Thermal Comfort in Social Housing Projects

Analysis of Bioclimatic Architecture in Hot and Humid Climates

Carolina da Silva Melo Miguez

Architecture and Urban Design Student

Lund University, Sweden

1 Introduction

The construction industry consumes a significant amount of energy and natural resources all over the world. Population growth and economic development contribute to increase this consumption, frequently causing environmental imbalances, and losses in the life quality of populations, especially in developing countries.

Current construction processes usually generate an extremely large amount of waste, drain natural resources and also use a lot of energy. Hence it is necessary to seek better solutions for buildings' construction process, and also to look for measures to increase their energy efficiency during the subsequent years of use.

The contribution of buildings in energy consumption is enlarging worldwide. Around 40% of the total energy consumed is used in buildings (Bodach, 2014), comprising a large percentage for hot climate countries considering there is no need for heating. However, much of the energy is intended to improve indoor environmental comfort and it is sometimes unnecessarily used in systems such as air-conditioning. "The cost of an air-conditioning system ranges between 10% to 15% of a building's construction cost and consumes over 60% of the electricity for its operation." (Stagno, 2013).

In hot humid climates there is a large need for air conditioning systems when buildings are not well adapted to high temperatures and humidity. However low-income families cannot afford systems to artificially achieve thermal comfort in their homes. Therefore, it is especially necessary to implement measures to enhance the energy and thermal performance in social housing projects, that besides the reduction in energy expenditures, would also enables the design of better quality homes.

2 Social Housing and Bioclimatic Architecture

The current reality in developing countries when it comes to social housing and its thermal and energy performance is that the climate aspects, such as temperature and humidity, are often not even considered in the design process. Moreover, architects usually do not pay attention to different factors that affect directly the thermal behaviour inside the buildings and consequently the inhabitant’s comfort, for instance the urban surroundings, building orientation, materials to be used and their properties. Therefore, it is common that buildings have bad indoor conditions in terms of thermal comfort, health and efficiency.

In an attempt to identify the reasons why climate aspects are generally not considered by the architects in low-income housing projects, a literature review was carried out in this paper to understand why buildings in developing countries are poorly adapted to hot and humid climates.

Standardization

One criteria that is generally prioritized for low-income housing projects is reducing the cost of dwelling units. The limited financial resources available for the significant amount of houses to be built, and the lack of measures to achieve energy efficiency – or even some basic requirements regarding, for instance, the size of the windows – frequently result in inferior construction quality and thermal performance. Low-income housing projects primarily follow economic viability criteria and seek to meet the most out of the housing demand. Building the largest number of housing units in short time and with the lowest possible expenses is a principle in various developing countries, where the housing deficit is a big problem to be solved. As a result, repetitive and large scale urban, architectural and constructive solutions become commonly adopted (Vieira, 2012).

Standardized social housing developments do not take into account the microclimatic conditions of the implementation site, disseminating the same typology and using the same materials in places with distinct climatic, geographical and cultural characteristics. When the natural conditions of the intervention area are not considered in the design project, the losses in its quality can be very significant.

Imported knowledge and loss of traditional techniques

The importation of typologies from cold weather countries is also a common practice when designing buildings and neighbourhoods. The excessive use of glass, for instance, may result in a great gain of heat when in fact the opposite is desirable. Glass and other materials may be seen as nice design decisions because they are largely used in developed countries. According to Rosenlund (2001), the lack of technical knowledge from part of architects and engineers leads to bad choices that cause an enormous impact in the thermal comfort and energy consumption. The latter is one of the reasons why buildings are poorly adapted to the climate.

Bodach (2014) states that the traditional knowledge is being lost over the years in the globalized world. The modernization of the building sector brings technologies produced massively and that do not consider each place individually as the traditional knowledge does. Through modern techniques it is also possible to achieve great thermal performance in the indoor environment. Therefore, the tendency is to forget the passive techniques of adaptation to the climate. This reality makes the energy consumption of the buildings to increase. There are two significant consequences of this situation. The first is the economic impact for the dweller, especially for the low-income families that in many cases cannot afford to pay for the thermal comfort. The second is the environmental impact that increases the demand for energy production, and might cause several negative impacts for the planet.

The pressure to supply the large demand for housing in developing countries is also one of the reasons for loss of traditional techniques and replacement for standard and industrialized solutions. The population in these countries grew in a very accelerated pace at the past decades and the necessity for shelter created the pressure to construct as many and as cheap as possible. One consequence of the mass production of housing is the misuse of materials, incorrect technical specifications for thermal insulation, openings, ventilation, among other aspects. The initial price of the unit might be lower, but the families either will afford for comfort or have to live in discomfort for years. On the other hand, a design that considers many climate aspects will help to achieve a good indoor environment, which means that no extra energy or very little of it will be spent for thermal reasons.

Social housing projects are generally designed without major concerns with aspects of environmental comfort and energy efficiency, elements that greatly contribute to the population's well-being. Problems in this kind of settlements, such as thermal discomfort and insufficient daylighting and natural ventilation, result in elevated energy consumption.

The importance of the site in decision making during the design stage is pointed out in Vieira's work. Taking into account local specificities such as climatic and physical conditions or constraints of the area influence the quality of the design. Therefore, the recognition of the site is of fundamental importance for the implementation of an architectural object, observing features such as boundaries, climate, light, vegetation, topography, scale, materials, colours and orientation. However, the application of these criteria requires a change in the ongoing design and construction practices. “The current situation tends to prioritize capital costs, without much consideration on the long term benefits and thermal performance” (Triana, 2015). Therefore, it is essential to look at the buildings from a life-cycle perspective, taking into account pay back periods for the benefits of the use of its components.

In order to achieve great performance when it comes to climatic design, it is fundamental to considerer local characteristics such as prevailing wind directions, solar incidence on surfaces and the surrounding’s interference. Contemplating all these aspects since the beginning of the design process is what will make each building unique.

> *“It is not practicable to plan a building exclusively on economic, functional or formal grounds and expect a few minor adjustments to give a good indoor climate. Unless the design is fundamentally correct in all aspects, no specialist can make it function satisfactorily. Climate must be taken into account when deciding on the overall concept of a project, on the layout and orientation of buildings, on the shape and character of structures, on the spaces to be enclosed and, last but by no means least, the spaces between buildings. In other words climate must be considered at the early design stage”* (Building Research Establishment [BRE], 1974, cited in Rosenlund, 2001, p. 9).

Evaluation of building performance

Apart from the design process taking into consideration the climate aspects and local specificities, it is also necessary to implement systematic and regular evaluations of buildings' performance, aiming to create solid databases that can be the roots for constant amelioration of standards and regulations, technical improvements or costs reduction. Interviewing the dwellers and analysing their perception of the living space, together with the technical information, is crucial to determine the indoor climate situation in existing low-income housing projects.

Furthermore, participatory strategies that bring the inhabitants to contribute in different parts of the process are important to be considered when intending to reduce the general cost of a housing unit. A well-established participatory program can be a significant tool to implement local traditional techniques in the construction and building typologies that take into consideration the environment and climate. Other instruments could also be used to keep and perpetuate the local skills, such as registration of the traditional knowledge and techniques or training programmes, for instance disclosures focused on the youth that might be responsible to perpetuate and improve these abilities in the future. In that scenario, it is more likely that the inhabitants accept the new conditions of living, since the different needs of each dweller might be fulfilled.

Besides the inclusion of feedback and evaluation of existing projects in the process, the use of technology within computer simulation softwares might provide useful results about a building's performance. It can especially contribute in the early stages of the design project, since there is the possibility to pre-test it and anticipate many potential problems, such as poor ventilation, inappropriate sunlight exposure, among others.

Another topic that is worth to be analysed is the use of building codes inspired by foreign countries' codes, that in some cases are imported from countries with cold climate and do not reflect the real necessities and habits from the locality. Each country, city and region have its peculiarity and the codes must reflect the characteristics of these places in a more unique way. The construction of low-income housing might need a specific regulation that covers its specificities, such as a regulated self-help construction system. When it comes to energy consumption and climate performance, the existing solutions for passive conditioning of buildings might represent an increase of initial costs for each unit. For that reason, establishing minimum requirements to be fulfilled might coerce industry and designers to come up with cheaper solutions, enough to provide everyone the same access to good thermal and energy performances.

As a result of the analysis made above, it becomes evident that the climate, as well as how the energy is spent, are very often left behind other issues, such as financial decisions. However, in order to provide a good living environment to the community, all aspects should be taken in an equal level of importance, which means that the designer in the process must consider all variables and climate aspects, and energy efficiency is part of these. It is, nevertheless, a challenge to take good climatic design decisions, to keep the costs as low as possible and to get the population to collaborate in the whole process. Consequently, the architect's involvement during the project and its construction becomes even more relevant to guarantee better living conditions for every citizen, regardless one's financial reality.

3 Passive strategies to achieve thermal comfort

Warm humid regions extend up to 25 degrees' latitude on each side of the Equator and are characterized by a climate that can be a real challenge when designing passively conditioned buildings since it is very uncomfortable throughout the year, with high humidity and constant high annual temperature. There is little seasonal variation, but in some areas seasons could be defined by rainfall. Therefore, design principles should focus on reducing heat gain and maximizing ventilation. Some passive strategies to achieve thermal comfort in buildings are the following:

To minimize the heat gain, and consequently the indoor temperature, the minimum of external surfaces should be directly exposed to solar radiation. Pitched roofs are a good choice since the radiation received is less than in horizontal surfaces. Furthermore, sloped roofs are more efficient in draining storm water from the building. With wide overhangs, they also help to crate shade and rain protection for the facades and indoor spaces. However, flat roofs can be better used if shaded by a structure that could also facilitate the establishment of different functions at the roof level. Ventilated attic spaces in the ceiling also help protect from solar heating through the roof. If light coloured, the heat emission downwards into the building also decreases.

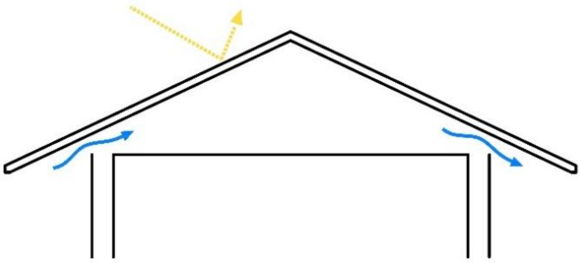

Figure 01: Pitched roof with ventilated attic. Elaborated by the author.

Vertical surfaces such as external walls and windows should also be protected from solar radiation according to the orientation of the façade. Besides shading devices as brises-soleil, a second skin could be used, avoiding direct solar radiation but allowing light entrance and air flows. Furthermore, to minimize the heat storage, since the variation between day and night temperatures is small, lightweight materials should be used in those facades, which should also be reflective.

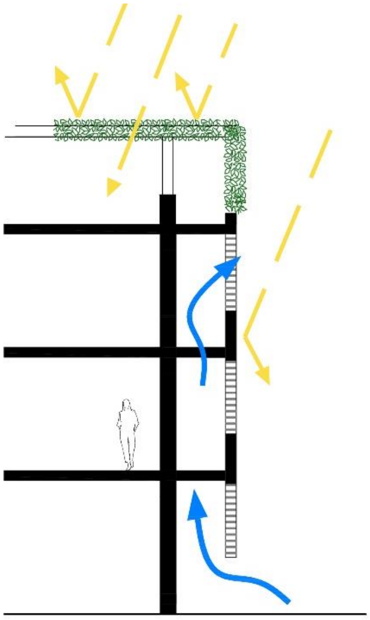

Figure 02: Second skin and shaded flat roof. Elaborated by the author.

To maximize natural ventilation, a building must be oriented taking into account the prevailing wind direction and have large openings, providing cross ventilation. However, it is possible to modify the landscape, for instance using vegetation, to cause wind deflection. Moreover, the space between buildings needs to be wide to optimize the wind flow.

Openings should be large enough not only to provide sufficient cross ventilation, but also to meet daylighting requirements. Furthermore, their placement needs to consider the design of solar protection, guaranteeing shade provision. Light conduits can also be used to improve lighting conditions in areas further from those openings.

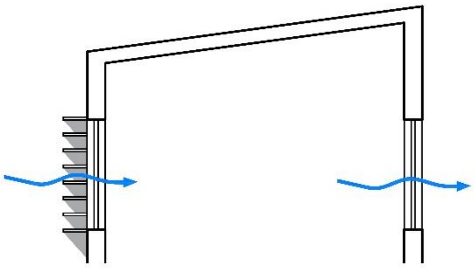

Figure 03: Cross ventilation and shading device in a window. Elaborated by the author.

4 The Role of Architects

"The practice of the profession is a process where we observe, analyse, draw, cross out and erase, until we reach the correct solution. We also criticize, and trial and error abound. Whenever this creative process is replaced by the automatic application of new technological developments, something important is lost along the way in the professional and regional heritage." (Stagno, 2013).

Many of the countries in hot and humid areas are developing countries, a fact that has direct influence in the way architects should work from a microclimatic point of view. Design principles must reflect the needs for minimizing thermal stress by cost-effective solutions. This means that professionals should search for tools and knowledge in order to passively achieve thermal comfort without the necessity of expensive industrialized solutions.

Nowadays the problems related to hot and humid climate and the appropriate architectural responses to it are largely discussed. Architects can resort to traditional knowledge involved in the local vernacular architecture and also look for current studies and technologies of how to passively condition a building.

It is a great responsibility of the professionals to provide climate conscious housing design, especially to the urban poor who cannot afford active thermal comfort systems. Therefore, while developing a project, the architect should analyse the microclimatic conditions of each site since the beginning of the design process.

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