UNIVERSITI TEKNOLOGI MARA

HEAT TRANSFER AND OPTIMUM THERMAL RESISTANCE OF BULK INSULATION FOR NATURALLY VENTILATED BUILDING IN TROPICAL CLIMATES

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulation of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledge as reference work. This thesis has not been submitted to any academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

A study was carried out to evaluate the benefits of thermal insulation for naturally ventilated building in a tropical climate of Malaysia. The study was divided into two phases, the field study and simulation study. The field study was conducted in two identical test buildings with dimensions of 4m x 4m x 3m located in Universiti Teknologi MARA Shah Alam. Both test buildings have identical design. The non-insulated was named as Test Building A (TBA) while the insulated was named as Test Building B (TBB) where the insulation was installed consecutively underneath the roof and above the ceiling. This study presents the findings on thermal impact on the non-insulated TBA and insulated TBB. These were appraised by the respective attic and indoor temperature. The comparison of benefit of thermal insulation shows insulation underneath roof was better because the thermal impact for attic and indoor both test buildings indicate an advantage during daytime but ceiling insulation imposed penalty at daytime attic space. The simulation study was run to validate the software as a realistic representation of the real system. Since the respective percentage difference between field study and simulation study 4.2% and 6.1%, the both data can be compared and new design of modelling will be able to predict other simulation data. This simulation study presents the findings on heat transfer and optimum of insulation thermal resistance to minimize the heat gain through building. The installation of thermal insulation at roof and wall consecutively has reduced the convective and radiative heat transfer but ceiling insulation has decreased the conductive, convective, and radiative heat transfer. The predominant heat transfer proportion through the envelope was via radiation. The determining of optimum thermal resistance of thermal insulation for several models was carried out to minimize heat gain through building. It was concluded that the optimum thermal resistance for thermal insulation installed at roof, ceiling, and wall was model R_2 with respective thermal insulation 2.94 $m^2.KW^{-1}$, 2.86 $m^2.KW^{-1}$ and 2.86 $m^2.KW^{-1}$.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

Malaysia is situated in a tropical climate that experiences a hot and humid climate with uniform temperature, high humidity, and copious rainfall throughout the year. Malaysia that lies between 2° 30' N latitude and 112° 30' E longitude has a yearly average daytime temperature between 26 °C to 31 °C and night-time temperature between 21 °C to 24 °C (Meteorological, 2011). In hot-humid tropical climate, buildings are overheated during the day due to solar heat gain through the building envelope and solar penetration through the windows. Global solar radiation is high with an average of $12MJm^{-2}$ per day (Azni Zain Ahmed, 1995).

Building envelope is the elements of the building that form the boundary between the internal environment of a building and external environment in foundation, roofs, walls, doors, and windows (Botswana, 2007). It serves as the outer shell to protect the indoor environment to facilitate its climate control. The building envelope can contribute up to 73% of the total heat gain/loss in a residence (Kelso, 2004). Thus, the characteristics of envelope such as building geometry and orientation, construction type, thermal properties of materials, and the outdoor weather influences the heat gain/loss through the envelope and energy required for space heating and cooling (Mini Malhotra, 2006).

Solar radiation is the most important natural contributors to heat gain in buildings. The heat is conducted into the roof and radiates into the roof space and the heat trapped in the roof space could pass through the indoor space via the ceiling and increase the temperature of indoor space. The most exposed surface to solar radiation are wall and roof (Caren Michels, 2008). Thermal insulation plays a key role in improving the overall thermal performance by reducing heat gain in building, beside to achieve thermal comfort for its occupant in a building. It retards and obstructs the heat transfer via conduction, convection, and radiation depends on the type of insulation. The thermal properties of insulation materials are indicated by low thermal conductivity (k-value) or high thermal resistance (R-value). Meanwhile, the envelope construction is indicated by low thermal