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Envelope retrofit and air-conditioning operational strategies for reduced energy consumption in mosques in hot climates

Ismail M. Budaiwi, Adel A. Abdou (✉), Mohammad S. Al-Homoud

Architectural Engineering Department, King Fahd University of Petroleum and Minerals (KFUPM), Dhahran 31261, Eastern Province, Saudi Arabia

Abstract

Thermal performance of buildings is mainly determined by their thermo-physical and operational characteristics as well as the prevailing climatic conditions. Mosques which represent a unique type of building in terms of construction and operation can be major consumers of cooling energy, particularly in hot climates, if not properly designed and operated. In this study, energy modeling and simulation is utilized to identify potential energy savings due to envelope retrofitting measures and air-conditioning (A/C) operational strategies while maintaining acceptable thermal conditions. Results revealed a good potential for energy reductions when proper thermal retrofitting and operational strategies are employed. As much as 26% reduction in annual cooling energy is obtained when applying roof and wall insulation and reducing air infiltration to 0.5 ACH. By implementing a proper A/C operational strategy and employing system efficiency improvements, the required cooling energy can be reduced by around 36%. The total reduction in cooling energy consumption due to combined A/C system and envelope retrofit measures can be as much as 48%. A number of recommendations pertaining to mosque design, retrofitting and A/C operational strategies are derived. These are expected to be of great use to mosque designers and operators worldwide, but particularly in hot climates.

Keywords

intermittent operation,
energy savings,
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mosques,
hot-humid climate

Article History

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1 Introduction

The mosque is a building of great importance in all Muslim communities all over the world. Mosques are characterized by their unique physical and intermittent operational characteristics. They are places of worship for *Muslims* which are intermittently operated for short durations (45 to 60 minutes) five times a day all year round. Mosques are normally built in a simple rectangular shape with a heavy constructed envelope. The long side of the mosque is normally directed towards "*Qiblah*" (i.e. facing *Mecca*). The architectural form, space, construction systems and building materials of mosques have evolved and developed as a result of regional, cultural and climatic influences and differences. In addition, development in materials and environmental control systems (e.g. air-conditioning (A/C)) have greatly influenced contemporary mosque architecture. Interior surfaces of contemporary mosques are mostly finished with reflecting materials such as plaster or marble, and the floor is usually carpeted. Hard painted concrete ceilings with a range of simple to elaborate decorations are commonly used. The lighting system is typically composed of uniformly distributed fluorescent luminaries. Electro-acoustic sound reinforcement systems have also been implemented in mosques of all sizes, particularly after the introduction of the A/C systems, to improve the acoustic conditions in the space. In hot climates, mosques are likely to be equipped with either a central A/C system, or multi-unitary systems in conjunction with ceiling fans. The basic elements of typical mosque design in terms of architectural form, space, construction system, and building materials as well as the activity/worship modes and considerations occurring in a mosque have recently been described in detail (Al-Homoud et al. 2009).

Most mosques are only used for daily prayers, but a few are used for both "*Daily*" and "*Friday*" prayers where on Friday, during the *Dhuhr (noon)* prayer, the mosque would be fully occupied with prayer preceded by a religious

E-mail: adel@kfupm.edu.sa