International Journal of Sustainable Built Environment (2017) xxx, xxx–xxx

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Gulf Organisation for Research and Development

International Journal of Sustainable Built Environment

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Original Article/Research

Reliance of building energy in various climatic regions using multi criteria

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Received 4 February 2017; received in revised form 25 August 2017; accepted 8 December 2017

Abstract

Selecting a ventilation system for a certain building has always been considered as one of the critical problems for designers. Kingdom of Saudi Arabia (KSA) is characterized by a large area of significant climatic changes. In this research, five criteria are identified to compare and select one of the most popular ventilation systems, mechanical or natural. The identified criteria include Energy efficiency in buildings, Building function, Thermal comfort, the Maintenance cost of building, and Microclimatic conditions. The use of a mechanical system may be useful for achieving the building function and thermal comfort, while it seems to be more expensive. On the other hand, the natural ventilation system saves energy in the long run but it may not meet a comfort level for many users. Three regions which cover most of the climatic variations in the country are selected as a case study. A Ventilation Decision Making Model (VDMM), depends on the Analytic Hierarchy Process (AHP) as a multi-criteria analysis technique, is proposed and developed. For feeding data to the VDMM, field measures for indoor air temperature and relative humidity are conducted as well as applying an energy simulation model to predict indoor energy performance in the selected regions. Based on the results of VDMM application on the investigated case study, a decision to KSA construction market is introduced. The results absolutely support using the mechanical system in both Riyadh and Jeddah regions while utilizing the natural system in Abha region is more preferable. The VDMM is characterized by its flexibility, accepting more alternatives or criteria and its validity to be applied to other regions inside or outside KSA.

Keywords: Ventilation system; Decision making; Energy saving; Sustainable buildings

1. Introduction

Saudi Arabia is considered as one of the largest countries in the Middle East, specifically located in the southwest of the continent of Asia, with an area of about two million square kilometers. It is consisted of deserts with some parts with oases and about half of uninhabitable desert produces a very hot weather type of climate. Most parts of the lands located in the western regions of Saudi Arabia are plateau, lowlands on the east, all producing a very hot weather condition (Groucutt and Michael, 2012).

The weather in Saudi Arabia is composed of extreme aridity and heat. It is among a few numbers of countries

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Peer review under responsibility of The Gulf Organisation for Research and Development.

https://doi.org/10.1016/j.ijsbe.2017.12.002

Please cite this article in press as: Alwetaishi, M. et al. Reliance of building energy in various climatic regions using multi criteria. International Journal of Sustainable Built Environment (2017), https://doi.org/10.1016/j.ijsbe.2017.12.002

in the world where temperatures during the summer period reaches above 50 °C. While there can be snow or freezing winter in the higher mountain ranges but this weather event does not happened every year. The average weather temperature during these winter periods are 8°–20 °C in areas such as Riyadh and 19°–29° C in places such as Jeddah which is located on the coast of the Red Sea. The mountain regions have the freshest weather condition that is responsible for it to become the greenest part of the entire Kingdom of Saudi Arabia (KSA).

Due to this extreme weather, and the desire to save energy on the long run as well as achieve the thermal comfort and good building function, the selection of a ventilation system became a complex problem in KSA. The selection of a method to ventilate a building in KSA faces another problem, which is the lack of a scientific method or model to select a suitable technique. This process is fundamental and has always been considered as one of the critical problems for designers.

Therefore nowadays, extensive efforts have been directed to support a selection of the alternatives in design. Each technique features many advantages and disadvantages in the selected criteria as will be explained later. Many criteria should be identified to be taken as a base for comparisons. Combining the advantages and disadvantages to compare and quantify the two ventilation system alternatives for the purpose of decision-making is exceedingly difficult. Therefore, the main aim of this study is proposing and developing a multi criteria decision-making model to support the decision makers who design the ventilation systems in a certain region in KSA. The proposed model embraces the broader sense of many criteria. Improving the performance of this method not only increases the benefits of architects but also minimizes cost of building on the long run. Feeding data for the model depends on field survey, field measures and using an energy simulation model in the selected region.

2. Research methodology

The proposed research methodology for this study can be summarized in the following steps:

1- Identifying the criteria affecting the two ventilation systems, mechanical or natural.
2- Proposing and developing a decision making model (VDMM) that can deal with the problem.
3- Selecting three regions that represent various climatic zones in KSA as a case study.
4- Conducting field measures for indoor air temperature and relative humidity as well as applying an energy simulation model to predict indoor energy performance in the case study regions.
5- Applying the VDMM model on the case study regions using collected data from last step.

3. Ventilation systems alternatives

Ventilation for any building is considered one of the main design concepts. Many reasons oblige designers to ventilate the building such as providing fresh air to occupants, providing natural 'passive' cooling, distributing heating or cooling and dilution and removing pollutants. Two familiar types of ventilation, mechanical and natural, are used in design. Each ventilation system has many advantages and shortcomings. Here is a short description for the two ventilation systems.

3.1. Alternative (A): Mechanical ventilation

A Mechanical ventilation system can be described as the use of heating and cooling load in order to bring the internal condition of the space to the thermal comfort level. People spend most of their time indoors; hence, the reliance on air conditioning system is essential. Moreover, the importance of such system becomes more crucial where the gap between outdoor temperatures swings and the desired indoor comfort become larger (Graudenz et al., 2005). However, there are some other issues in association with air conditioning system such as the existing of sick buildings which suffer from the lack of natural ventilation (Seppanen and Fisk, 2002). There are so many kinds of air conditioning which can be used in buildings. Some of which are quite complex such as central air conditioning system, and others are very simple such as window unit. However, the major purpose of the air conditioning system is transferring the indoor condition into more comfortable environment. This indicates that there is a strong correlation between outdoor condition, indoor and building fabrication. The air conditioning system comes at the end to ensure adequate indoor condition which is affected by outdoor features such as temperature, and building fabrication.

3.2. Alternative (B): Natural ventilation

Natural ventilation is quite associated to cooling purposes, but there are many other purposes for it, one of which is indoor air quality. It has to be mentioned that even in cooler regions where there is no need for natural ventilation as a cooling method, there should be at least a minimum of air-exchange with external environment to release the contaminated air indoors (Awabi, 2003; Guiaus and Allard, 2005), and (Liddament, 1996). There are many types of natural ventilation and the most common techniques as follows: creating positive and negative pressure inside the building (Liddament, 1996; Szokolay and Auliciems, 2008), outside techniques (Szokolay and Auliciems, 2008; Awbi, 2008) and Stack driven pressure (Awbi, 2008). It may be hard to apply natural ventilation in hot and humid regions due to extreme of outdoor envi-

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