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Design and simulation of a new energy conscious system, (basic concept)

Mohamed B. Gadi*

*Member of International Advisory Committee for the IEF, School of the Built Environment,
The University of Nottingham, University Park, Nottingham NG7 2RD, UK*

Abstract

A new passive cooling and heating system is introduced in this paper. The system was designed to be adaptively, integrated into the fabric and layout of buildings in North Africa. After discussion of the passive thermal design principles, a number of traditional and modern passive cooling and heating strategies are reviewed and analysed. Lessons learned from these examples have greatly helped design the new system. Development of the new system was based on both architectural design and principles of building engineering. © 1999 Elsevier Science Ltd. All rights reserved.

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1. Introduction

For a human to be thermally comfortable, means to experience a condition of mind which expresses satisfaction with the thermal environment [1]. The body usually exchanges heat with the enclosing environment by radiation, convection and evaporation. The rate of radiative heat exchange, for instance, is largely influenced by the temperature difference between the body and the enclosing surfaces. Convective heat transfer can be promoted by natural or mechanical air movement. Air movement occurs due to wind induced pressure difference through the space and to a lesser extent, as a result of density difference within air layers enclosed. Metabolic heat lost by convection from the body surface is approximately 35% [2]. Evaporative heat loss from the skin may also take place and continue provided the vapour pressure on the skin is higher than the ambient vapour pressure and the room temperature is

* Tel.: +44-115-951-3118; fax: +44-115-951-3159.

E-mail address: mohamed.gadi@nottingham.ac.uk (M.B. Gadi).

lower than the skin temperature. In hot dry regions, the radiation heat loss in summer is highly potential due to large differences between day and night temperatures. This feature also means the possibility of utilising night time cooling, through introducing outdoor cooler air into the building. For the heating season, there is usually a high level of solar radiation, which could be collected, stored and radiated to indoor space.

2. System design

2.1. Learning from traditional forms

Along the coastal part of North Africa, the open courtyard is the most noticeable form of traditional architecture, which is believed to be related to the warm and humid summers and mild winters, Fig. 1. Moving towards the desert, one begins to see a change in the courtyard form, as a result of local climatic and social impacts. There is, however, a transition zone where the courtyard opening reduces to a smaller rectangle covered with local vegetation elements. Within the desert landscape, where stormy and dusty summer prevails, the courtyard opening is further reduced to small openings, (holes). One reason for this is to reduce the amount of sand thrown into the house and to avoid unpleasant glare effects from the strong sunlight. In addition to the courtyard, also appeared domed and vaulted roofs, Fig. 2. In summer, about 40% of domed or vaulted roof would be shaded from direct sunlight. Compared with a fully exposed flat roof, a dome or vaulted roof would have part of its indoor surface cooler than the rest. A curved roof, on the other hand, can be much more load bearing. It is also possible to incorporate an opening at the apex of the dome without the structural safety problems associated with a flat roof. Besides the dome, vault and the courtyard, also appeared the Malqaf (wind catch), Fig. 3, an indication, perhaps, that other forms were not sufficient in conditioning the indoor space. The Malqaf seemed more appropriate for dense areas, where wind induced ventilation through wall openings was not effective. The Malqaf can also be used to cool and moisten the air introduced into the indoor space by water along its passage. In some parts of the region the Malqaf was integrated into buildings together with

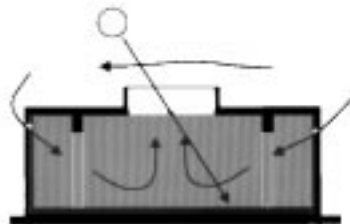


Fig. 1. Some of the concepts which inspired development of the new system. Traditional house with a courtyard.

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