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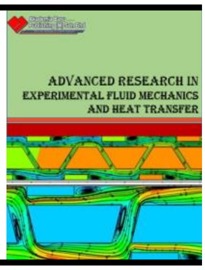


# Effect of Rockwool Insulation on Room Temperature Distribution

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**ABSTRACT**

The excessive energy consumption through the last decades especially in air conditioning due to the negative awareness behaviour of consumers has reflected not only on the economy but also on the weather and environment. The aim of this study is to find the optimum thickness of Rockwool insulation to reduce the cooling load inside the buildings. Two items have been used through this research, VELOCICALC to measure the air temperature, humidity, and air velocity, with Infrared Thermometer to measure profile temperature of the walls. Three different thicknesses have been selected for the Rockwool insulation which are one layer 50 mm, two layers 100 mm and three layers 150 mm, as well as without insulation. The data present the 100 mm thickness layer of Rockwool is a better insulation thickness to reduce the heating load inside the room, the differential between outside and inside is 0.9°C, the Rockwool of one layer reduced only 0.5°C and the maximum thickness with three layers reduced only 1°C, which is not much effective compared to the two layers but even more costly. The results observed that the optimum thickness insulation is between 50 mm and 100 mm to reduce the temperature inside the room without wasting any cost for over insulating.

***Keywords:***
Saving energy; rockwool insulation; optimum thickness; tropical climate

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## 1. Introduction

In most countries the major issue which plays a very important role in economics and industrial developments is energy. Since the energy sources in the world are limited saving energy is a challenge in modern life. Malaysia for instance is a hot and humid country where most of the year this leads the population to use air conditioning to change the room temperature from hot to comfort condition. In several countries, the energy used for space heating and cooling of a building accounts for approximately 60% of the overall energy used in buildings, which accounts for the highest percentage of energy use, and accounts for approximately 40% of global energy demands. [1]. For long ago, the main concept of the insulation material has been to minimize heat flow from/to surfaces, the study showed the performance using polyethylene aluminum single bubble (PASB) as

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insulation in Malaysia and reported a 2.7$^{o}$C reduction [2]. Most of the research focus on heating and cooling of buildings insulation [2-8] while, [9-18] are focusing on the piping line insulation, due to the large possibility for energy conservation. However, most of these studies consider uniform insulation thickness. The recent concerns of saving energy and awareness of the limited energy resources encouraged revisiting the problem of thermal insulation [3, 19]. An experimental study about energy consumption showed that almost 20% of energy in the buildings is wasted; this is due to non-efficient energy management. Therefore, by revising the energy management in the buildings it can be revived [20]. Thermal insulation is a great contributor and distinct practical and logical first step towards achieving energy efficiency considerably in envelope-load in the building located in harsh climatic conditions, the appropriate use of thermal insulation contributes to reducing the required air conditioning as well as the annual energy cost, it also improves in extending the periods of thermal comfort without reliance on mechanical air-conditioning especially during inter-seasons periods [21]. Based upon an early study conducted by [22], increasing the thickness of insulation has a beneficial impact on heating load rather than cooling load, according to the studies. In 2015, Asdrubali *et al.* [23] conducted a review study of possible commercial insulation materials. The purpose of this study is to find the optimization effective thickness of Rockwool insulation and its ability in reducing cooling load and the heat gain from the roof.

## 2. Methodology

The prototype of this study is a wooden room of a volume of 1 m$^3$ made to apply the Rockwool on its roof and measure the temperature of the walls as well as the inner temperature of the room and use the results as inputs for his solid works simulation for the project. The room has 5 sides, leaving the bottom of the room uncovered to allow air circulation as the room will be placed on stands, and the front side of the room has a hole to allow the entrance of the temperature measuring tools. The insulation material (Rockwool) is provided in layers with a thickness of 0.05m for each layer according to the market's standard, where the layers will be placed on the roof of the wooden room to determine the Rockwool's effect on the temperature of the room. Balsa wood has been used to fabricate the wooden room model for the present study. The properties of Balsa wood shown in Table 1.

**Table 1**
Balsa wood specifications

| Property | Value | Units |
|---|---|---|
| Thermal Conductivity | 0.05 | W/(m.K) |
| Specific heat | 1420 | J/kg.K |
| Density | 178 | Kg/m$^3$ |
| Elastic Modulus | 0.175 | GPa |
| Poisson ratio | 0.29 | - |

Source [24]

The Rockwool comes in 6 layers pack covered with plastic as shown in Figure 1, with dimensions of (1.2 m × 0.6 m) according to the market's standard and had to be adjusted in dimensions to fit the roof of the prototype designed.

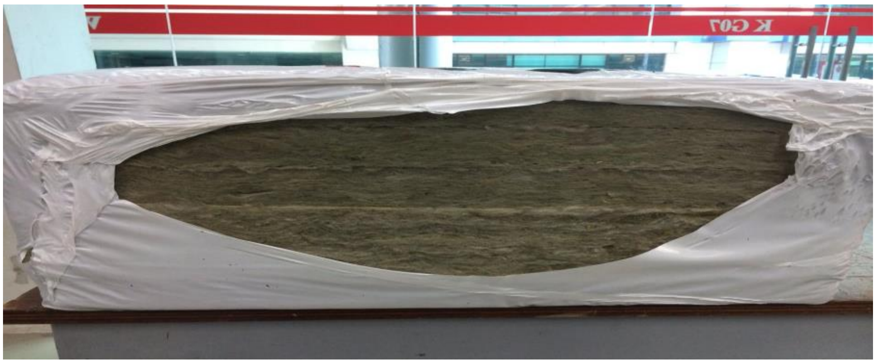


**Fig. 1.** Rockwool pack containing 6 layers, each of 50mm thickness

Rockwool is considered as a hazardous insulating material where required extra precautions dealing with the material whether in cutting it to fit the roof of the wooden room or in applying it on the wooden room. Table 2 present Rockwool's specifications:

**Table 2**
Rockwool's specifications

| Specifications | Values |
|---|---|
| Density (kg/m$^3$) | 120.0 |
| Cp (J/kg.k) | 840.0 |
| Thermal Conductivity k (w/m.k) | 0.045 |

Source [25]

This study was conducted to determine the amount of heat transferred into the prototype model through the roof for a wooden box. The parameters measured were air temperature, air velocity and walls temperature. There has been one wooden box built as a prototype model, which was made of balsa wood. The data that was measured during this project are the air temperature, air velocity, and walls temperature from 10 am to 3 pm during the peak hours. The prototype model was exposed to the sun for most of the day, where the prototype model dimensions were of (1.2 m height × 0.9 m length × 0.9 m width) with one layer of Rockwool insulation as shown in Figure 2. The three different thicknesses of Rockwool insulation which been used are installed on the top of the wooden box as roof insulation, the model has been covered by insulation to decrease the heat flux through the roof therefore, the wooden box has been considered as a room with an insulated roof.

**Fig. 2.** Wooden Room Applying One Layer (50 mm) of Rockwool insulation

Data measurements were the air temperature inside and outside the test models, and air velocity inside and outside the prototype model, from 10 am – 3 pm during the peak hours. The indoor and outdoor transactions were measured for air temperature, and air velocity by using a velocity meter – VELOCICALC and Infrared Thermometer to measure the profile temperature, as shown in Figures 3 and 4, respectively.

**Fig.3.** VELOCICALC Meter

**Fig.4.** Infrared Thermometer

## 3. Result and Discussion

### *3.1 Experimental result*

This experimental work is concerned about expressing the effect of Rockwool insulation in reducing the temperature of buildings. For achieving this goal, a wooden box was built as a prototype model and the measurements that have been built on was related to the size of the Rockwool layer to be applied on the roof. Data was collected for three different thicknesses of Rockwool insulation, as well as without insulation. For a total of 20 days, measurements of air velocity, air temperature, and wall temperature were taken. The prototype model was insulated with different thicknesses of Rockwool insulation and one without any insulation. By referring to Figure 5, where shows the average results between the outer air temperature and the inner air room temperature of the test that included applying the 1$^{st}$ layer of Rockwool insulation on the roof of the room to record the effect of the 1$^{st}$ layer on the inner room temperature, as the highest outer temperature was recorded in Degrees Celsius at 1 pm reaching to an approximate temperature of 34.6$^{o}$C while the inner room temperature at the same timing was close to 34.2$^{o}$C which shows a small effect of the 1st layer of Rockwool resulting in a 0.5$^{o}$C difference between the inner & outer temperatures.

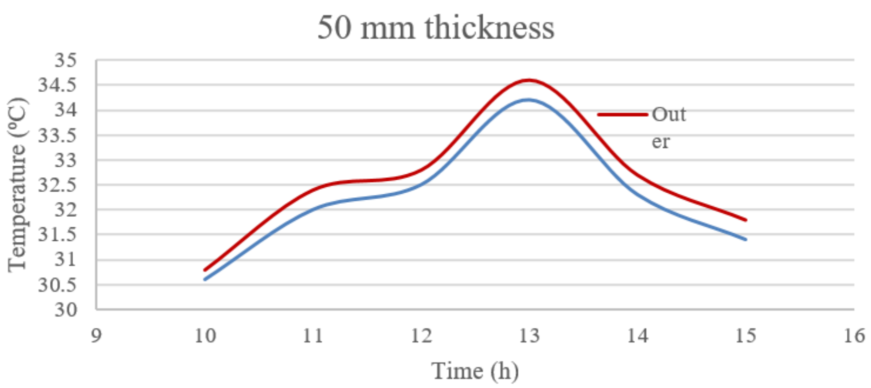


**Fig. 5.** Temperature Distribution Inside and Outside the Room with Single Layer of Rockwool Insulation

While Figure 6, shows the average results between the outer air temperature and the inner air room temperature of the test that included applying the 1st and 2nd layer of Rockwool insulation with a thickness of 100 mm on the roof of the room to record the effect of both layers on the inner room temperature, as the highest outer temperature was recorded in Degrees Celsius at 1 pm reaching to an approximate temperature of 34.9$^{o}$C while the inner room temperature at the same timing was 34$^{o}$C which shows a great improvement in the effect of the 1st and 2nd layers of Rockwool compared to the 1st layer alone resulting in an approximate difference of 0.9$^{o}$C.

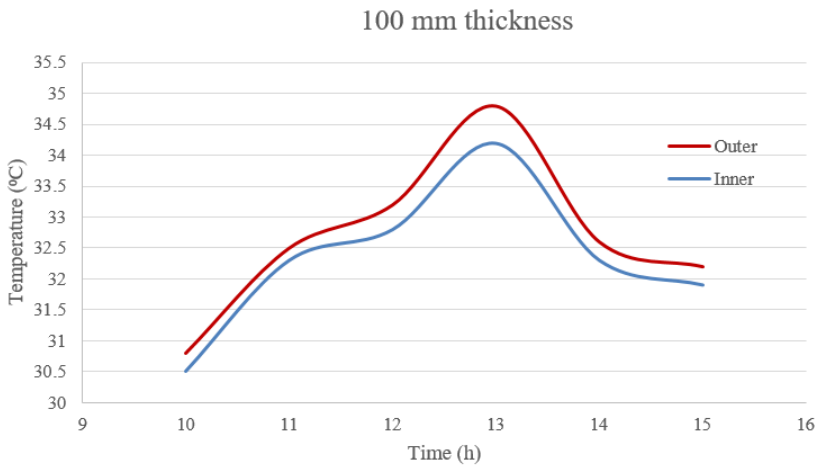


**Fig. 6.** Temperature Distribution Inside and Outside the Room with Two Layers of Rockwool Insulation

In Figure 7, it shows the average results between the outer air temperature and the inner air room temperature of the test that included applying all 3 layers of Rockwool insulation with a thickness of 150 mm on the roof of the room to record the effect of the insulation on the inner room temperature, as it is shown in the figure the highest outer temperature was recorded at 1 pm reaching to an approximate temperature of 35.6$^{o}$C while the inner room temperature at the same timing was 34.4$^{o}$C which shows a great improvement in the effect of all layers together compared to the 1st layer alone, but at the same time, not much difference compared to the 2nd test that included two layers of Rockwool as it reduced around 1$^{o}$C.

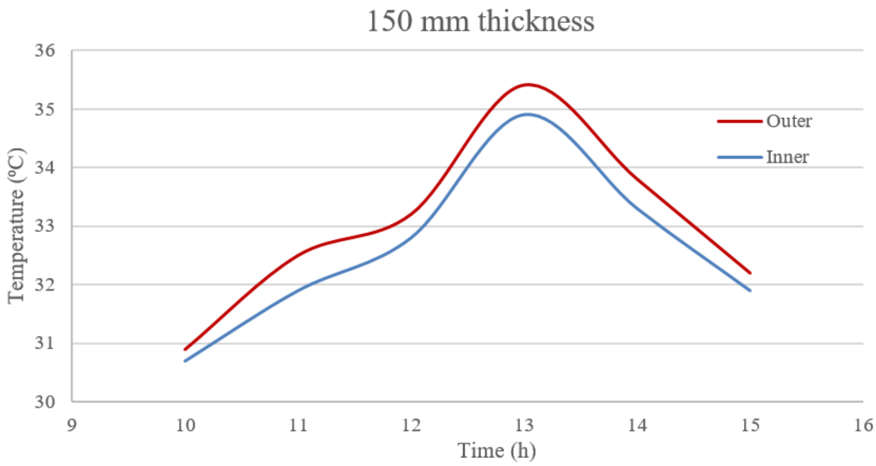


**Fig. 7.** Temperature Distribution Inside and Outside the Room with three layers of Rockwool Insulation

Based on the presented results, Rockwool insulation with a thickness of 100 mm had the greatest temperature control and cost savings, while the 50 mm thickness was ineffective, and the 150 mm thickness decreased the temperature but only slightly relative to the 100 mm thickness layer and cost more, which was not worth it.

## 4. Comparison between Different Thicknesses Effect

According to the results obtained from the simulation, applying 2 layers with a maximum thickness of 100mm gives the best results in reducing inner room temperature and in cost-saving purpose, as it decreased the room temperature by 2.31% compared to the test that included applying only one layer of Rockwool with a thickness of 50mm only which only reduced the temperature by 1.49% and the test that included applying three layers of Rockwool with a thickness of 150mm that even though reduced the temperature by 2.52% but doesn't give a bigger difference and doesn't worth the cost.

According to a study conducted by Mahlia [7], on thicknesses of insulation materials, a polynomial function based on Eq. (1) was given to find the optimum thickness of insulating material.

$$x_{opt} = a + bk + ck^2 \quad (1)$$

Where $a = 0.0818, b = -2.973$, and $c = 64.6$ & $k =$ Insulation thermal conductivity.

therefore, Eq. 2 present the full calculation of the optimum thickness of the Rockwool.

$$x_{opt} = 0.0818 + (-2.973)(0.045) + (64.6)(0.045)2\ (2) = 0.078\ \mathrm{m} = 78.8\ \mathrm{mm} \quad (2)$$

This demonstrates that a thickness of 100 mm is superior to 50 mm and 150 mm, since the cost of 150 mm is somewhat greater than 100 mm, and the reduction difference is not important.

## 5. Conclusion

The objective of this study has been achieved by finding the optimum thickness of the Rockwool insulation by measuring the air temperature and air velocity inside an insulated room outside a room with three different layers. The three different layers of the Rockwool insulation with 50 mm thicknesses each were applied on top of the roof of a prototype wooden room. Based on the data collection and the calculation analysis, it can conclude by the results that the Rockwool layer with a thickness of 100 mm is more worthy of using than the 50 mm thickness layer or the 150 mm thickness layer. The best results achieved from the thermal analysis for the Rockwool layer (100 mm thickness) was 0.9$^{o}$C difference between outside temperature and inner room temperature for an approximate cost of RM 19 (Malaysian ringgit) compared to the results given by the Rockwool layer (50 mm thickness) which reduced 0.5$^{o}$C for an approximate cost of RM 9.5 & to the Rockwool layer (150 mm thickness) which reduced 1$^{o}$C for an approximate cost of RM28. Therefore, if the dimensions of a UCSI lecture room is to be considered, then applying Rockwool insulation with a thickness of 100 mm would cost around RM 1520 as a UCSI lecture room is of 8 m width & 9 m length.

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