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Technical note

Development of energy-efficient passive solar building design in Nicosia Cyprus

Kefa Rabah

Department of Physics, Eastern Mediterranean University, Gazimagusa, North Cyprus, via Mersin 10, Turkey

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Abstract

Analyses have been done on different techniques of passive solar control using local climatic data (for 25-year period) to obtain physical building design. Our main aim is to provide general and appropriate information at strategic pre-design stages to make better use of passive solar energy in urban planning and building design for better indoor 'comfort' climate. It utilizes manual analysis techniques or Mahoney tables and ACHIPAK to develop 'comfort zones', and 'control potential zones', for the Capital City of Nicosia (Cyprus). The use of the control potential zones (CPZs) in pre-design of buildings and their objectives are discussed. Opportunities and limitations of the pre-design guidelines are also discussed.

Keywords: Climatic design; Solar energy; Passive solar architecture; Thermal comfort; Human comfort

1. Introduction

The local weather and environmental conditions are both known to have physical and emotional effect on man and, therefore, of central importance in building design and development. Respect for building site and local climate, permits use of climate-specific passive solar design to heat or cool naturally, thereby achieving better indoor climate suitable for human comfort. Comfort may be defined as the sensation of complete physical and mental well-being of a person within built-environment [1]. Passive solar building

E-mail address: krabah@hotmail.com.

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design can be described as the utilization of the sun's energy together with the characteristics of a local climate and materials of the building, to directly maintain thermally comfortable conditions within built-environment, while minimizing the energy consumption. This should include sufficient 'tuned' thermal mass corresponding to the insulation and window design. Further, analysis of whole building permits 'right' sizing of building features, which can be implemented by placements of highest efficient external systems like windows and doors for effective utilization of natural day-lighting and ventilation. The implementation of these strategies is expected to greatly enhance building design and in-effect lead to better indoor comfort climate and low energy running cost. Unlike many of the building technologies, good passive solar (climate) design is as much a matter of the art of design as it is the knowledge of technology. The development of this art into science and its application is known as *psychophysics*. In general, it is the study of the relationship between physical climate and psychological events in human beings within a dwelling [2,3].

Most of the research work undertaken to-date in many countries involve continuing investigation, analysis and definition of the many complex thermal processes that can take place within a building structure, for the purpose of quantifying the parameters necessary to achieve an energy-efficient built-environment with better indoor 'comfort' climate [4–16]. The Aspen Energy Forum 1977 [17], whose theme was 'Solar Architecture', emphasized passive solar design and its great contribution in the area of energy conservation in buildings. Hence, one of the physical designer's main tasks is to create an environment inside the building, which is appropriate for all the human activities likely to take place there. The occupants' biological, emotional and physical characteristics also come into play. It is, therefore, of great importance to consider the response of the user's physiological make-up in relation to the environmental conditions it is exposed to [18]. The body as a self-regulating system prefers to relate harmoniously with the climatic conditions and the environment around it.

The work of Humphreys [19] at the UK Building Research Establishment and its continuation by Auliciems [20,21] at the University of Queensland, conclusively showed that thermal neutrality of people in their normal environment and chosen clothing, depend on the prevailing climatic conditions as well as the seasons and, is a simple function of the mean outdoor (dry bulb) temperature (DBT). Fanger [10] suggested that the thermal preference of all humans is the same and it depends only on activity level (*metabolic rate*) and the amount of clothing. While the work of Houghten and Yagloglou [22] led to the recognition of two environmental parameters, which contribute to the thermal sensations: air temperature and humidity. Artkinson [23] was the first to propose the distinction of only four climate types from the point of view of building design namely: cold, temperate, warm-humid and hot-dry conditions. Olglay [24] introduced the concept of 'bioclimatic design' and defined it as 'comfort zone' on his bioclimatic chart. Similarly, Givoni [3] used the psychrometric chart as the bases to define the comfort zone and stretched out the probable extent of outdoor conditions under which certain passive control techniques can ensure indoor comfort. The relationship of these quantities is normally shown on a psychrometric chart, as will be seen later.

In recent years, physical design researchers such as Winett et al. [25] and Williamson and Coldicutt [26] have both evaluated these measures in an attempt to better match,