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Survey on Post-Occupancy Evaluation of Vernacular Houses in Madeira (Portugal)

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Abstract. Vernacular housing in the Island of Madeira (Archipelago of Madeira, Portugal) is built anonymously. This architecture is made by the people and for the people without the aid of an architect. This built heritage demonstrates the relationship between the population and its surroundings, through the care with which they treated the climatic constraints and that is clearly related to the seasonal variation of temperature, regardless of cultural differences and of the level of development of each community. The Island of Madeira has temperate climates characterized by mild temperatures all year round. The climate is largely influenced by the Eastern branch of the Azores anticyclone especially from spring to autumn. These buildings are strongly marked by an agricultural economy and are characterized by great regional diversity. The agricultural feature took care of the fertile alluvial land, giving rise to the first settlements. However, with the growth of the population began the conquest of the coast, occupying the dense forest that provided them with good timber for local consumption and for export. With the land tamed, the next challenge was to control the waters, the first paths between the places of difficult access, which carried the waters of irrigation at various locations, including the north and the south shores. The built vernacular heritage of the Island of Madeira had a primary function of shelter, and then housing and nowadays new uses are being implemented. The research and study of the essence, the behaviour, the possibilities of traditional technologies used in a specific territory are like the rediscovery, always renewed, of the profound meaning of the Portuguese architecture. This paper analyses through surveys whether a very specific type of vernacular heritage housing in the Island of Madeira provides comfort. In fact, questionnaire responses from the initial survey regarding 66 vernacular houses were analysed to understand the residents' satisfaction with the existing conditions through post-occupancy evaluation. Several variables were associated with dwelling and thermal comfort. This way, a post-occupancy evaluation is proposed including energy monitoring for fine-tuning and increasing energy efficiency as well as for gathering knowledge for planners and developers. This study not only provides valuable information for future housing sustainable rehabilitation but also it may enable the identification by the Local Authority of ways of improving the quality of life for residents.

1. Introduction

Vernacular building traditions are repeatedly cited in academic literature as exemplary models of environmental practice. Therefore, research that addresses the vernacular traditions of the Island of Madeira may emphasize its potential for continuity and viability for maintenance and rehabilitation.



Sustainability is indissolubly linked to vernacular architecture and the lessons learned from this architecture of the past can teach us which knowledge to apply in the future [1], [2], [3]. Sustainable buildings aim to be adapted to local social–economic, cultural and environmental contexts. They should include all factors that may affect the natural environment or human health, having in mind the consequences for future generations [4]. The demand for sustainable buildings with minimal environmental impacts is increasing, thus leading the construction industry to adopt new technologies for building design [5], [6].

Post Occupancy Evaluation is becoming an increasingly suitable tool not only for the academic community. It seeks, from the perspective of the user, the opinion about the buildings in use. This practice provides feedback data regarding the design process and the building's overall performance. Strategies are often driven by construction and project management perspectives rather than focusing on organizational issues and user behaviour [6], [7]. More recently, this kind of evaluation took a closer look at ultimate-user satisfaction. Consequently, during the evaluation survey which targeted early occupation of template design schools in Victoria, it was discovered that teachers and students were more likely to extend their learning environment into the new shared spaces. Results of a survey to the staff and students who use a net-zero-energy building regarding the users' perceptions of some of the environmental control systems installed were reported [8]. Although the study showed that the people surveyed were overall satisfied with their work environment, the authors stated that more information on how to get the best from the windows and the ceiling fan systems was needed especially regarding those who may only use the classrooms intermittently.

Other surveys were carried out to evaluate the users' opinion regarding different types of buildings and even different cultural backgrounds. A post-occupancy evaluation survey targeted full-time representatives of the wider working population in Australia to help assess discomfort glare in open plan green buildings [9]. Three green buildings located in Brisbane (Australia) were selected. It was concluded that green buildings may not achieve comfort along with the subsequent energy savings. A suggestion is made for further research on these types of buildings and on the people to ensure that the maximum financial, social and environmental benefits. The customers' experiences and feelings in daylight and non-daylight cafes as well as the cultural differences between two countries, the UK and South Korea, were studied [10]. The questionnaire fell upon the quality of lighting, feelings, attractiveness, satisfaction and eye discomfort. The authors found that there was a significant cultural difference in factors affecting perceived lighting quality. Nevertheless, there was no significant relationship between perceived lighting quality and perceived eye discomfort in daylight cafés [6].

Housing is the kind of building that is familiar to all users. Post-occupancy evaluation of user satisfaction was carried out to perceive the residents' building and environmental conditions of old and new housing in Bangkok [11]. From the study, it was possible to make recommendations for future improvements to public housing quality regarding the quality of life for residents. An analysis of Viennese housing estates in the Passive House (PH) standard that have been inhabited for more than two years was done [12]. Based on this study, it was possible to present recommendations for future housing projects and assessment systems to fulfil the envisaged goals of sustainable buildings design.

This paper analyses, through inquiries, whether a very specific type of vernacular heritage housing in the Island of Madeira, Portugal, provide comfort. Earlier Carlos, Martins and Vieira studied this kind of vernacular housing and its post-occupancy [6]. So, this study provides valuable information for future housing sustainable rehabilitation. This may also enable the identification, by the Local Authority, of ways of improving the quality of life for residents.

However, it is an approach for future work in the field. Post-occupancy evaluation is suggested including energy monitoring for fine-tuning and increasing energy efficiency as well as for gathering knowledge for planners and developers [6], [12].

2. Madeira's vernacular architecture contextualization

This architecture is made by the people and for the people without the aid of an architect, and demonstrates the relationship between the population and its surroundings through the care with which they treated the climatic constraints at regional and local levels and that is clearly related to the seasonal variation of temperature, regardless of cultural differences and of the level of development of each community [6], [13]. The Island of Madeira has temperate climates, characterized by mild temperatures all year round. The climate is largely influenced by the Eastern branch of the Azores anticyclone especially from spring to autumn [14]. The research and study of the essence, the behaviour, the possibilities of traditional technologies used in a specific territory, is like the rediscovery, always renewed, of the profound meaning of the Portuguese architecture. Thus, this work allows the knowledge of Portuguese cultural memory through the construction processes to the mark and characterization in geographic space and in historical time. On the other hand, this work allows the safeguarding of identities that make up features of a country and a region. Traditional solutions and resources to "ways of doing" always improved the Portuguese creativity [15]. This knowledge transmitted through the local architecture is based on the careful planning of housing: in its shape and orientation, in the size, number and orientation of the doors and windows, in the size and orientation of the roof in relation to the sun and wind, in the use of various techniques of walls and roofs insulation, in the control of ventilation and shade density as well as the appropriate choice of materials [6], [16].



Figure 1. Vernacular houses of Madeira with thatched high-pitched roof and wooden or stonework walls.

The main characteristics of the vernacular houses in Madeira are the wooden structure and the thatched high-pitched roofs. Some of the houses are made of wooden walls and a few of stonework as shown in Figure 1. This vernacular architecture, which can be found in the Island of Madeira, stands out for being an unidentifiable type from outside of the Portuguese territory. There are three types of these vernacular houses: "Fio" or "Empena", "Meio-Fio" and "Redonda" (Figure 2) [1], [6].

The typology of the "Redonda" house was the permanent home of the farmers in the parishes of S. Jorge or on the Ilha and the "Fio" House, which later evolved into "Meio-Fio", arose from the need to have a shelter in the parish of Santana which was fast to build and had the minimum of comfort. The parish of Santana, being flatter, was the place of the crops and the parishes of S. Jorge and Ilha were the place of residence. As they were distant and so that the population did not need to return every day from work to their residences the "Fio" House emerged. However, currently, on the Ilha, there are no records of the "Redonda" House. Thus, for the reasons presented the "Redonda" House has an interesting

complexity, and by being lesser-known by touristic reasons, this was the type chosen for an academic proposal for seasonal housing [1], [6].

The “Fio” or “Empena” house, a one-floor building, built entirely of wood, with a full frame fitting that joins together perfectly. Supports of its longitudinal beams are directly on the stones of the floor. These constructions are able to be moved to another site thus changing the first implantation site. This typology is characterized by having the kitchen in a separate area of the house, which is built entirely in wood, with a frame filled with fittings that join and fit perfectly [1], [6].

The "Meio-Fio" house presents the elevation frame coverage around the perimeter about 90 cm above the soil. This innovation arose in the twentieth century, allowing better use of interior space, and in more evolved cases, it is provided with an attic whose access is made through an outside steep staircase [1], [6].

The "Redonda" house presents four facades and a hip roof with rounded corners. The shutters sliding of the windows are found only in this type of construction. In some buildings, there is also an attic accessed through a steep staircase. This typology was more concentrated in the parishes of São Jorge and Ilha. In the parish of Ilha, this typology is already non-existent [1], [6].



Figure 2. Vernacular houses of Madeira: “Fio or Empena”, “Meio-Fio” and “Redonda” house types

3. Research method – a case study survey

There is no information available on the characteristics and environmental conditions of the vernacular dwellings in Madeira. Therefore, the aim was to investigate the level of (dis)comfort felt in these buildings, based on the occupants' satisfaction. In this study, the post-occupancy evaluations focused on the quality of daylight, thermal comfort and ventilation. The study involved field surveys which were conducted in S. Jorge and Santana, places in the Island of Madeira, Portugal. The objective was also to understand the relationship between different use patterns and their influence on or association with overall satisfaction [6]. The goal was to collect data that would represent the different types of occupancy of these old dwellings, as housing, residential tourism and bar/restaurant.

A total of 13 out of 66 vernacular buildings were chosen for the field surveys [6] and typical outer views are illustrated in Figure 2 (“Fio” or “Empena”, "Meio-Fio" and "Redonda" house types). The main characteristics of these houses are the wooden structure and the thatched high-pitched roofs. Some of the houses are made of wooden walls and a few of stonework which elevates the frame coverage above the soil. This vernacular architecture in Madeira stands out as being present in most of the dwellings that characterize most of the island of Madeira. They were developed according to the habits and customs of the population and were adapted to the site and built with local materials without any influence of foreign styles [1], [6].

Participants were interviewed based on a questionnaire reproduced in Figure 3. It is a single simple page survey and the questions in it can be broken down into three groups of general information: i) Perceived daylighting quality; ii) Perceived thermal satisfaction; iii) Perceived airing/ventilation of the building. Buildings were randomly selected during the field survey. In these field surveys, the owners who lived in the buildings for a few years were asked to complete a questionnaire in order to provide enough adaptation time for the indoor environment conditions all over the year [6].

Participants were individuals with a nontechnical background, so they could provide a significant answer on the (dis)comfort issue. The final goal is to set an experienced background to define a new field of research, both through a more detailed questionnaire and also through monitoring, in order to quantify what level of comfort can be experienced within these buildings [6].

Identification and location of the building: _____						
1 - Level of satisfaction with the quality of daylight:						
-3	-2	-1	0	1	2	3
Very unsatisfied						Very satisfied
2 - Level of thermal comfort during the winter:						
-3	-2	-1	0	1	2	3
Very cold			Comfortable			Very hot
3 - Level of thermal comfort during the summer:						
-3	-2	-1	0	1	2	3
Very cold			Comfortable			Very hot
4 - On thermal discomfort, which of the following best applies?						
Morning			Night			
Afternoon			Always			
5 - On thermal discomfort, which of the following best describes)						
Lack of airing			Cold ventilation			
Too much daylight			Lack of heating			
Draft			Lack of cooling			
Lack of daylight			Other: _____			
Hot ventilation						
6 - Which of the following uses to adjust your comfort?						
Open/close shutters, curtains			Use of cooling			
Open/close windows			Use of fan			
Open/close door			Other: _____			
Use of heating						
7 - What kind of heating do you use? _____						
8 - Is the air usually stuffy?						
Yes			No			
9 - If it appears that the air is stuffy when it is noticed? (eg: winter, summer, in the morning, Etc.)						

Figure 3. Questionnaire base

Determining satisfaction is a very subjective issue since it is dependent on personal experiences and individual emotions. This data collection does not reflect the demographic, socio-economic factors and living conditions. Interviews were conducted to explore residents' experiences whether the participant

is or is not experiencing discomfort [6]. A lack of familiarity on the indoor environment may result in an inconsistency between different results. However, it is considered to be the first approach to future work in the field. Most of the inquiries are related to "Meio-Fio" house types [6].

In a Carlos, Martins and Vieira study [6], [16], it was observed that the overall lighting conditions of these houses were approximately gloomy. Therefore, the first general lighting question asked occupants to describe their overall satisfaction with the quality of daylight. Of interest is whether there is a relationship between general daylighting and building operation where the options were chosen to cover a broader range of possibilities from "very unsatisfied" to "very satisfied" [6]. The second part of the survey dealt with dwellers' experiences of their physical environment reflected through an individual's perception of thermal comfort. The levels of satisfaction from a -3 (uncomfortable – very cold) to 3 (uncomfortable – very hot), being comfortable or neutral registered as zero. It is expected that any occupant who selected comfortable, views their current environment in a positive manner. One third part dealt with indoor air quality. It was of interest to analyse if the inhabitants perceived the quality of the air [6].

4. Results and future work

To understand the situation of the vernacular housing in the Island of Madeira, an enquiry was carried out by quickly interviewing the residents. Some of the original owners had allocated the house to others by selling and some of them had changed their final purpose (restaurant). Others had allocated the rooms to others by short renting periods (tourism purposes). The length of the residency of the respondents, which was more than 5 years, made them able to elaborate on the satisfaction with the indoor environment [6]. Thus, satisfaction with the indoor environment was related to natural lighting, thermal comfort (Figure 4), ventilation and air quality [6].

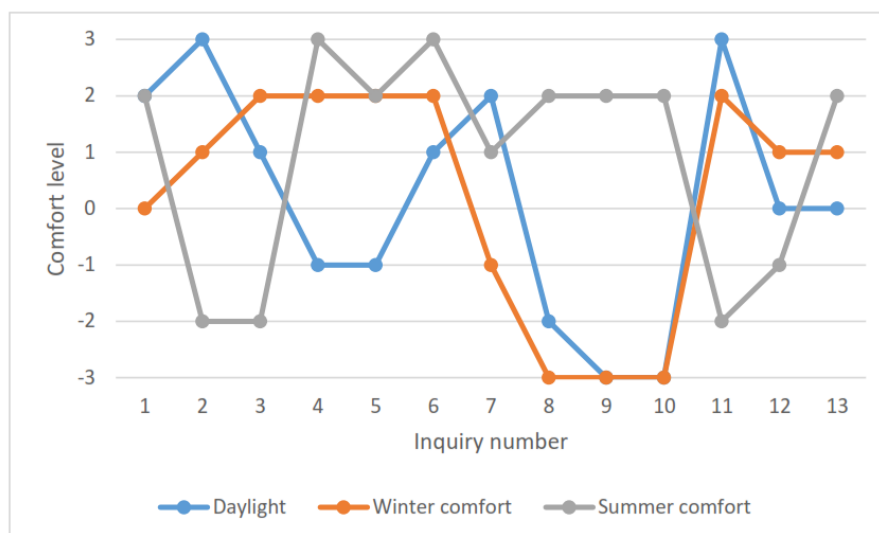


Figure 4. Responses to the indoor comfort questions

Questions on the level of satisfaction with the quality of daylight were asked to residents. As it was verified that the indoor space was a little gloomy, the range of the possible answers was from "very unsatisfied" to "very satisfied". In relation to the building unit satisfaction, the natural lighting presents an undefined rank. The answers were dispersed from "very bad" to "very good". The best score was obtained from a "Redonda" house. This kind of building has windows on every façade, against windows on two façades for other buildings. This kind of dwelling gets certainly more daylight than the others. All buildings have in their interior brown finishing with low light reflection [6].

Regarding the questions that asked residents how satisfied they were regarding thermal comfort, only two of the respondents had heating devices. Nine of the thirteen answered from neutral to hot in winter and from warm to very hot in summer. Operating windows and the external door during the summer was not enough to obtain comfort. In fact, 5 reported a lack of heating and also poor daylight levels for considering the environment as uncomfortable. None of these had reported a very unpleasant daylight environment. In spite of the roof finishing, only 3 complained about too much draft. Overall, 6 mentioned that thermal discomfort was felt in the morning, while 4 considered it was felt during the night. Questions on the air quality were enquired. All the respondents were fairly satisfied [6].

To understand how the personal background and socio-economic factors of the respondents may affect satisfaction, several factors should be analysed. We have found a few well-maintained buildings. Most of the residents had very little opportunity to manage the building due to the limited financial capacity. As a community feature, satisfaction and accessibility to leisure and daily activities can be identified in further interviews as being important to the residents' well-being and enjoyment of their surroundings [6].

In terms of natural lighting, the presence windows on several facades affect light. The two-sided window façade allows sunlight to the centre of the dwellings. This is better on the four-sided window façade to distribute daylight through the whole floor. There were no complains about solar radiation. However, there is a need to further investigate natural lighting levels and how it affects the occupants [6].

Building satisfaction dimension may cover questions on dwelling material satisfaction and should also be asked to residents who might experience many problems, such as cracking, leaking, and degradation of floors, walls and roof cover. There were also questions when how building elements perform based on the occupants' comfort as the operation of windows, doors, but not on the missing sanitary facilities [6].

5. Conclusions

This research demonstrates that, currently, planning ahead means studying the past and understanding the techniques used in traditional architecture but also evaluate the post-occupancy of these architectures. In fact, this research is the only study conducted at the participant's own places, on these terms, and it is also the only study that collects opinion on comfortable issues as specified by participants. It has explored the relationship between lighting quality and occupants' welfare through the analysis of the evaluation path obtained from a field survey. The results have shown large differences between the responses derived from an inconclusive luminous environment.

One conclusion of this study is the clear influence that draft has on perceived indoor air quality and its subsequent effect on occupant health, although uncomfortable in indoor environments during wintertime.

In order to validate, more concretely, the outcomes, further field studies are recommended as the current study includes a few limitations. First, the results could be affected by the different kind of buildings and also influenced by the cultural and socio-economic background of the respondents. Secondly, the study did not address any monitoring of the variables proposed in this study and causal relationships between the perceived comforts and building operation.

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