Proceedings of 2nd Conference: ***People and Buildings*** held at Graduate Centre, London Metropolitan University, London, UK, 18th September 2012. Network for Comfort and Energy Use in Buildings: http://www.nceub.org.uk

Thermal and visual comfort in Greek vernacular architecture

Ilianna Ntarladima
MSc Architecture, Energy & Sustainability, London Metropolitan University, UK

Abstract
This paper looks at the design parameters of Greek vernacular architecture in terms of sustainability. It studies whether traditional residential dwellings in the old town of Xanthi (Greece) correspond to the sustainable demands of today in terms of thermal and visual comfort during summer months. Moreover, it researches whether the windows with their size, orientation and location provide comfortable indoor environment. Temperature monitoring, illuminance data collection and HDR images took place during July in order to examine the comfort levels in the rooms. In addition, a questionnaire was developed to overview the occupants' opinion, experience and their adaptive behaviour to feel comfortable.

Keywords: vernacular architecture, Greece, residential building, thermal comfort, visual comfort

1 Introduction

In the past decades, valuable natural resources had been used by the construction industry, resulting to the pollution of the environment. Nowadays, the term sustainability is introduced in order to restore the lost balance between man and nature. Nevertheless the sustainability is not a new term. As Mclennan, J.F. (2004), states, "sustainable design is not about the features. It is when you design a building respecting the surrounding environment and get inspired by it and its features". The first practice of sustainable design starts from the early stages of the architectural expression, known as vernacular architecture. It reflects the cooperation of the man with the natural environment. Windows and their shading devices always had an important role in architecture, especially in anonymous architecture, as they contribute to the visual and thermal comfort of the users. This paper examines whether traditional residential dwellings correspond to the sustainable demands of today, and more specifically the role of windows in terms of thermal and visual comfort. Temperature monitoring took place for 11 days during July using temperature loggers (ibuttons). Moreover, illuminance recordings and HDR images (luminance maps) were taken towards to generate an overview of the available daylight and its distribution in the spaces. Furthermore, questionnaires were delivered to the occupants concerning thermal and visual comfort of the spaces with purpose of gathering residents' point of view.

2 Climate in Greece

The climate of Greece can be described as Mediterranean but because of the strong natural topography of the terrain, the country can be divided in three climatic zones (fig.2.1), from the coldest one to the warmest, depending on the climatic conditions (Loukopoulos, D., 2001).

- Coastal zone: Islands and coastal areas (A)
- Lowland zone: a) Mountains of low height (B)
  b) Plains (C)
- Mountainous zone: Mountainous areas (D)

Depending in which region the building is located, there are different styles of construction (fig.2.1). It can be seen from the image that the warmer the climate higher thermal mass is required to offset temperature swings. In the mountains, the buildings are suggested to have a heavy ground floor and a lighter upper floor to allow seasonal migration.

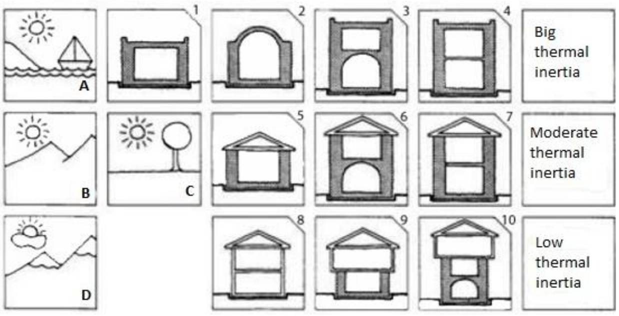


Figure 2.1 Building envelopes and climatic zones (Source: Loukopoulos, D., 2001)

3 Vernacular architecture

Greece has a great assortment of vernacular dwellings because of the great diversity of the terrain, the environmental conditions in each area, the social organisation of the community and the available natural resources and materials. In general, it can be said that there are 3 main types of dwellings, depending on where they are located. There are dwellings in plains (C), continental dwellings (B, D) and insular dwellings (A). In the old town of Xanthi, there are vernacular residential dwellings of continental architecture. The majority of the buildings have two floors with a few examples of three. The ground floor consists of thick masonry or mud brick walls, where few, small windows can be located. The upper floor has more and bigger windows and the construction is more lightweight made of timber. The choice of different constructing materials in each floor was mainly because of the internal migration between spaces, so as the occupants to restore their thermal comfort (Sakarellou-Tousi N., et al., 2009). Not all of the vernacular buildings have shutters as shading devices, some have curtains as shading devices. Christian neighbourhoods had no use of shutters whereas Muslim adapted to external ones. This is related to the different social and religious characteristics. (Mavridis, D., 2005). Another reason for the absence of shutters on the ground floor area is that it used to be a shop, a storage room or a place for processing tobacco leaves (Lianos, N., 2004). A survey in the old town confirmed these types: buildings with internal shading devices only, buildings with external (upper floor) and internal (ground floor) shading devices and dwellings with external shading devices only.

4 Data Analysis

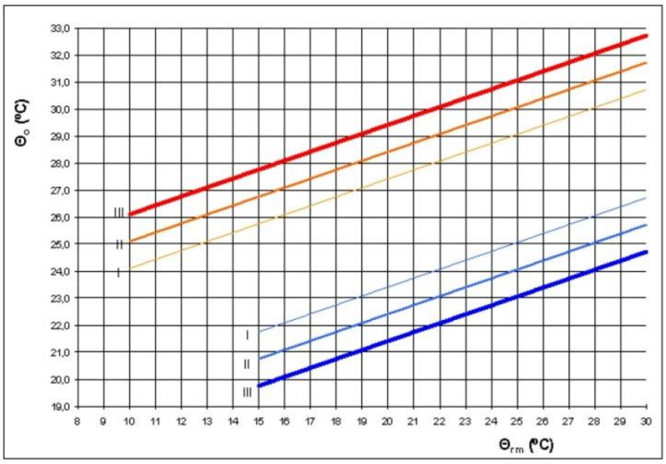
The case study is a residential building with three floors located in the old town of Xanthi (fig.4). It is an old manor house which was built in 1896. The main facade of the building faces south. This area is densely constructed with narrow streets.

Figure 4. Building of study

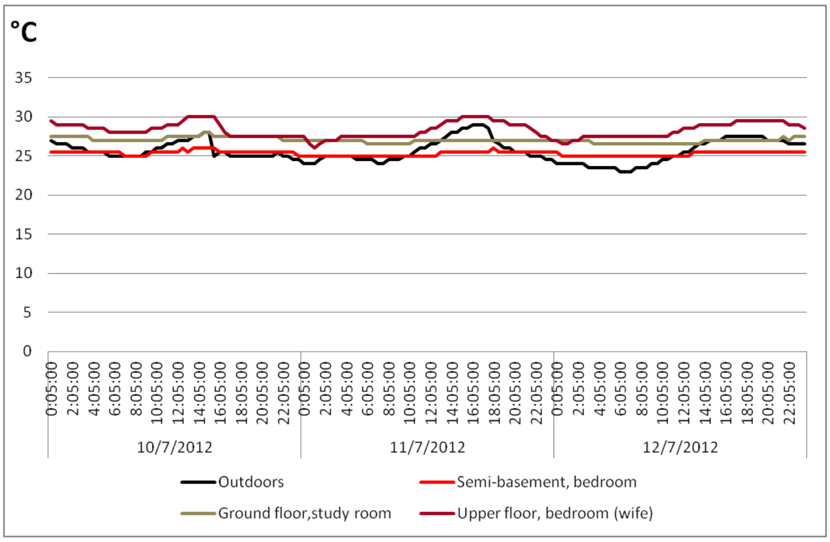
4.1 Thermal Comfort

The data loggers (i-buttons) were placed in every floor of the building in order to record the indoor temperature of the selected rooms, recording every 30 minutes for 11 days. According to British Standard BS_EN_15251:2007 the building, belongs to Category III, as it has not been refurbished. The selected benchmarks for thermal comfort were the values for the indoor operative temperature for buildings without mechanical cooling systems (fig.4.1).

Figure 4.1 Design values for the indoor operative temperature for buildings without mechanical cooling systems (Source: British Standard BS_EN_15251:2007)



Graph 4.1 Temperature difference between external and interior temperatures of selected spaces facing south



All the selected spaces of the graph have south orientation. It can be seen that the highest recordings are the ones on the upper floor, reaching 30°C (around 14:00). This might be a result of the thinner wall construction and the location under a non insulated roof. In addition, unsatisfactory ventilation of the space may also occur. Nevertheless, all temperatures of these areas are within the acceptable range of 23.5°C-31.5°C.The bedroom located at semi-basement levels, maintained stable temperature rates of 25.5 °C. This might be because of the heavy mass of the walls, which contribute to the conservation of the low indoor temperature, despite the fluctuation of the external environment. Moreover, the low temperatures of the space may be because of the property's position. It is a semi-basement area, and the surrounding obstructions consist of buildings with two floors, blocking the sun some hours during the day. From the graph it can be seen that the space recordings had the same fluctuation frequency as the outdoors temperature ones. When the outdoor temperature was rising, the room's temperature was rising as well.

4.2 Visual comfort

4.2.1 Illuminance readings

In order to examine whether the spaces are well daylit or not, benchmarks of maintained illuminance were selected so as to make a comparison. It is known that in order to examine if one residential space is well daylit throughout the day, the calculation of the Daylight Factor (DF) is needed. However, in this project it was not possible to measure the unobstructed illuminance. So, recommended illuminance levels from "SLL The Lighting Handbook (2009)" were adapted. Readings were recorded with curtains kept as they were so as to have a more realistic approach of the existing daylight level. There was no direct component of the sun, only diffuse component (light from the sky) due to the obstructions.

Table 4.2.1.1 Overview of used benchmarks and assumptions
(Source: SLL, Lighting Handbook, 2009)

Location	**Maintained illuminance (Lux)**	**Assumptions**
Reception desk	300	(For the study rooms)
Study bedroom	150	(For the study area of the bedroom)
Small kitchen	150	-
Lounge	150	(For the living room)
TV Lounge	50	(For the living room with a TV)

Table4.2.1.2 Illuminance recordings of the spaces

	Average Illuminance (Lux)
Ground Floor-Small living room	290
Ground Floor-Study room	151
Ground Floor-Bedroom	187.5
Ground Floor-Guestroom	19.5
Ground Floor-Living room	32.4
Upper Floor-Bedroom (son)	139
Upper Floor-Bedroom (wife)	75
Upper Floor-Kitchen	98.7
Upper Floor-TV Lounge room	24.2
Semi-basement Level-Study area	21.5
Semi-basement Level-Bedroom	30

Results concerning illuminance readings showed that the lux levels in the spaces where within the selected benchmarks in general (table 4.2.1.2). The spaces are well daylit despite the presence of dark colours and poor reflective surfaces, which affect the distribution of natural light in the interior. The tasks areas appear well daylit, as they are located near the windows. The rooms with the lowest readings in relation to the benchmarks are the living room and the guest room on the ground floor and the wife's bedroom on the upper floor. The low readings are probably a result from the presence of the curtains and from the decoration with dark furniture. In the case of the guest room, the low illuminance levels are a result of the orientation (north), size and the presence of external obstructions (patio area with walls). Spaces located in the semi-basement area have significant problems of visual comfort. The living room area has no windows at all. This is because the semi-basement area was originally a cellar, where no daylight was needed. In general, it must be said that the access of natural light during the day is heavily affected by the presence of neighbouring buildings and narrow streets.

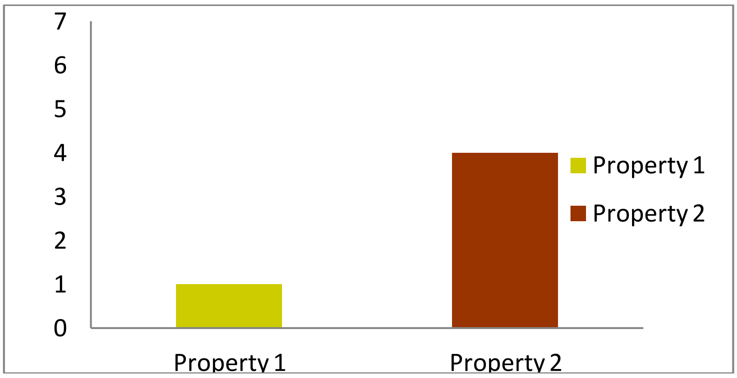
4.2.2 HDR images

Figure 4.2.2 Luminance map

The bedroom located in the semi-basement area has good distribution of natural light (fig4.2.2). In general, the walls near the window are in light blue and yellow which indicates good levels of luminance levels. The fairly light colour (yellow) of the walls contributed to this spreading of daylight. Interreflections within the room are endured, as reflected light from the street reaches the interior of the room. It can be seen from the big yellow patch on the ceiling close to the wall of the windows. The only dark spots appear to be the curtains and pillows by the window and the desk as well. All of them are dark coloured and made by poor reflective material, so the low luminance rates are justified.

4.2.3 Occupants' comfort and preference vote

Graph4.2.3 Overall comfort rating during summer months



The occupants of property 1(semi-basement property) rate the property's overall comfort levels during summer months as being *"much too cool"* and they wouldn't change their vote. On the other hand, the occupants of property 2(ground and upper floor) describe the overall comfort levels as *"comfortable, neither cool nor warm"*. Concerning thermal comfort, property 1 is *"much too cool"* without any complaints and property 2, has votes of "comfortable neither cool nor warm", with the spaces located on the ground floor being cooler than the ones on the first floor, described as *"comfortably cool"*. This view of the occupants is justified by the temperature recordings as the spaces on the ground floor are cooler than the upper floor ones.

There is a dissatisfaction for two rooms in the upper floor that face north (wife's and son's bedrooms), as being *"too warm"* and they would prefer to feel *"much cooler"*. The temperature readings in these two rooms were quite high comparing to the other spaces.
Relating to visual comfort, the residents of Property 1 answered that the visual comfort of the spaces during summer is not satisfactory in general. In property 2, occupants appeared quite satisfied with the levels of natural light and they think that the windows provide the interior with enough daylight during the day.

3 Conclusions

The customization of the spaces by the residents plays an important role in contribution of light. The size, orientation and ratio of the windows might be satisfactory in relation to the room size but the selection of dark colors and poor reflective surfaces of the walls and objects, do not promote daylight distribution in the interior. The windows' shape, size and orientation of the building are satisfactory, with illuminance readings being within the suggested benchmarks. In some spaces the average illuminance levels are not satisfactory according to the selected benchmarks. These benchmarks cannot be taken strictly into consideration but it is better to consider them as guidelines in order to form an overview of the rooms' comfort. All of the recorded rooms have temperature recordings within the range of the suggested benchmarks and the occupants expressed high levels of satisfaction with their thermal environment. Moreover, the types of shading devices of windows affect the thermal performance of the space. External shading devices, such as shutters, when closed during the hot hours of the day, contribute to the stable temperature of the space. Internal shadings devices, as curtains, may diffuse or block sunlight but the solar radiation is admitted and may lead to overheating of the space. Furthermore, internal shading devices tend to interfere with ventilation aggravating the dissipation of the heat trapped in the space. Generally, it cannot be ignored, that Greek vernacular buildings were built according to the environmental conditions and the surrounding environment. The designing principles that were used are similar to the ones of sustainable design of today.

References

CIBSE "Daylighting and window design", Lighting guide LG10:1999

CIBSE "The SLL lighting Handbook" The society of Light ad Lighting, 2009

Lianos, N. "Morphological characteristics of the buildings of the Old Town of Xanthi.", 2004

Loukopoulos, D., "Environmental planning of cities and open" Volume A'. Environmental technology, Greek Open University, Patra 2001

Mavridis, D., A., "Craftsmanship and artistry in Old town of Xanthi" Municipal Development of Xanthi-Cultural Development Centre of Thrace, 2005

Mclennan, J. F. "The philosophy of sustainable design" Ecotone LLC, 2004

Moutsopolos, N.K, et al. "Balkan traditional architecture" Melissa Press, 1993

Oikonomou, A. "Comparative investigation of the architectural form and the environmental behavior of the traditional houses of 19th century in Florina" PhD Thesis, NTUA 2007

Papapetrou, M. "Sustainability and Greek traditional architecture", 4th Conference ΠΕΕΚΠΕ, Nauplio (12-14//12/2008)

Rapoport, A. "House, Form and Culture", 1969

Sakarellou-Tousi N., Lau B. The Vernacular Dwellings of Mount Pelion in Greece: A migratory living pattern: PLEA2009 - 26th Conference on Passive and Low Energy Architecture

Lais, M. "The traditional and anonymous architecture of Crete. The case of Rapti settlement" Lecture, NTUA