APPROVAL OF SUPERVISOR

"I hearby declared that I have read through this report and I found that it has comply the partial fulfilment for awarding the degree in Bachelor of Mechanical Engineering (Thermal Fluid)"

Signature : ……………………….................

Supervisor 1: Mr. Shamsul Bahari B. Azra'ai

Date : ....

HEAT TRANSFER IN A TERRACE HOUSE WITH USING ROCK WOOL

MOHD MU'ADZ B MD ESWAN

This report is submitted as partial requirement for the completion of the Bachelor of Mechanical Engineering (Thermal Fluids) Degree Programme

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

APRIL 2009

DECLARATION

"I hereby, declare this thesis is result of my own research except as cited in the references"

Signature	: ………………………….
Author Name	: Mohd Mu'adz Bin Md Eswan
Date	: ………………………….

DEDICATION

To

My Beloved Family

AKNOWLEDGEMENT

First, l would like to this opportunity to express my deepest appreciation and thanks to my supervisor, Mr. Shamsul Bahari Bin Azra'ai for his supervision, encouragement, guidance during undertaking the project.

Also, I express my heartfelt thanks to Dr Mohd Yusuf Bin Sulaiman and Mr. Mohd Firdaus B Sukri for assistant, my friend Heinsen bin Jepanih, Saiffudin bin Ngspar invaluable knowledge and progressive, advices until the project completed successfully.

I would like to express thanks to all technicians and staffs from Mechanical school for their advices and response given whenever I encounter predicaments

Finally yet importantly, I greatly appreciate my family whose unfailing moral support and their advices.

ABSTRAK

Di negara-negara tropika, penyerapan haba paling besar berlaku melalui bumbung sebuah rumah. Umumnya, haba yang hilang daripada sesuatu sistem untuk persekitaran adalah pembaziran dan mempunyai kesan langsung ke atas kecekapan sistem itu. Juga untuk sistem-sistem yang wujud dijalankan sebagai sistem penyejukan, haba memperolehi daripada persekitaran akan mengurangkan kecekapan proses penyejukan. Dalam semua kes-kes ini haba dipindahkan oleh konduksi di luar permukaan dan ia kemudian dipindahkan oleh perolakan dan radiasi kepada alam sekitar. Walaupun rumah pada masa kini telah dipasang siling, bagaimanapun ia tidak begitu berkesan bagi mengurangkan haba pemindahan ke dalam rumah. Perkara ini akan menyebabkan dalam rumah memerlukan penyaman udara atau kipas untuk menyejukkan dalam rumah. Perkara ini akan menyebabkan penggunaan tenaga elektrik lebih banyak daripada yang sewajarnya. Kerugian ini telah dapat dikurangkan dengan menggunakan bahan penebat haba. Kajian ini telah dijalankan disebuah rumah teres dan menunjukkan dengan menggunakan *rock wool* sebagai bahan penebat dapat menolong mengurangkan pemindahan haba didalam rumah teres sekaligus dapat mengurangkan guna elektrik untuk menyejukkan dalam rumah. Kajian ini juga telah dijalankan dengan menggunakan bahan penebat dan tanpa bahan penebat penggunaan. Setiap kajian, suhu telah diambil dan dibuat analisis diantara kajian-kajian ini untuk dibuat perbandingan. Di akhir kajian, mendapati bahawa pengaliran haba tanpa menggunakan bahan penebat hanya dapat dikurangkan sehingga 0.122 W/m^2 manakala dengan menggunakan bahan penebat, pengaliran haba dapat dikurangkan sehingga 0.116 W/m^2. Kesimpulanya, dengan menggunakan bahan penebat *rock wool* dapat menggurangkan permindaan haba ke dalam rumah dan sekaligus dapat menjimatkan penggunaan kuasa elektrik rumah.

ABSTRACT

In tropical countries, the greatest thermal gain occurs through the roof of a house. Generally, heat lost from a hot or warm system to the surroundings is waste and has a direct effect on the efficiency of the system. Also for systems which are operated as cold systems, heat gained from the surroundings reduces the efficiency of the cooling process. In all these cases heat is transferred by conduction to the outer surfaces and then it is mainly transferred by convection and radiation to the environment. . Although home on time has now heat insulator call ceiling (asbestos), nevertheless it not so effective to reduce heat transfer into the house. This matter will cause in the conditions house need air conditioning or fan to cool state indoors. Nevertheless this matter will cause electricity usage that many from those duly. This loss can be reduced by the use of heat insulator material. This study was conducted at a terrace house and it was shown that the usage of rock wool as insulating material can help reduce heat transfer inside terrace house and can reduce electric use to cool down the house indoors altogether. This study was also conducted by using insulating material and without use insulating material. In every study, the temperatures was taken and analyzed for comparison to be done. As the study ends, it was found that heat flow without using insulating material could only be reduced till 0.122 W/m^2 while by using insulating material, heat flow could be reduced till 0.116 W/m^2. In short, by using rock insulating material wool, heat transfer into a house can be reduced while saving the lump sum house usage of electrical energy.

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LIST OF SYMBOLS

Q	=	Heat Flow Rate (W)
A	=	Area,(m^2)
U	=	Overall Heat Transfer Coefficient, ($W\ m^{-2}K^{-1}$)
R	=	Thermal Resistance, ($W^{-1}.K$)
Q_r	=	Radiated transferred energy (W)
Q_{co}	=	Conducted transferred energy (W)
Q_{cv}	=	Convective transferred energy (W)
dt	=	temperature difference (^oF, K)
A_1	=	Area of Radiating surface (m^2)
l_t	=	thickness of layer (inches)
A_2	=	Area of Receiving surface (m^2)
C	=	layer conductance (Btu/hr $ft^2\ ^oF$)
K	=	layer conductivity (Btu in/hr $ft^2\ ^oF$)
β	=	coeff. of vol expansion (1 /K)
θ	=	Temperature difference (k)
h	=	heat transfer coefficient (W /m^2 K)
k	=	Thermal conductivity (W/mK)
v	=	Fluid velocity (m/s)
g	=	acceleration due to gravity (m/s^2)
T_1	=	Ambient Temperature (°C)
T_2	=	Top roof Temperature (°C)
T_3	=	Bottom roof Temperature (°C)
T_4	=	Attic Temperature (°C)
T_5	=	Top Ceiling Temperature (°C)
T_6	=	Bottom Ceiling Temperature (°C)
T_7	=	Room Temperature (°C)
T_8	=	Rock Wool Temperature (°C)

LIST OF ABBREVIATION

ASHRAE	=	American Society of Heating Refrigeration and Air-conditioning Engineers
HVAC	=	Heating, Ventilation and Air-conditioning
IAQ	=	Indoor Air Quality

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CHAPTER 1

INTRODUCTION

1.1 Background study

Generally, heat lost from a hot or warm system to the surroundings is waste and has a direct effect on the efficiency of the system. Also for systems that are operated as cold systems, heat gained from the surroundings reduces the efficiency of the cooling process.

In the vast majority of cases, a great deal can be done to increase the energy efficiency of older properties, reducing the energy requirement and consequently lowering household energy bills substantially.

Building insulation refers broadly to any object in a building used as insulation for any purpose. Whilst the majority of insulation in buildings is for thermal purposes, the term also applies to acoustic insulation, fire insulation, and impact insulation. Often an insulation material will be chosen for its ability to perform several of these functions at once. Other types of insulation are designed to withstand high vibrations, and support heavy industrial applications

Thermal insulation in buildings is an important factor to achieving thermal comfort for its occupants. Insulation reduces unwanted heat loss or gain and can decrease the energy demands of heating and cooling systems. It does not necessarily deal with issues of adequate ventilation and may or may not affect the level of sound insulation. In a narrow sense insulation can just refer to the insulation materials employed to slow heat loss, such as: cellulose, fiberglass, rock wool, polystyrene, urethane foam, vermiculite but it can also involve a range of designs and techniques to address the main transfer - conduction, radiation and convection materials, and earth or soil modes of heat.

1.2 Problem statement

The hot weather in tropical climate causes the internal temperature of the house increase. Apart from that the heat transferred outside the house into inside the house caused the heat radiation increase to 75% from house roof. Other than are caused by other factor. Although residential home nowadays used asbestos as heat insulator for ceiling, it is ineffective to reduce heat transfer into the house. This matter will cause the conditions in house need air conditioner or fan to cool or reduce the heat in the house. This consequence will increase the usage of electricity for the residential house. The material that been proposed is rock wool. Therefore, with the good insulation material in building, the energy can be save more than we need.

1.3 Objective

To observe the temperature various with specified time in a terrace house
To analyze the temperature variation with and without using rock wool
To compare the heat transfer with and without using rock wool

1.4 Scope

- To study the rock wool as a insulation material in a house.
- To measure air temperature with and without rock wool in a house.
- To determine the heat transfer in a house using analytical approach

1.5 Benefit

The study about a good insulation material in building will improves the cooling conditions inside the buildings where it will definitely reduces the power consumption and economical involved for all the parties concerned in the construction process. With good insulation, material in building will reduce electric consumption costs up to 40% thus saving money and the country's energy resources. Furthermore, it cans reduce environment pollution and the heat transmitted into the buildings, reduces the level of energy consumption, which helps to minimize the problems caused by excessive loads of generators and the distribution networks and reduces its initial cost. The usage of AC is minimized and so are the loads of AC cables and ducts. This helps to reduce the cost of power consumption and electromechanical item's initial cost.

CHAPTER 2

LITERATURE REVIEW

2.1 Thermal performance of insulated roof slabs in tropical climates

From journal Halwatura R.U, Jayasinghe M.T.R (2007), in topic “Thermal performance of insulated roof slab in tropical climates” tells reinforced concrete roof slabs can be an ideal alternative to traditional roofs considering the better cyclone resistance that can be offered due to the self-weight. However, the concrete slabs do not perform satisfactorily in warm humid tropical climatic conditions and tend to act as heated bodies for the occupants in free running spaces. His journal describes a detailed study carried out on the thermal performance of reinforced concrete roof slabs provided with resistive insulation located in warm humid climatic conditions.

In order to determine the effect of insulation thickness, they have constructed four models. One was without insulation (Case 1). Others had 25 mm (Case 2), 38mm (Case 3) and 50 mm (Case 4) thicknesses. The insulation used was expanded cellular polyethylene. It has a thermal conductivity of 0.034 $W/K.m^2$.

2.1.1 The Result

Halwatura R.U, Jayasinghe M.T.R (2007) carried out two important parameters that can affect the indoor comfort at the top floor of a free running building. The ceiling temperature (suffix temperature in the case of roof slab) and the amount of heat transmitted through the ceiling. These two are interconnected in the case of a roof slab. The heat flow will depend on the air-to-air receptivity of the roof slab and the temperature gradient, which depends on the rooftop and suffix temperatures.

The air to air receptivity of the roof slabs have been estimated as 0.99, 1.37, 1.71, 0.25 W/ m^2K for 25 mm, 38 mm, 50 mm and without insulation, respectively. The corresponding ''U'' values are 1.01, 0.73, 0.58, 4.0 W/m^2K. Figure 2.1 indicates a significant drop in heat flow with insulation.

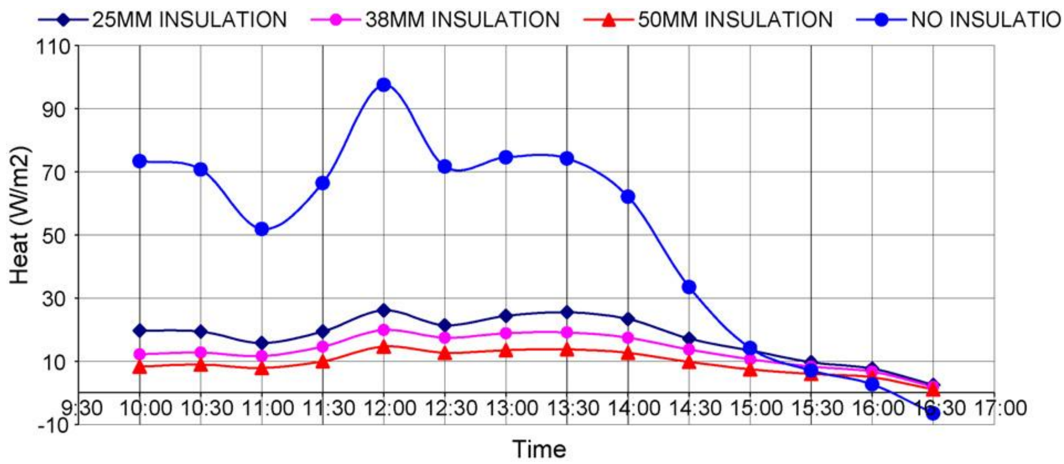

Figure 2.1: Heat flow values for different insulation thicknesses. (Source : Halwatura R.U, Jayasinghe M.T.R 2007)

2.1.2 The model

The model was a small building intended for storage of various laboratory equipment as shown in Figure 2.2. It has plastered one brick thick walls and a reinforced concrete slab as the roof. The roof slab thickness was 125 mm. It was not provided with any insulation. This allowed gathering of some useful temperature data prior to the installation of insulation system.

Figure 2.2: Large-scale model. (Source: Halwatura R.U, Jayasinghe M.T.R 2007)

2.1.3 The temperature measurements

In a warm sunny day, the suffix temperature reached a maximum value of 45 ^{0}C with the roof top temperature reaching 55 ^{0}C. After the installation of 25 mm of insulation, the suffix temperature remained below 35 ^{0}C when the roof top temperature reached 55 ^{0}C as shown in Figure 2.3. This clearly indicated that roof insulation is working effectively even though the resistive insulation thickness was only 25 mm.

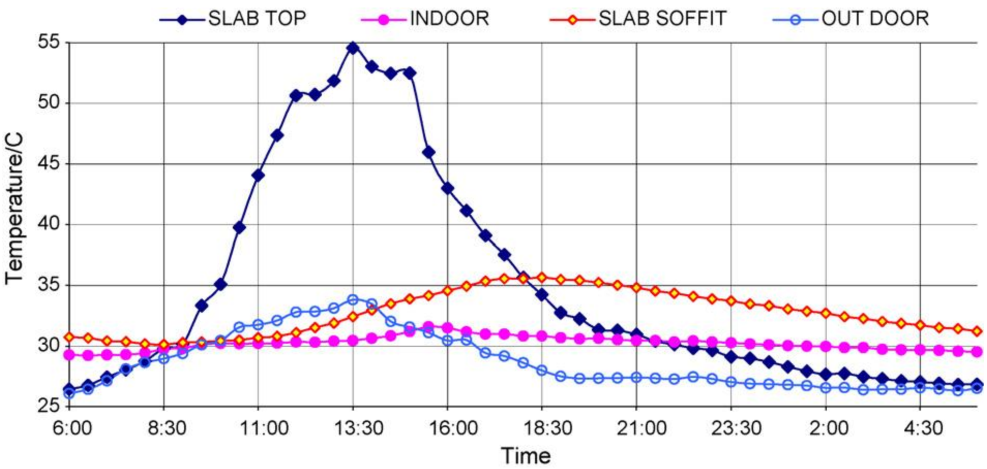

Figure 2.3: Temperature variation with 25 mm slab insulations in a day with bright sunlight. (Source: Halwatura R.U, Jayasinghe M.T.R 2007)

2.1.4 Conclusions

Halwatura R.U and Jayasinghe M.T.R (2007) showed that reinforced concrete roof slabs could be an ideal alternative to conventional lightweight roofs as far as preventing the uplifting during tropical cyclones is concerned. The poor thermal performance of concrete slabs can be significantly improved with resistive insulation. It is shown that an insulation thickness of only 25 mm can provide a noteworthy improvement in tropical climatic conditions specially with respect to reducing the slab suffix temperature. The comfort zones generated by combining various guidelines proposed previously have indicated that those acclimatized to warm humid conditions when plenty of ventilation is available could tolerate temperatures up to 35 ^{0}C. This indicates that there is very low possibility for an insulated roof slab to act as a heated body when located above free running spaces. There is a potential to improve the performance further by adopting the roof top gardens concept. Thus, insulated roof top slabs with a robust insulation system could be a viable and effective alternative to conventional roofs in tropical climatic conditions

2.2 Theoretical/experimental comparison of heat flux reduction in roofs achieved through the use of reflective thermal insulators

(Caren Michels, et.al (2007) presents a compact apparatus for the determination of the efficiency of insulation sheets based on the use of heat flux transducers. In addition, two models using thermal resistances, which give simple correlations of great usefulness, are presented. The sensitivity of the efficiency in relation to the several variables involved can be verified by exploring these correlations algebraically. Test results for different types of insulation sheets are reported and compared with the theoretical models.

2.2.1 Experimental apparatus

The experimental apparatus is based on information on the heat flux which passes through the system. The flux is measured by a type of transducer, called ‘a tangential gradient, with dimensions of 100 mm x 100 mm. Apart from its high sensitivity (20 mV/[W/m^2]), the main feature of this sensor is its reduced thickness (300 mm), thus allowing measurements with low noise. The apparatus aims to reproduce the characteristics of a conventional roof, in terms of thermal resistances. A diagram of the experimental apparatus can be seen in Figure 2.4 and Figure 2.5, where the heat resistor simulates the heating by solar radiation and insulation layer 1 the thermal resistance of the roof. Insulation layer 2 reproduces the thermal resistance of a conventional slab added to the thermal resistance of the internal air of the building. The apparatus has a work area of 0.6m x 0.6 m and a variable thickness, depending on the lateral insulation. As a standard 40 mm or 20 mm x 20 mm have been used when the sheet is installed.

The heat flux transducer is placed in the central region of the metal plate. A type-T thermocouple, in differential mode, monitors the difference between the temperatures of the sides. The heat resistance has a maximum power of 2500 W (6944 W/m^2) at 220 V, and can be controlled through a variable volt or PID system voltage controller. The lower temperature is kept equal to the ambient temperature with forced convection induced by six axial fans (diameter 120 mm). The thermal exchange in the upper side of the heat resistor (simulating the external air) is by natural convention, in a controlled temperature environment (approximately 22 ^{0}C). All surfaces, including those of the transducer, are painted with black matt paint (e = 0.95). The voltage generated by the heat flux transducer and by the thermocouple is measured by an AGILENT micro voltmeter, model 34401A, with a resolution of 0.1 mV.

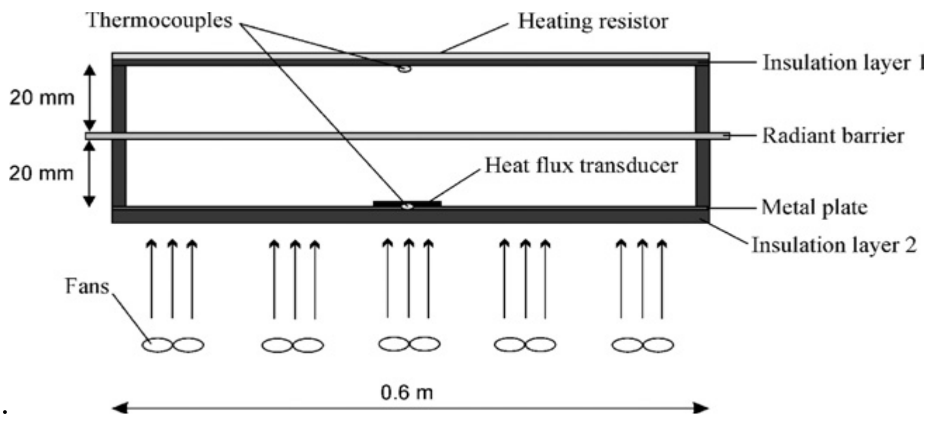

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Figure 2.4: Cross section of the experimental apparatus (Source: Caren Michels, et.al , 2007)