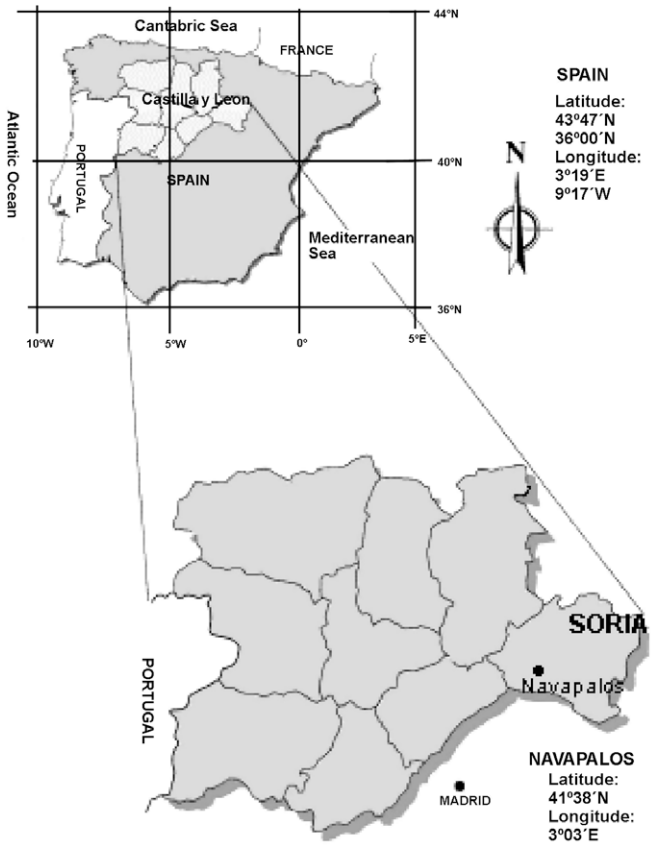

Fig. 1. Map of location of the studied area.

Foundation lives in the village. Despite the existence of many abandoned, but well maintained, traditional houses, the foundation decided to install a prefabricated wooden building for the only inhabitant in the village. Aiming at assessing the advantages of reusing abandoned rural buildings, three houses in the village were monitored, one of them is the prefabricated wooden house and the others are houses constructed with traditional materials and techniques. Assuming that the thermal performance of traditional and modern buildings is different [10], we try to analyze the comfort conditions inside the studied cases. In addition, it should be taken into account the influence on the indoor air caused by the habitant of the house. It is expected that the habitant makes good use of the openings and shutters to improve the indoor thermal comfort, however the presence of the habitant increases the indoor temperature and relative humidity by the body radiation and evaporation.

2. Description of studied houses

In the traditional houses usually found in the interior areas of Spain the structural system used was the bearing walls. The envelope was an important structural element primarily designed to support mechanical loads, therefore its thickness was quite high. The construction materials in traditional houses were those abundant in the area.

Other performance requirements such as weather resistance and energy efficiency were not taken into account, but some differences in the type of building materials and the thickness of the walls according to climatic parameters were observed [11].

Many buildings in the village were in ruins. Since 1985 some private buildings have been bought and restored as canteens, dwellings and conference centers. Every summer the Navapalos Foundation organizes international meetings, conferences and courses about traditional construction. Since the aim of this paper is to analyze the influence of the building materials and construction design on the indoor thermal performance, we chose three buildings whose envelope is made of different materials. The two traditional houses are used as dwellings for the participants in these actions. In the following we describe the three studied houses.

2.1. Traditional house made of stone

It is a traditional house made of local stone that was partially renovated to serve for the accommodation of volunteers coming to the village in summer to carry out restoration works. The renovation consisted of the construction of three bathrooms, and a glazing surface oriented to the south for the use of passive solar heating, and the installation of solar photovoltaic panels in the roof to obtain electrical energy. There is no heating or cooling system in the house. Figs. 2 and 3 show a picture and the floor plans of ground and first floors.

Floors: This house has two floors.
Walls: The closure walls are made of limestone with a thickness of 50 cm; the partition walls are made of brick.
Structure: The structure is based on bearing walls. The flooring is made of ceramic tiles.
Roof: The roof structure is made of wood and it is covered by clay tiles.
Openings: The windows are wooden framed with single glazed.
Orientation: Most of the openings are oriented to the south.

2.2. Traditional house made of adobe (called pine house)

It is a traditional house made of adobe. From a state of ruins its reconstruction began in 1990. The pine house is a recognized type

Fig. 2. Southern facade of stone house showing the glazing surface and the solar panels.